Scapular Fractures and Dislocations: Diagnosis and Treatment

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Abstract

Traumatic injuries of the scapula and the scapulothoracic articulation have received little attention in the literature, since they are uncommon. Scapular fractures constitute only 1% of fractures in general, and scapulothoracic dissociations and dislocations are extremely rare. The vast majority can and should be managed nonoperatively. However, recent experience has shown that injuries that involve significant displacement can have long-term adverse functional consequences for both the shoulder complex and the upper extremity as a whole. In these situations, surgery should at least be considered. Various scapular fractures and dislocations are discussed, with particular emphasis on those requiring operative care.

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Scapular fractures and dislocations can result in considerable morbidity and therefore deserve more respect and effort than they have been accorded in the past. The purpose of this review is to summarize the principles of the evaluation and treatment of these challenging injuries.

Incidence and Mechanisms of Injury[1-5]

Scapular fractures are uncommon, constituting only 1% of all fractures, 3% of shoulder-girdle injuries, and 5% of all shoulder fractures. A variety of reasons have been offered for this low frequency, of which the most important are that (1) the scapula is protected by the rib cage and thoracic cavity anteriorly and a thick covering of soft tissues posteriorly, and (2) the mobility of the scapula allows considerable dissipation of traumatic forces. Fractures of the scapular body and spine make up approximately 50% of the total; fractures of the glenoid neck, 25%; fractures of the glenoid cavity, 10%; and fractures of the acromial and coracoid processes, 7% each. Any fracture line that runs from the posterior margin of the scapular spine or acromion to the undersurface of the acromion all the way to the deepest point of the spinoglenoid interval is considered an acromial fracture.

Scapular fractures are usually caused by high-energy trauma. Direct forces are most common, although indirect mechanisms can be responsible, such as a fall on the arm that causes the humeral head to impact the glenoid cavity. As a result, 80% to 95% of these fractures are associated with other injuries, which may be multiple, major, and even life-threatening. Consequently, scapular fractures are often diagnosed late, and definitive treatment is often delayed. This fact, combined with the possibility of injury to adjacent osseous and / or soft-tissue structures, may compromise the patient's final functional result.

Indirect forces may also cause a variety of avulsion fractures at musculotendinous and ligamentous attachment sites, such as the superior scapular angle (insertion of the levator scapulae), the superior scapular border (omohyoid muscle attachment), the tip of the coracoid process (attachment of the conjoined tendon), the superior border of the coracoid process (attachment of the coracoclavicular ligaments), the acromial margin (origin of the deltoid muscle), and the inferior angle of the scapula (insertion of the serratus anterior). Scapular fractures caused by forceful muscle contractions associated with seizures, electroconvulsive treatment, and electrical injuries are well documented. In addition, fatigue and stress fractures are occasionally seen.

Diagnosis

The physician's attention is initially drawn to the scapular region by the patient's complaints of discomfort in the area, often accompanied by

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abnormal physical findings such as swelling and ecchymosis, or by abnormalities noted on a chest radiograph. If a scapular fracture is noted or suspected, true scapular anteroposterior (AP) and lateral views as well as a true glenohumeral axillary projection make up the routine "trauma series." The scapular body and spine, the three processes (the acromial, coracoid, and glenoid processes), and the three articulations (the scapulothoracic, glenohumeral, and acromioclavicular [AC] articulations) must be evaluated. Oblique views may be helpful in certain situations, and a stress AP projection with weights should be obtained if an injury to the AC articulation is suspected. Because of the complex osseous anatomy in the area, computed tomographic (CT) scanning with reconstructions is often necessary to accurately detect and define the extent of injury.

Nonoperative Treatment

The vast majority (more than 90%) of scapular fractures are only minimally or acceptably displaced, primarily because of the thick, strong support provided by the surrounding soft tissues. Treatment is symptomatic. Short-term immobilization in a sling and swathe bandage is provided for comfort. Early progressive range-of-motion exercises and use of the shoulder out of the sling within clearly defined limits are begun as pain subsides. In some cases, close radiographic follow-up is necessary to ensure that unacceptable displacement does not occur. Most scapular fractures heal completely by 6 weeks, and all external support is discontinued at this time. Progressive use of the upper extremity is encouraged. Range-of-motion exercises continue until full shoulder mobility is recovered. As range of motion improves, progressive strengthening exercises are added. It can be anticipated that full functional recovery will take several months. Ultimately, the prognosis for these fractures is excellent.

Approximately 50% of scapular fractures involve the scapular body and spine. Both avulsion fractures caused by indirect forces and injuries caused by direct trauma have been described. The latter may be severely comminuted and displaced. Despite sporadic reports describing operative management, there seems to be little enthusiasm for surgical treatment. There are two reasons for this reluctance: (1) there is little substantial bone stock for internal fixation aside from the scapular spine and lateral scapular border, and (2) these fractures seem to heal reliably with a good functional result without surgical treatment. If painful scapulothoracic impingement occurs at a later date, bone prominences over the ventral scapular surface can be removed surgically.

Operative Indications

While the vast majority of scapular fractures are managed quite successfully without surgery, most agree that surgical management should be considered for severely displaced injuries. Since these fractures are so rare, large personal series and strictly controlled studies comparing nonoperatively and operatively managed injuries are unavailable. However, the literature does contain relevant case reports and the personal experience of a number of investigators. This review will draw on this information as well as the experience of the author to provide the orthopaedist with operative guidelines (indications and technical principles) for the management of these challenging fractures.

The following injuries occur with enough frequency to merit discussion: (1) significantly displaced fractures of the glenoid cavity (glenoid rim and glenoid fossa), (2) significantly displaced fractures of the glenoid neck, and (3) double disruptions of the superior shoulder suspensory complex (SSSC) in which one or more elements of the scapula are significantly displaced.

The following injuries are quite rare and will not be discussed: fracture of the scapular body with a lateral spike protruding into the glenohumeral joint; significantly displaced, functionally important avulsion fracture of the scapula; displaced coracoid fracture associated with neurovascular compression; coracoid fracture in the area of the suprascapular notch with suprascapular nerve paralysis; significantly displaced fracture of the distal coracoid process in which the coracoclavicular ligaments are attached to the distal fragment; combined rotator cuff tear and acromial fracture caused by traumatic superior displacement of the humeral head; and isolated but significantly displaced fracture of the acromial process.

Significantly Displaced Fractures of the Glenoid Cavity (Rim and Fossa) [6,7]

Fractures of the glenoid cavity make up 10% of scapular fractures, no more than 10% of which are significantly displaced. Figure 1 offers a classification scheme that outlines the various mechanisms of injury and fracture patterns that can occur. For the purpose of this discussion, one need consider only whether the glenoid rim or the glenoid fossa is fractured.

Fractures of the glenoid rim occur when a laterally applied high-energy force drives the humeral head against the glenoid margin. Surgical management is indicated if the fracture results in persistent subluxation of the humeral head,

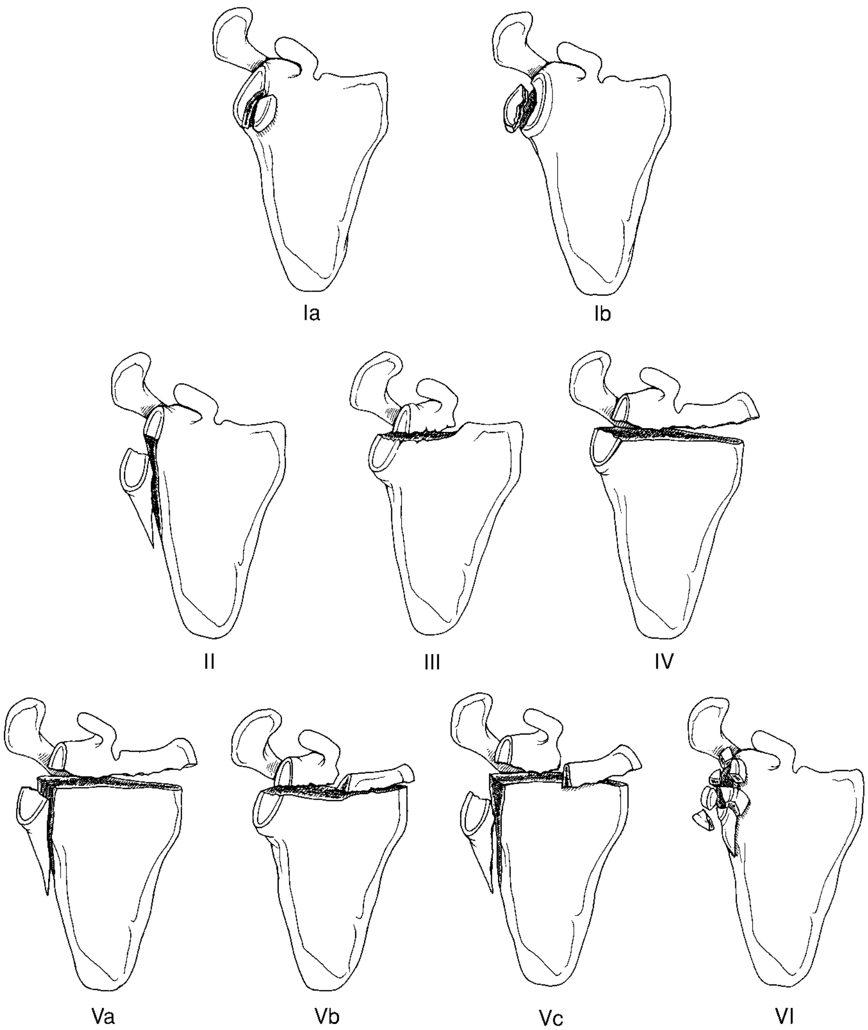


Fig. 1 Scheme for classification of fractures of the glenoid cavity: type Ia, anterior rim fracture; type Ib, posterior rim fracture; type II, fracture line through the glenoid fossa exiting at the lateral border of the scapula; type III, fracture line through the glenoid fossa exiting at the superior border of the scapula; type IV, fracture line through the glenoid fossa exiting at the medial border of the scapula; type Va, combination of types II and IV; type Vb, combination of types III and IV; type Vc, combination of types II, III, and IV; type VI, comminuted fracture.

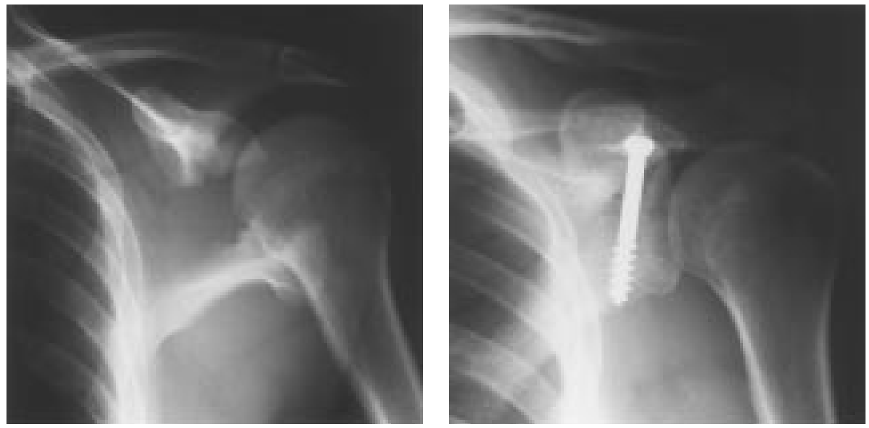
defined as failure of the humeral head to lie concentrically within the glenoid fossa, or if the reduction is unstable. DePalma[8] has stated that instability can be expected if the fracture is displaced 10 mm or more and if at least one fourth of the anterior aspect of the glenoid cavity or one third of the posterior aspect of the glenoid cavity is involved. Hardegger et al[9] concurred and stated that "operative reduction and fixation of the fragment is indicated to prevent recurrent or permanent dislocation of the shoulder." Guttentag and Rechtine[10] and Butters[5] agreed with these recommendations.

Fractures of the glenoid fossa occur when a laterally applied high-energy force drives the humeral head directly into the glenoid cavity. The fracture generally begins as a transverse disruption, which then propagates in one of several possible directions depending on the vector of the traumatic force. The degree of resultant incongruity of the articular surface is of prime concern. Hardegger et al[9] reported that "if there is significant displacement, conservative treatment alone cannot restore congruence" and that "stiffness and pain may result . . . for this reason, open reduction and stabilization is indicated."

Kavanagh et al[11] reported on their experience at the Mayo Clinic with ten displaced intra-articular fractures of the glenoid fossa treated with open reduction and internal fixation (ORIF). They found ORIF to be "a useful and safe technique for the treatment of selected displaced fractures of the glenoid fossa," which can "restore excellent function of the shoulder." In their series, the range of displacement of the major intra-articular fracture fragments was 4 to 8 mm. They emphasized that it remained uncertain how much incongruity of the glenoid articular surface could be accepted without long-term sequelae of pain, stiffness, and / or traumatic osteoarthritis.

Soslowsky et al[12] found the maximal depth of displacement of the glenoid articular cartilage to be 5 mm. Consequently, if displacement at the fracture site is 5 mm or more, subchondral bone is exposed, making posttraumatic osteoarthritis a possibility. Case reports by Aulicino et al[13] and Aston and Gregory[14] lend support to the role of surgery in the management of significantly displaced glenoid fossa fractures. Rüedi and Chapman[2] have stated that "grossly displaced intra-articular fractures of the glenoid that render the joint incongruent and unstable profit from operative reconstruction and internal fixation as incongruities will result in osteoarthritic changes." Rowe[15] has also advocated surgical management of severely displaced injuries.

On the basis of these reports, it seems reasonable to conclude that a fracture of the glenoid fossa with an articular step-off of 5 mm or more must be considered for surgical intervention to restore articular congruity and that displacement of 10 mm or more is a definite indication. Other indications for surgical management include (1) glenoid fossa fractures that result in significant displacement of the humeral head such that it fails to lie in the center of the glenoid cavity, thereby resulting in glenohumeral instability (Fig. 2); and (2) fractures of the glenoid fossa with such severe separation of the fracture fragments that a nonunion is likely to occur (Fig. 3).

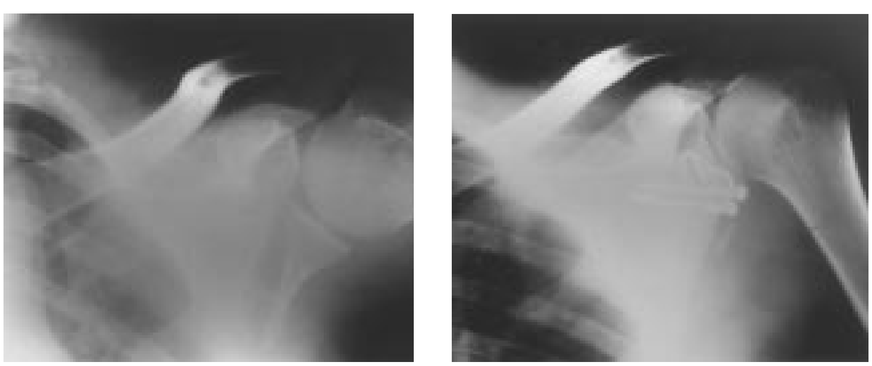


A B

Fig. 3 Radiographs of a patient who sustained a type IV fracture of the glenoid cavity. **A,** Preoperative AP radiograph shows severe separation of the superior and inferior segments of the glenoid fossa and scapular body. **B,** Postoperative AP radiograph shows anatomic reduction and stabilization of the superior and inferior segments of the glenoid fossa and scapular body with restoration of articular congruity.

To detect and define these fractures, a true AP view of the glenohumeral joint should be obtained. This will allow the best visualization of disruptions to the glenoid fossa and associated articular incongruity and/or separation. A true axillary radiograph of the glenohumeral joint will define fractures of the glenoid rim and will indicate whether the humeral head is subluxated and whether the reduction is stable. However, CT scanning is usually necessary because of the complex osseous anatomy in the region. Axial CT images demonstrate fractures of the glenoid rim precisely, while reconstructions in the coronal plane are necessary for assessment of glenoid fossa fractures.

If ORIF is necessary,[16,17] four regions of substantial bone stock are available for internal fixation: the glenoid neck, the scapular spine, the lateral scapular border, and the coracoid process. Fixation can be achieved with a variety of devices. However, the most useful are appropriately contoured 3.5-mm reconstruction plates and 3.5-mm interfragmentary compression screws. I have found cannulated screws extremely useful. The choice of implants depends on the surgeon's experience and preference and the available bone stock. Rigid internal fixation is the desired result, but inability to achieve rigid fixation does not necessarily preclude an excellent anatomic and functional result.



A B

Fig. 2 Radiographs of a patient who sustained a type II fracture of the glenoid cavity. **A,** Preoperative AP radiograph shows significant displacement of the inferior glenoid fragment and a severe articular step-off. **B,** Postoperative AP radiograph shows anatomic reduction and stabilization of the inferior glenoid fragment with restoration of articular congruity.

Treatment of Fractures of the Glenoid Rim

Surgery is indicated if a glenoid rim fracture results in persistent subluxation of the humeral head or if the reduction is unstable. As previously noted, instability is anticipated if the fracture is displaced by 10 mm or more and if at least one fourth of the anterior aspect of the cavity or one third of the posterior aspect of the cavity is involved. The goal of operative intervention is to reestablish osseous stability, thereby preventing chronic glenohumeral instability.

Fractures of the anterior rim are approached anteriorly, and fractures of the posterior rim are approached posteriorly. The fracture fragment is reduced anatomically and fixed to the glenoid process with an interfragmentary compression screw. If the fragment is severely comminuted, it is excised, and an appropriately shaped tricortical graft, harvested from the iliac crest, is rigidly fixed into the osseous defect. Alternatively, the periarticular soft tissues can be sutured to the glenoid process, thereby obliterating the osseous defect.

Treatment of Fractures of the Glenoid Fossa

Surgical management should be considered if there is (1) an articular step-off of 5 mm or more (this value represents a relative indication; a step-off of 10 mm or more is a definite indication); (2) enough separation between the glenoid fragments to make a nonunion likely; and (3) significant displacement of the glenoid fragment such that the humeral head follows and fails to lie in the center of the glenoid cavity. The goals of operative intervention are to prevent posttraumatic glenohumeral osteoarthritis, to avoid chronic glenohumeral instability, and to prevent a nonunion at the fracture site.

All fractures of the glenoid fossa are approached posteriorly. If access to the inferior portion of the glenoid process or the lateral scapular border is necessary, the interval between the infraspinatus and teres minor muscles is developed. If a superior glenoid fragment is present and is significantly displaced, a superior approach to the glenoid process is added. The major fracture fragment (or fragments) is reduced as anatomically as possible and is internally fixed as securely as possible with use of either an interfragmentary compression screw or a contoured reconstruction plate. Associated SSSC disruptions (e.g., clavicular or acromial fractures) are surgically addressed if unacceptable displacement remains.

Treatment of Type VI Fractures

These injuries include all comminuted fractures of the glenoid cavity. Nonoperative care is usually indicated because attempts at ORIF can disrupt what little soft-tissue support remains. The shoulder is placed in a position that maximizes articular congruity. The choices are sling-and-swathe immobilization, an abduction brace, and overhead olecranon-pin traction. Early range-of-motion exercises are begun in an effort to mold the articular fragments into as normal a relationship to each other as possible. At 2 weeks sling-and-swathe immobilization is used in all cases. By 6 weeks osseous union is complete. Physical therapy is continued until range of motion and strength have been maximized. Type VI fractures pose the greatest risk of late symptomatic degenerative joint disease and glenohumeral instability.

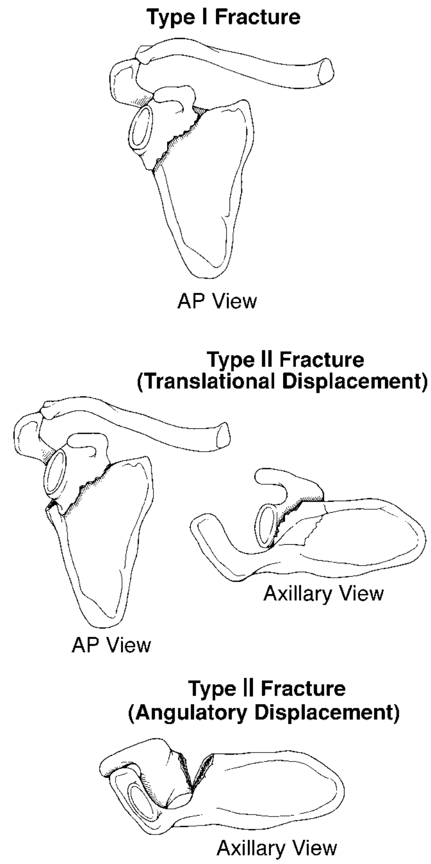


Fig. 4 Classification of fractures of the glenoid neck. Type I includes all minimally displaced fractures. Type II includes all significantly displaced fractures (either translational or angulatory displacement).

Significantly Displaced Fractures of the Glenoid Neck[3,18]

Fractures of the glenoid neck make up 25% of scapular fractures; of that number, 10% or fewer (2.5% of the total) are significantly displaced. Figure 4 offers a classification scheme that is based on whether these injuries are minimally or significantly displaced. If significant displacement exists, it may be in either the translational or the rotatory plane.

Fractures of the glenoid neck may be caused by a direct blow over the anterior or posterior aspect of the shoulder, a fall on an outstretched arm, or a fall on the superior aspect of the shoulder. Displacement may occur if the fracture is complete, with the fracture line exiting through both the lateral and superior scapular margins. If the superior support structures (the clavicle–AC joint–acromion strut or the coracoid process–coracoclavicular ligaments linkage) are disrupted, displacement is especially likely.

DePalma[8] has stated that severe angulation of the articular surface of the glenoid fossa must be corrected because it interferes with normal glenohumeral motion and may predispose to subluxation or dislocation of the joint. He reported that, in general, marked displacement should be treated more aggressively. Bateman[19] has asserted that significant displacement can interfere with abduction and that significant angulation can lead to instability. Nordqvist and Petersson[20] evaluated 37 glenoid neck fractures treated nonoperatively and found the functional results at 10- to 20-year follow-up to be fair or poor in 32% of cases. They believed that in some cases early ORIF might have improved the result.

Ada and Miller[21] retrospectively reviewed 16 displaced glenoid neck fractures characterized by translational displacement greater than or equal to 1 cm or angulatory deformity greater than or equal to 40 degrees in either the transverse or the coronal plane. The average postinjury follow-up period was 36 months. They found that 20% of patients had decreased range of motion, 50% had pain (of whom 75% had night pain), 40% had weakness with exertion, and 25% noted popping. In particular, they found that these individuals frequently had shoulder abductor weakness and subacromial pain due at least in part to rotator cuff dysfunction. They recommended ORIF for glenoid neck fractures with this degree of displacement.

Hardegger et al[9] noted that displaced glenoid neck fractures result in functional imbalance because the relationship of the glenohumeral joint with the acromion and nearby muscle origins is altered. They concluded that in terms of restoration of normal function, operative treatment is preferable to conservative management.

There is, therefore, reasonable support in the literature to suggest that surgery is indicated or should at least be considered for significantly displaced fractures of the glenoid neck (translational displacement greater than or equal to 1 cm and / or angulatory displacement greater than or equal to 40 degrees in either the transverse or the coronal plane).

The basic radiographs necessary to detect and define these fractures include true AP and lateral views of the scapula and a true axillary view of the glenohumeral joint. However, CT scanning is usually necessary to determine whether a complete fracture of the glenoid neck is present, to define the degree of translational or angulatory displacement, and to reveal injury to adjacent osseous structures. Three distinct patterns may be seen: (1) fractures of the anatomic neck (exiting through the lateral scapular border and the superior scapular border lateral to the coracoid process); (2) fractures of the surgical neck (exiting through the lateral scapular border and the superior scapular border medial to the coracoid process); and (3) fractures through the inferior glenoid neck that then run along or through the inferior border of the scapular spine before finally exiting out the medial or superior border of the scapula (these fractures frequently look like displaced fractures of the glenoid neck on plain radiographs; however, CT scanning shows that these are primarily fractures of the scapular body, and they should be treated as such).

If surgical management is indicated (type II fractures),[17,18] the glenoid neck is approached posteriorly, and the interval between the infraspinatus and teres minor muscles is developed to gain access to the inferior glenoid process and the lateral scapular border. A superior extension can be added to gain access to the superior aspect of the glenoid process. After reduction of the fracture, fixation is generally achieved with a 3.5-mm contoured reconstruction plate applied along the posterior aspect of the glenoid fragment and the lateral border of the scapula (Fig. 5). Temporary and supplemental fixation can be provided by Kirschner wires or interfragmentary screws passed between the glenoid fragment and the adjacent osseous structures.

Occasionally, comminution of the scapular body or spine can be so severe or the size of the glenoid fragment so small as to preclude plate fixation. In these cases, Kirschner-wire or interfragmentary-screw fixation can be used to secure the reduced glenoid fragment to adjacent osseous structures, including the acromial

A

B

Fig. 5 Radiographs of a patient who sustained a type II fracture of the glenoid neck. **A,** Preoperative AP radiograph shows significant angulatory displacement of the glenoid fragment. **B,** Postoperative AP radiograph shows reduction and stabilization of the glenoid fragment.

process and the distal clavicle. In those rare instances in which the scapular body and spine, the acromial process, and the distal clavicle are all severely comminuted, overhead olecranon-pin traction must be considered, or displacement of the glenoid neck fracture must be accepted.

If a disruption of the clavicle–AC joint–acromion strut is also present (most commonly a fracture of the clavicle), fixation of that injury may indirectly reduce and stabilize the glenoid neck fracture in a satisfactory position. If significant displacement persists, the glenoid neck fracture must be addressed. Conversely, ORIF of the glenoid neck fracture may satisfactorily reduce and stabilize the clavicle–AC joint–acromion strut. If not, the associated disruption must be addressed. Disruptions of the coracoid process–coracoclavicular ligaments linkage are indirectly managed by reducing and stabilizing the glenoid neck fracture and restoring the integrity of the clavicle–AC joint–acromion strut.

Double Disruptions of the SSSC With Significant Displacement of One or More Scapular Elements[22]

The SSSC is a bone–soft-tissue ring at the end of a superior and an inferior bone strut (Fig. 6). The ring is composed of the glenoid process, the coracoid process, the coracoclavicular ligaments, the distal clavicle, the AC joint, and the acromial process. The superior strut is the middle third of the clavicle. The inferior strut is the lateral scapular body and spine. Each individual structure has its own particular functions. The complex as a whole maintains a normal stable relationship between the scapula and upper extremity and the axial skeleton, allows limited motion to occur through the AC joint and the coracoclavicular ligaments, and provides a firm point of attachment for several soft-tissue structures.

Traumatic disruptions of one of the components of the SSSC (Fig. 7) are common. They tend to be minor injuries, however, since such single disruptions usually do not significantly compromise the overall integrity of the complex. If the traumatic force is sufficiently severe or adversely directed, the ring may fail in two or more places (termed a “double disruption”), a situation in which significant displacement at both the individual sites and of the SSSC as a whole frequently occurs. Similarly, a disruption of one portion of the ring combined with a fracture of one of the struts or fractures of both struts also creates a potentially unstable anatomic situation. This, in turn, often leads to adverse long-term functional consequences, including delayed union, nonunion, and malunion; subacromial impingement; decreased strength and muscle-fatigue discomfort due to altered shoulder mechanics; neurovascular compromise due to a drooping shoulder; and glenohumeral degenerative joint disease. Consequently, injuries to the SSSC need to be carefully evaluated for the presence of a double disruption. Computed tomography with reconstructions is

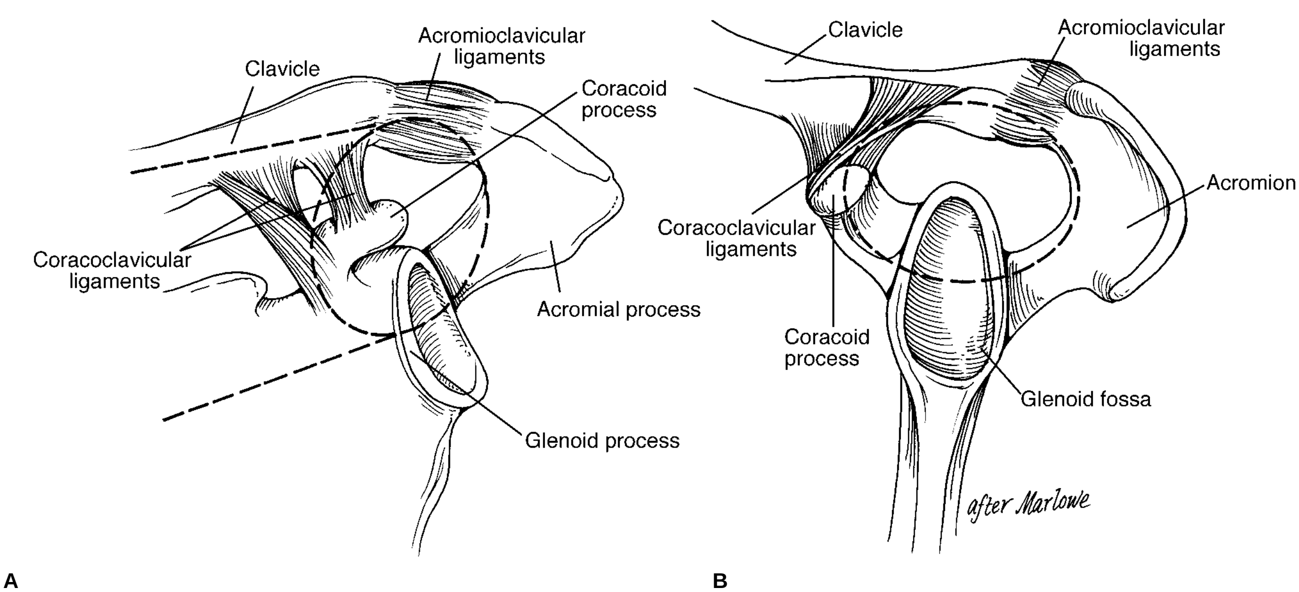


Fig. 6 Superior shoulder suspensory complex **A,** AP view of the bone–soft-tissue ring and superior and inferior bone struts. **B,** Lateral view of the bone–soft-tissue ring.

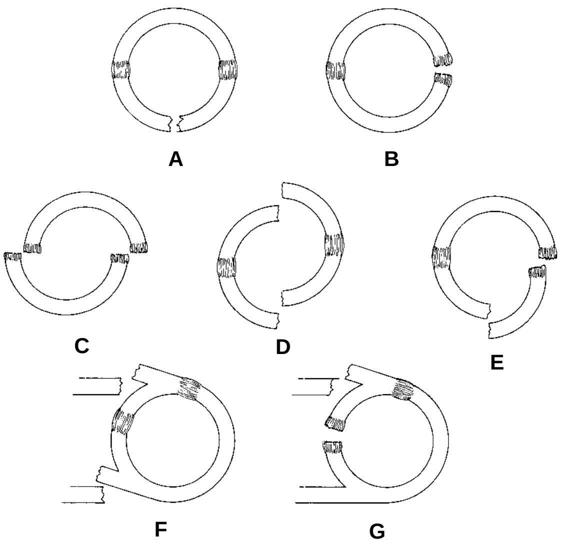


Fig. 7 Types of traumatic ring/strut disruptions. Single disruptions of the bone–soft-tissue ring may be a break **(A)** or a ligament disruption **(B).** Double disruptions of the bone–soft-tissue ring may be a double-ligament disruption **(C),** a double break **(D),** or a combination of a bone break and a ligament disruption **(E).** Other double disruptions may be a break of both struts **(F)** or a break of one strut and a ring disruption **(G).**

often necessary to make a definitive diagnosis. If unacceptable displacement is present, surgical reduction and stabilization of one or more of the injury sites is necessary. Frequently, operative management of one of the injury sites will satisfactorily reduce and stabilize the second disruption indirectly.

Fractures of the glenoid, coracoid, and acromial processes may each be part of a double disruption and require surgical management. All of the various combinations cannot be detailed, and some are extremely rare. However, some of the more commonly seen disruptions will be described to illustrate the double-disruption principle as it applies to scapular fractures.

Fractures of the Glenoid Process

Fractures of the Glenoid Neck With Another Disruption of the SSSC[18]

Each of these disruptions in isolation is usually minimally displaced and is therefore treated nonoperatively. However, when a fracture of the glenoid neck is combined with another SSSC disruption (e.g., an associated fracture of the middle third of the clavicle), together they constitute an anatomically unstable situation that some have called a "floating shoulder." The glenoid neck fracture allows significant displacement to occur at the clavicular fracture site, and vice versa.

If displacement at the clavicular fracture site is unacceptable, surgical reduction and stabilization is indicated, most commonly with the use of plate fixation. This may indirectly reduce and stabilize the glenoid neck fracture satisfactorily. If not, the glenoid neck fracture may also need to be addressed surgically. Leung and Lam[23] reported on 15 patients with surgically treated fractures (average follow-up period, 25 months). In 14 of the 15 patients the fractures healed with a good or excellent functional result.

Herscovici et al[24] reported the results in nine patients with ipsilateral clavicular and glenoid neck fractures (average follow-up period, 48.5 months). Seven patients were surgically treated with plate fixation of the clavicular fracture and achieved excellent results. Two patients were treated without surgery and were found to have decreased range of motion as well as "drooping" of the involved shoulder. The authors strongly recommended ORIF of the clavicle to prevent glenoid neck malunion.

Fractures of the Glenoid Cavity With Another Disruption of the SSSC[6]

A type I fracture of the distal third of the clavicle in isolation is usually minimally displaced and treated nonoperatively, as is a fracture of the glenoid cavity in which the superior aspect of the glenoid process and the coracoid process are a separate fragment. In combination, however, each disruption may lead to unacceptable displacement at the other fracture site. The glenoid fracture may allow the clavicular fracture to displace widely, while the clavicular fracture may allow the superior glenoid fragment to displace laterally, creating an articular step-off that can result in late traumatic degenerative joint disease.

If displacement at the clavicular fracture site is unacceptable, surgical reduction and stabilization is indicated, usually with a Kirschner wire–tension band fixation construct. Since the proximal clavicular segment is attached to the superior glenoid–coracoid process fragment by means of the coracoclavicular ligaments, this may indirectly reduce and stabilize the glenoid cavity fracture satisfactorily. If not, the glenoid fracture may also need to be addressed surgically, using the surgical techniques previously described.

Fractures of the Acromial or Coracoid Process With Another Disruption of the SSSC

Isolated fractures of the acromial and coracoid processes are almost always minimally displaced and are therefore managed nonoperatively. If they are combined with another disruption of the SSSC (e.g., a fracture of both processes), an unstable anatomic situation is created.

If displacement at either or both sites is unacceptable, surgical management is indicated. Generally, ORIF of the acromial fracture is all that is required because this will indirectly reduce and stabilize the coracoid fracture satisfactorily and is less difficult than ORIF of the coracoid fracture (Fig. 8). Fractures of the distal acromion are generally stabilized using the dorsal tension-band technique. Disruptions of the proximal acromion are more amenable to plate fixation. Fractures of the coracoid process are stabilized with interfragmentary-screw fixation if the distal fragment is sufficiently large and noncomminuted. Otherwise, the fragment and conjoined tendon are reattached with use of a heavy nonabsorbable suture placed in a Bunnell fashion through the tendon and then through a drill hole in the coracoid process proximal to the fracture site.

Postoperative Management and Rehabilitation

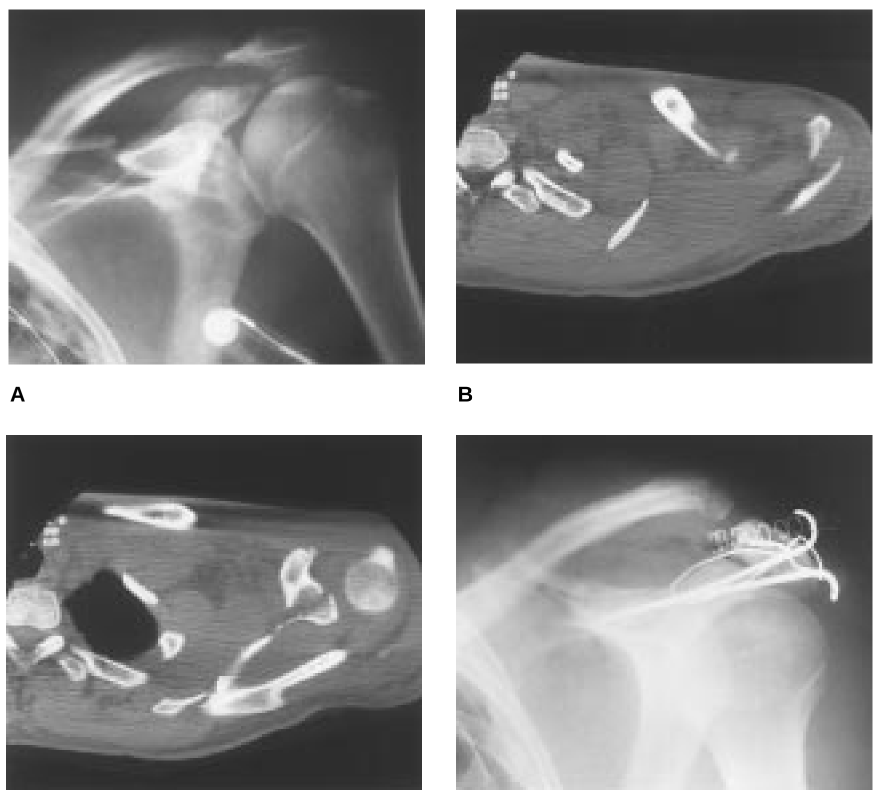
The postoperative care of surgically treated scapular fractures depends on the degree of stability achieved. Rigidly fixed fractures are protected in a sling and a swathe bandage. Early progressive range-of-motion exercises are begun, and functional use of the shoulder out of the sling is permitted as symptoms allow. If stabilization is less than rigid, full-time postoperative immobilization in a sling and a swathe bandage, an abduction splint, or even overhead olecranon-pin traction for 7 to 14 days may be necessary before initiating the rehabilitation program.

By 2 weeks, most fractures need only a sling and a swathe bandage for protection. Progressive range-of-motion exercises are begun at this point, and gradually increasing functional use of the arm is permitted within clearly defined limits. The patient is carefully monitored. At 6 weeks, bone union is usually complete, all external protection is discontinued, and progressive functional use of the articulation is encouraged. If transfixing Kirschner wires have been placed, they are removed at this time. Physical therapy is continued until range of motion and strength have been maximized. The initial emphasis is on regaining range of motion. As range of motion improves, progressive strengthening exercises are added.

The patient must be encouraged to continue to work diligently on his rehabilitation program, since range of motion and strength can still improve, and often the end result is not achieved for approximately 6 months to 1 year after injury. The functional outcome after operative treatment of significantly displaced scapular fractures is dependent on the specifics of the injury, the adequacy of the reduction, the quality of the fixation, and the rigor of the postoperative rehabilitation program.

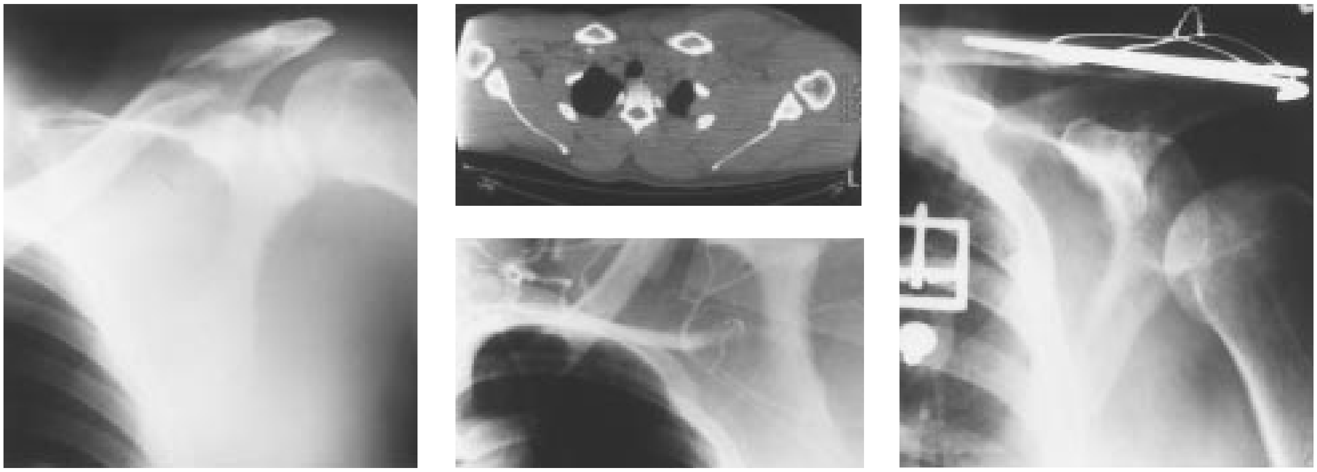
Scapulothoracic Dissociation (Lateral Dislocation of the Scapula)[25]

Scapulothoracic dissociation (Fig. 9) is a rare traumatic disruption of the scapulothoracic articulation caused by a severe direct force over the



A B C D

Fig. 8 Images of a patient who sustained fractures of both the coracoid and the acromial processes. **A,** Preoperative AP radiograph of the involved area. **B,** Axial CT image of the acromion. Note the wide separation between the acromial fragments due to the associated coracoid process fracture. **C,** Axial CT image shows the fractured coracoid process. **D,** AP radiograph of the shoulder after ORIF of the acromial fracture using the dorsal tension-band technique.



A B C

Fig. 9 Images of a patient who sustained a left scapulothoracic dissociation. **A,** Preoperative AP radiograph shows significant lateral displacement of the scapula and a significantly displaced fracture of the distal clavicle. **B (top),** CT image shows significantly increased distance between the left scapula and the rib cage as compared with the opposite (uninjured) side. **B (bottom),** Arteriogram shows disruption of the subclavian artery. **C,** Postoperative AP radiograph shows reduction and stabilization of the distal clavicle (and secondarily the scapulothoracic articulation) obtained with use of a tension-band technique.

shoulder accompanied by traction applied to the upper extremity. Although the skin remains intact, the scapula is torn away from the posterior chest wall, prompting some to call this injury a "closed traumatic forequarter amputation." Due to the violent forces involved, any of the three bones in the shoulder complex (the clavicle, the scapula, and the proximal humerus) may be fractured, and any of the remaining three articulations (the glenohumeral, AC, and sternoclavicular joints) may be disrupted. Neurovascular injury is common. Disruption of the subclavian or axillary artery (most frequently the former) and complete or partial disruption of the brachial plexus also occur.

In addition, there may be severe damage to the soft-tissue supporting structures, especially those that run from the chest wall to the scapula or from the chest wall to the humerus. Complete and partial tears of the trapezius, levator scapulae, rhomboids, pectoralis minor, and latissimus dorsi have all been described.

A presumptive diagnosis is based on a history of violent trauma and the presence of massive soft-tissue swelling over the shoulder girdle. A pulseless upper extremity, indicating a complete vascular disruption, and a complete or partial neurologic deficit, indicating injury to the brachial plexus, are quite suggestive. Significant lateral displacement of the scapula seen on a nonrotated chest radiograph confirms the diagnosis. As with all rare injuries, awareness of the clinical entity is critical to making the correct diagnosis.

Treatment recommendations have focused on care of the accompanying neurovascular injury. If the vascular integrity of the extremity is in question, an emergency arteriogram is performed, followed by surgical repair if necessary. The brachial plexus is explored at the same time. If a neurologic deficit is present, electromyographic testing is performed 3 weeks after injury to determine the extent of injury and to assess the degree of recovery, if any. Cervical myelography can be performed at 6 weeks.

If nerve avulsions or a complete neurologic deficit is present, the prognosis for a functional recovery is poor. However, partial plexus injuries have a good prognosis, and most patients achieve complete recovery or regain functional use of the extremity. If some portions of the plexus are intact and others are disrupted, neurologic repair is a possibility. Late reconstructive efforts are guided by the degree of neurologic return, and musculotendinous transfers are performed as needed.

Care of the surrounding soft-tissue supportive structures (musculotendinous and ligamentous) has been nonoperative, consisting of immobilization of the shoulder complex for 6 weeks to allow healing, followed by a closely monitored physical therapy program designed to restore range of motion initially, followed by strength. Magnetic resonance imaging of the involved area now offers the ability to visualize important disruptions that may be amenable to surgical repair.

Injury to the sternal-clavicular-acromial linkage (a disruption of the sternoclavicular or AC joint or a fracture of the clavicle) is frequently, if not invariably, present in these injuries, permitting posterolateral displacement of the scapula. This component of scapulothoracic dissociation has been largely ignored in terms of both diagnosis and treatment.

Of the three possible disruptions, fracture of the clavicle seems to be the most common. This constitutes a very unstable anatomic situation, with the clavicular fracture allowing maximal displacement of the scapula. The unstable scapulothoracic articulation also causes significant displacement at the clavicular fracture site. Consequently, surgical ORIF of the clavicular fracture site should be considered (1) to avoid a delayed union or nonunion at the clavicular fracture site; (2) to restore as much stability as possible to the shoulder complex, in order to avoid adverse functional consequences; and (3) to protect the brachial plexus and the subclavian and axillary vessels from further injury caused by tensile forces.

Similar therapeutic reasoning would apply to scapulothoracic dissociations accompanied by disruption of the AC joint. Open reduction and internal fixation of a sternoclavicular disruption has less appeal because of the technical difficulty involved.

Summary

Scapular fractures and disruptions are decidedly uncommon. Because of the complex osseous and articular anatomy in the area, CT scanning with or without reconstructions is usually needed to detect and accurately define these injuries.

Most scapular fractures are not significantly displaced, and nonoperative treatment will reliably yield a good to excellent functional result. Fractures that are significantly displaced can result in adverse healing and long-term functional consequences and should therefore be considered for ORIF.

Scapulothoracic dissociations associated with a vascular disruption must be diagnosed promptly, so that the appropriate vascular repair can be performed. Reestablishing the integrity of the sternal-clavicular-acromial linkage is advisable if possible.

In all scapular fractures and dislocations, an optimal end result is dependent on the severity of the injury, the adequacy of the reduction, the quality of the fixation, and the rigor of the postoperative rehabilitation program.

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