Fractures of the Scapula: A Narrative Review on Diagnosis and Management

Sujayendra Murali[1], Sandesh Madi[1], Raghuraj Kundangar[1], Monappa Naik[1], Anika Sait[1]

Abstract

Scapula fractures are relatively rare when compared to fractures of the other bones of the shoulder region. High-velocity injuries encountered in road traffic accidents are responsible for the increased incidence of these fractures. Intra-thoracic and cervical spine injuries can be associated with these fractures and warrants a thorough clinical examination. In an acute setting of patient resuscitation, the initial diagnosis of these fractures is frequently missed or delayed. Radiological assessment should include dedicated shoulder trauma X-ray series and computed tomography scans with three-dimensional reconstruction. Being suspended by the dense muscles of the shoulder complex, the union of these fractures is rarely a concern. However, with a better understanding of the biomechanics, the management of these fractures is gradually evolving. Only in recent times, the criteria for surgical intervention for these fractures have been defined. This narrative review aims to provide a brief overview of the recent advances and the changing concepts of these uncommon fractures.

Keywords: Trauma; Scapula; Fracture classification; glenoid; algorithm

Introduction

Fractures of the scapula account for 3–5% of fractures of the shoulder girdle and about 0.7% of all fractures [1]. Most of these fractures have been traditionally treated by nonoperative methods with good functional outcomes. Recent studies have demonstrated that the scapula acts as a dynamic stabilizer of the shoulder girdle. With this understanding, the effect of scapular malunion on shoulder range of movement, strength, endurance, and reaction time of the shoulder girdle is being questioned. Hence, the role of surgical fixation of displaced scapular fractures is now gaining popularity [1]. Except for displaced intra-articular glenoid fractures which require surgical fixation, the criteria to manage the scapular fractures by surgical fixation have been poorly understood. With a better understanding of shoulder anatomy, pathomechanics of scapular fractures, and evolution of surgical treatment, there has been a paradigm shift in the management of displaced scapular fractures with surgeons preferring to fix these fractures to restore articular surface and alignment surgically.

[1]Department of Orthopaedics, Kasturba Medical College, Manipal Academy of Higher Education, Manipal

Address of correspondence :
Dr.Sujayendra Murali
Department of Orthopaedics, Kasturba Medical College, Manipal Academy of Higher Education, Manipal -576104
E-mail: sujayendra16@gmail.com

Anatomical Considerations

Like any other joint, the shoulder joint has both static and dynamic stabilizers. The static stabilizers include the articular surface, the negative intra-articular pressure, the glenoid labrum, and the capsule-ligamentous structures. The rotator cuff muscles act both as dynamic as well as a static stabilizer by applying a constant axial compressive force on the humeral head against the glenoid [2]. Studies have now shown that scapula also acts as a dynamic stabilizer with glenoid trying to center itself over the moving humeral head. Hackney described this as an analogy of a seal trying to balance a ball on its nose [3]. With both the nose and the ball moving independently, the control of the ball (humeral head) depends on the control of the nose (glenoid). This centering of the humeral head against the glenoid is required for the optimal functions of the rotator cuff. At extremes of translation between the humerus and glenoid, the protective rotator cuff reflexive arc prevents dislocation, as described by Myers et al. [4].

Scapula provides attachment to 18 muscles. These are classified into the scapulo-axial system that connects the scapula to the vertebral column and the chest wall, and scapulo-brachial system that connects the scapula to the humerus and proximal forearm. The first system controls the movement of scapula over the chest wall, and the second controls the movement between the scapula and the arm. Thus, the scapula integrates the activities of the two groups of muscles and plays a central role as a dynamic stabilizer of the humeral head during movement. Consequently, scapular

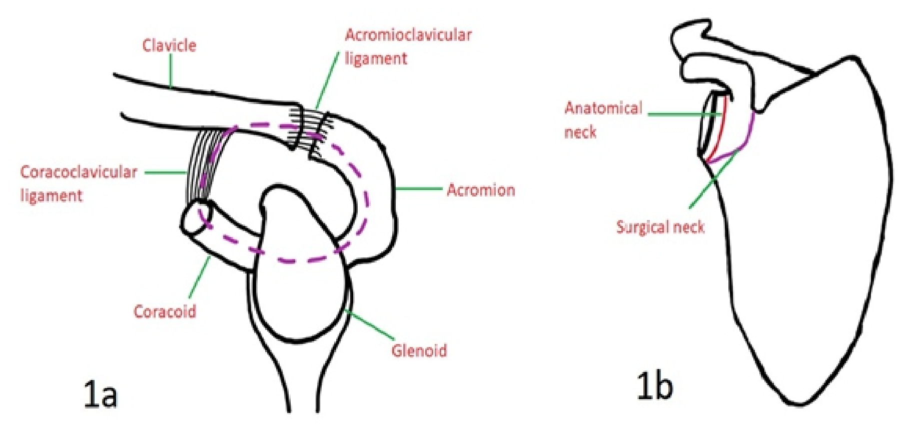

Figure 1: (a) Superior suspensory shoulder complex (illustration) (b) Anatomical and surgical neck (illustration).

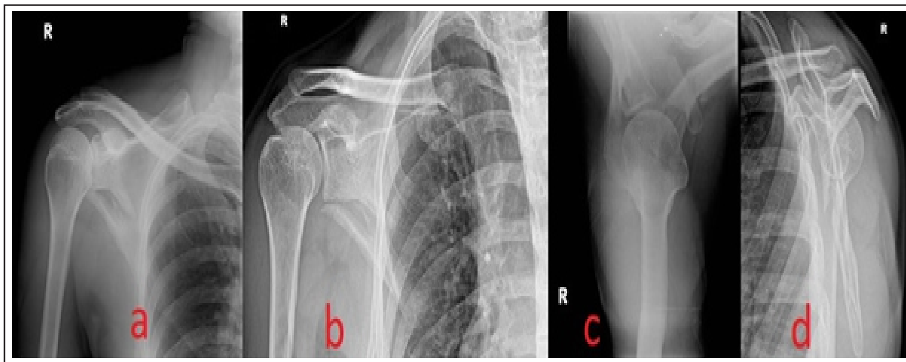

Figure 2: Scapula x-ray series; (a) standard AP view, (b) Grashey view, (c) axillary view, (d) Y view.

malunion is bound to affect these dynamic stabilizers in a way that promotes fatigue and symptoms of dysfunction. Cole et al. [2] identified five patients with shoulder symptoms associated with malunion of scapula neck and/or body fracture. Corrective osteotomy of the malunited scapula yielded good functional results.

Goss [5] in 1993 described the superior shoulder suspensory complex (SSSC) as an osseoligamentous ring composed of the glenoid, coracoid, acromion, the acromioclavicular joint, lateral end of the clavicle, and the coracoclavicular ligaments. Two bony struts hold the ring – the superior consisting of the middle third of the clavicle and the inferior, consisting of the junction between the most lateral portion of the scapular body and the most medial part of the scapular neck. The ring maintains a stable mechanical relationship among the scapula, extremity, and axial skeleton. Disruption of any two of the structures constituting the ring is called "floating shoulder" and is an indication for surgical intervention [6] (Fig. 1).

Clinical Examination

Scapular fractures occur as a result of direct trauma to the scapula, fall from a height, motor vehicle accident, or fall of a heavy object on the shoulder. The physical examination should include a thorough evaluation of the head, neck, spine, chest, and the upper extremity. The clinical assessment should hence begin and proceed according to the protocols of advanced trauma life support. The injured extremity should be splinted in an arm sling during the evaluation.

Baldwin et al. [7] reviewed a database of 9453 scapular fractures over 6 years to identify concomitant diagnoses and noted that ipsilateral clavicle fracture, rib fractures, spine fractures, hemopneumothorax and even, pelvic injuries frequently occurred in individuals with scapular fractures. Mayo et al. [8] in their study on fractures of the glenoid fossa identified rib fractures (52%), ipsilateral upper extremity fractures (37%), pulmonary contusion (26%), and nerve injury (brachial plexus or peripheral 7%) to occur concomitantly with scapular fractures. Fractures that extend to involve the spinoglenoid notch are at a particular risk of injuring the suprascapular nerve.

Radiological Evaluation

Imaging plays a key role not only to diagnose the injury, but it also facilitates appropriate decision making in further management. For the radiological assessment of the suspected scapula fractures, one must be able to visualize the entire shoulder girdle, including three bones (clavicle, scapula, and proximal part of the humerus) and three joints (glenohumeral joint, acromioclavicular joint, and the sternoclavicular joint). Thus, a typical imaging series should include a standard anterior-posterior (AP) view of shoulder, a Grashey view (true AP view of the shoulder), an axillary view, and a scapular 'Y" view [9] (Fig. 2). The Grashey and the axillary views are mainly useful for evaluating the glenohumeral intra-articular fractures.

Grashey view, also known as Neer 1 projection, is obtained by rotating the affected side posteriorly approximately 35–45° such that plane of the scapula is parallel to the cassette, positioning the arm in neutral and directing the beam tangentially to the shoulder joint [10].

The glenopolar angle (GPA) and the lateral border offset (LBO) can be measured on the Grashey view to quantify the displacement [1]. The GPA is the angle created at the intersection of the two following lines (Fig. 3).

- A line is drawn from the superior apex of the glenoid fossa to the inferior angle of the scapula

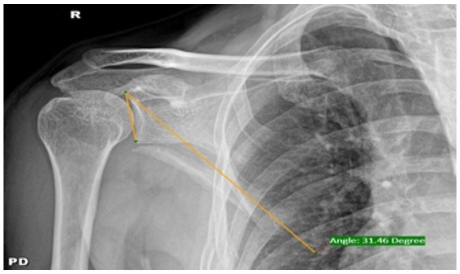

Figure 3: Glenopolar angle measured on X-rays.

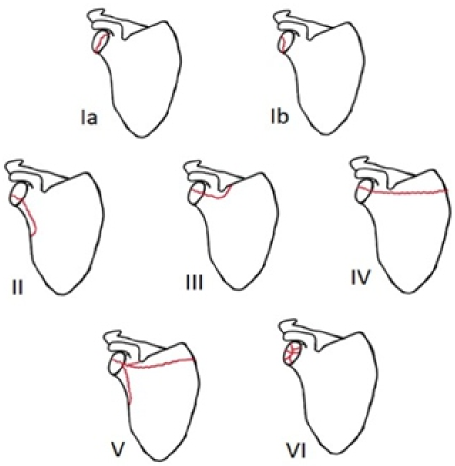

Figure 4: Glenoid fracture (Goss) classification (illustration). Type Ia – anterior rim fracture. Type Ib – posterior rim fracture. Type II – inferior glenoid fracture involving part of the neck. Type III – superior glenoid fracture extending through the base of the coracoid. Type IV – horizontal fracture involving scapular neck, body, and runs below the spine of the scapula. Type V – combination fractures. Type VI – comminuted fracture of the glenoid.

- A line is drawn from the superior apex of the scapula to the inferior glenoid fossa.

The normal GPA has a range of 40.6°±4.299 [11]. The LBO indicates the displacement of the glenoid relative to the lateral border of the scapula.

The scapular "Y" view, also known as Neer 2 projection, is a true lateral view of the scapula and allows the assessment of fracture angulation. These radiographic measurements form the basis for determining the modality of treatment.

Besides these dedicated shoulder X-ray series, the radiological evaluation should invariably include a standard chest anteroposterior radiograph (to rule out rib fractures and hemopneumothorax) and a lateral view radiograph of the cervical spine (to identify spinal injuries) [7].

Sometimes, in an acute setting, it may not be possible to position the patient for the desired X-rays. The imaging modality of choice to better understand the fracture morphology, intra-articular extension, and comminution is, however, a computed tomography (CT) scan with a 3D reconstruction [12]. The transverse cuts are helpful in the assessment of the glenoid fossa. CT scans have been shown to have better inter-observer and intra-observer reliability than plain radiographs in the assessment of scapular fractures [13]. If the fracture is displaced and warrants surgery, then a three-dimensional (3D) CT scan helps to determine the best approach for fixation [14]. 3D CT images add value by mitigating artefacts produced by patient body habitus, patient positioning, and imaging technique [9]. CT scan also helps in identifying concomitant thoracic injuries and pulmonary contusions [15]. Thus, CT scan with 3D reconstruction is reliable and accurate in identifying the fracture geometry and the extent of the injury.

Classification Systems [16, 17]

Anatomical

The most basic form of classification is based on the anatomical location of the fracture. Fractures can be classified based on the part involved, such as coracoid, acromion, body, neck, spine, and glenoid fractures. It does not have any prognostic value.

Glenoid fractures

Numerous classification systems are described for glenoid fractures; however, none is considered as the gold standard. Ideberg, Goss, Habermeyer, and Mayo are some of the well-known systems. Most popular is by Ideberg et al., which was later modified by Goss et al. (Fig. 4) [1, 8]. Finally, Bigliani et al. have classified the glenoid rim fractures associated with recurrent anterior shoulder dislocation into three types [18].

"Postage stamp fractures" are the unique anterior glenoid rim fractures that occur when the suture anchors used for Bankart repair give way resulting in a serrated edge at the glenoid margin. (Fig. 5) A recently conducted systematic review noted that this potential complication is frequently seen in males, age 25 years or younger, participants in sporting activities and fractures initially stabilized with three or more anchors or conventional knot-tying anchors or that experienced osteolysis around anchor sites [19].

AO: In 2018, the AO foundation updated

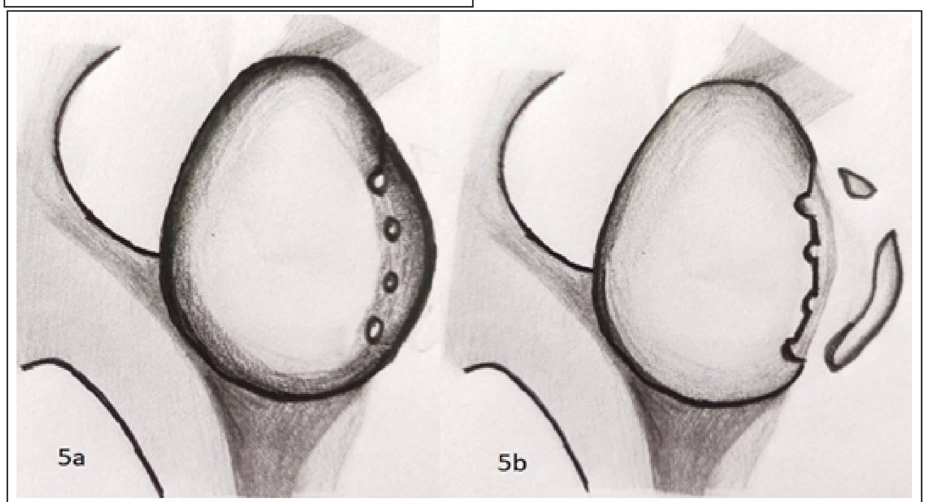

Figure 5: Postage stamp fracture (illustration).

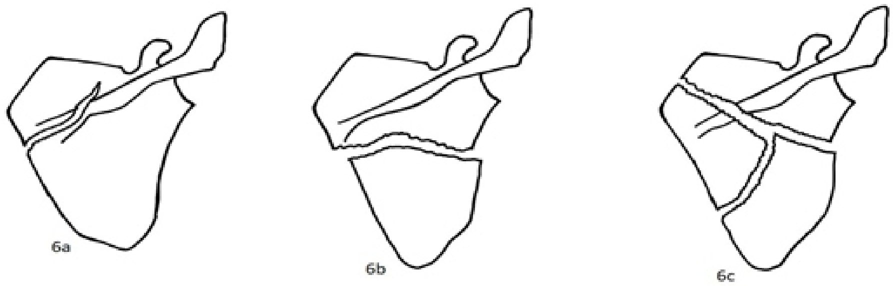

Figure 6: Scapula body fracture classification (illustration). (a) Fracture through the spinal pillar (intact lateral pillar). (b) Fracture through the lateral pillar (intact spinal pillar). (c) Fracture involving both the pillars.

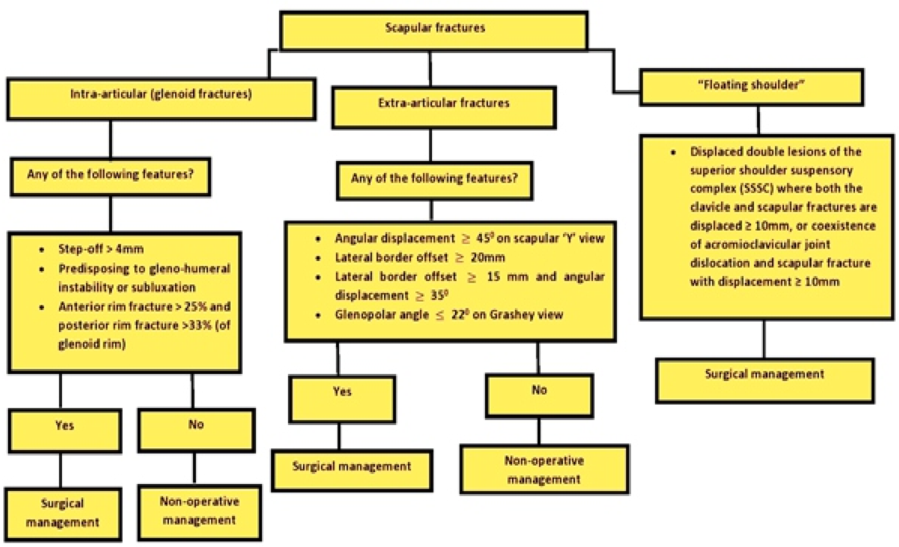

Figure 7: Treatment algorithm.

its comprehensive alpha-numeric classification system of fracture and dislocation (scapula). According to the revised system:

- Scapula is 14
- Fractures of the processes (coracoid, acromion, spine) are 14A
- Fracture of the body is 14B
- Fracture of the glenoid fossa is 14F.

Further detailed AO classification for scapula fractures is beyond the scope of this review.

Scapula body fractures

Recently, Bartonicek et al. [16] have described a clinically oriented classification system for the body fractures. Based on the 3D reconstruction of scapula, they studied the course of fracture lines and attempted to define the "body" fractures. They presented a concept of "biomechanical body of scapula," which is an area surrounded by a triangular construct comprising of two pillars (spinal and lateral pillars) and a medial border. Accordingly, a body fracture is one in which the fracture lines must involve at least one of the pillars. Based on this, three groups were identified: Scapular body fractures involving only the spinal pillar, those involving only the lateral pillar, and fractures affecting both pillars (Fig. 6). They concluded that this system provided pre-operative guidance for planning the fracture fixation.

Floating shoulder

Goss classified as single or double disruption of the osseoligamentous ring of the superior suspensory shoulder complex leading to a "floating shoulder" [5].

Treatment (Fig. 7)

The approach to the treatment of scapular fracture has evolved over the years from managing all fractures non-operatively to trying to establish indications for surgical management. Literature over the years has shown poor long-term outcomes of displaced scapular fractures managed non-operatively with patients subsequently suffering from persistent pain, inability to perform activities of daily living, and rotator cuff dysfunction [1, 2, 20-22]. There have also been studies that have demonstrated satisfactory outcome following nonoperative treatment of displaced scapular body fracture [23]. Another study by Jones and Sietsema compared the results between operative and nonoperative cohorts and found similar outcomes [24]. In general, studies have shown that nonoperative management is reserved for fractures displaced <15–20 mm and angulated <30–45° [1, 23-26].

Besides the fracture location, degree of displacement, and geometry, other factors to be taken into consideration for operative intervention include patient's age, activity level, hand dominance, and surgeon's preference.

Intra-articular fractures (glenoid fractures)

Glenoid rim fractures are typically associated with joint dislocations, and central fossa fractures are seen in high impact injuries along with fractures of other parts of the scapula. The primary objective is to correct the joint congruity, prevent joint instability, and arthritis.

Based on these classification systems by Ideberg [8] and Goss [5], several indications for open reduction and internal fixation have been proposed:

- An intra-articular "step-off" of more than 4 mm or involvement of more than 20% of the articular surface
- Any fracture of the glenoid that predisposes to or cause instability and/or subluxation of the

glenohumeral joint
- Anterior rim fractures involving more than 25% of the glenoid rim and posterior rim fractures involving more than 33% of the glenoid rim [27].

Extra-articular fractures

For extra-articular fractures of the neck and body, Cole et al. [1, 2, 28] have suggested the following relative indications for surgery:

1. Angular displacement ≥45° on scapular "Y" view
2. LBO ≥15 mm plus angular deformity ≥35°
3. LBO ≥20 mm
4. GPA ≤22° as measured on true Grashey view
5. Displaced double lesions of the SSSC where both the clavicle and scapular fractures are displaced ≥10 mm or coexistence of acromioclavicular joint dislocation and scapular fracture with displacement ≥ 10 mm.

The last indication, that is, the lesions involving the SSSC, has been debated over the years, with few authors preferring to manage both fractures nonoperatively if minimally displaced [29, 30]. Goss [5], however, suggested that the threshold for managing these lesions nonoperatively should be low as they frequently lead to instability.

Being mostly a flat bone, trauma surgeons operating on scapula fractures must be aware that the area for optimal implant position and screw purchase is limited. Gardner et al. [31] suggested that the bone condensation regions are in the glenoid neck, the acromion, the coracoid, and the lateral scapular border and are ideal for placement of fixation to optimize screw purchase.

Coracoid and acromion processes

Isolated fractures of acromion and coracoid are rare. Displaced fractures and those associated with disruption of SSSC warrant surgery. Displacement more than 10 mm is considered as an indication for surgery and literature in the past has shown good functional outcomes and union rates [32-37].

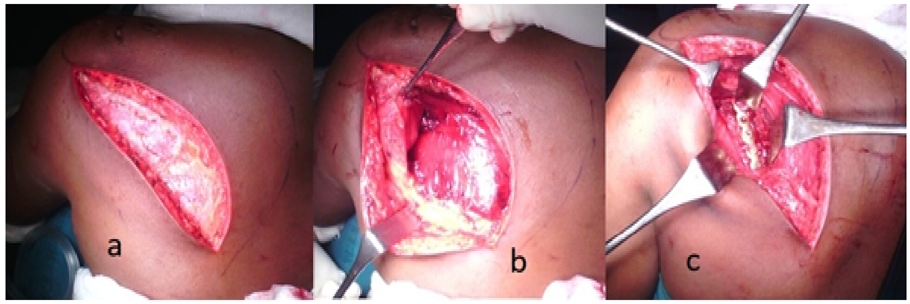

Figure 8: (a) Surgical incision; (b) muscle plane; (c) fixation.

Surgical approaches

The surgical approach for reduction and fixation depends on the fracture pattern. CT scan with 3D reconstruction is invaluable in this regard. Armitage et al. [14] mapped 90 scapular fractures from the analysis of 3D CT to illustrate various fracture patterns and the basis for their surgical approach. It is preferred that surgical planning and approach be individualized based on the patient's CT scan.

Classical Judet's [38]

It is the workhorse approach for most of the fractures of the body and spine. Described by Robert Judet in 1964, this extensile approach provides exposure to

1. Posterior and inferior rims of the glenoid
2. Neck of scapula
3. Lateral and medial borders of the scapula
4. Spine of scapula.

The incision begins from the posterior aspect of the acromion. It is continued up to the spinomedial angle along the spine of the scapula, where it curved to extend along the medial border up to the inferior angle. The skin and subcutaneous tissue are raised as a flap and retracted inferolaterally. Two important intervals are to be identified thereafter:

1. The interval between the posterior fibers of deltoid and infraspinatus at the spine of the scapula. Medially, these two muscles are covered by a common fascia. The fibers of deltoid should be gently elevated off the spine and retracted laterally
2. The interval between the infraspinatus and teres minor to expose the posterior circumflex humeral vessels. Once these vessels are ligated and cut, the infraspinatus can be elevated gently, taking care to avoid damage to the suprascapular nerve at the spinoglenoid notch.

This approach requires extensive soft tissue dissection, and there is always the risk of damaging the neurovascular bundles, especially the posterior circumflex humeral artery and the axillary nerve in the quadrangular space and the suprascapular nerve at the spinoglenoid notch. The elevated posterior fibers of the deltoid and infraspinatus are to be carefully re-attached once the internal fixation is over to avoid the weakness of these muscles (Fig. 8).

Modified Judet's

Several modifications have been described. A modification to this approach has also been proposed to aid in better visualization of the bony fragments and limit damage to the musculature, mainly the rotator cuff [33, 34]. The most important step in both approaches is developing an interval between teres minor and infraspinatus, which gives access to the lateral border of the scapula. Distal and lateral to this interval are the quadrangular space containing the axillary nerve and the posterior circumflex humeral artery and care must be taken while developing this interval.

Minimal invasive

A minimally invasive approach has also been described to reduce the insult to the soft tissues. In this approach, incisions are made on anatomic bony "perimeters" to access the scapula borders for reduction and fixation [36].

All Arthroscopic

For the glenoid rim fractures, there has been tremendous progress in the field of shoulder arthroscopy in the last decade. Arthroscopy is advantageous in effectively manipulating the fracture and visualizing its accurate reduction. Fixation can be accomplished utilizing suture anchors, screws, bioabsorbable pins, and buttons. It has been recommended that the arthroscopic indications are limited to the fresh rim or avulsion fractures, involving up to 35% of articulating surface [39]. Some of the recently described techniques include.

- All arthroscopic technique that involves special posterior glenoid guide and two pairs of round buttons, connected with No. 5 high-strength orthopedic sutures [40]
- Arthroscopic indirect fragment reduction by ligamentotaxis technique using suture anchor [41]
- Arthroscopic reconstruction of a multi-fragmented anteroinferior glenoid rim fracture using a modified knotless anchor technique and bioabsorbable pins [42].

Recently, a comparative study observed that both open and arthroscopic techniques for glenoid rim fractures (Ideberg type IA) have similar functional outcomes. However, arthroscopy group had lower complications and re-operation rates [43]. Thus, the arthroscopic technique appears to be a promising approach.

Since most of the fractures involve the scapular neck and body, a posterior Judet approach [38] is preferred. An extensile approach involving elevation of the entire infraspinatus has also been described for fractures at multiple places on the body of the scapula [44]. Articular fractures require anterior or posterior approaches to the shoulder joint, depending on the pattern of the fracture on CT scan.

Rehabilitation

Nonoperative cases

Following 2 weeks of sling immobilization, the passive shoulder range of movement exercises is begun to achieve full range by the end of 1 month. In the 2nd month, the aim is to restore the active range of movements. Strengthening of rotator cuff muscles and parascapular muscles may be started by the 3rd month [45].

Operated cases

Post-operative rehabilitation in the form of immediate commencement of passive and active range of movement of the shoulder joint should be emphasized. Strengthening and resistance exercises, followed by endurance training, should be gradually introduced under the supervision by 8 weeks postoperatively [1].

Summary

The management of scapular fractures has evolved over the years, and surgical management of displaced fractures is gaining popularity. The associated, more grievous injuries such as multiple rib fractures with pulmonary contusion and hemopneumothorax, spine injuries, and pelvic injuries have to be identified and managed accordingly. Literature has been able to lay down definitive and relative indications for surgery with angularity and displacement measured radiologically, forming the basis. CT scan with 3D reconstruction is an immensely valuable investigation in identifying fracture patterns and planning the surgical approach. Although there is a paucity of randomized controlled trials to compare the outcomes following surgical fixation, literature has shown good results following surgical fixation. Malunion of scapular fractures may cause persistent pain, disability and even rotator cuff dysfunction leading to poorer outcomes in the long term. Following the principles of AO, with a keen emphasis on the biological fixation with the protection of soft tissue sleeves, enables faster rehabilitation and better outcomes.

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