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Acromioclavicular and Sternoclavicular Injuries and Clavicular, Glenoid, and Scapular Fractures

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Acromioclavicular joint injuries—or separations, as they are commonly described—are common sports-related injuries resulting from falls or other direct forces on the superolateral aspect of the shoulder pushing the acromion in an inferior direction. Acromioclavicular joint injuries represent a spectrum of severity, ranging from a simple sprain of the acromioclavicular ligament with no displacement to widely displaced injuries associated with severe soft-tissue injury to the acromioclavicular ligament, the coracoclavicular ligament, and the deltotrapezial fascia. Treatment options vary according to the severity of the injury and logically reflect the associated soft-tissue involvement. This lecture briefly outlines the types of injuries and current recommendations for treatment.

Classification

The modified Rockwood classification system is the most commonly used method of categorizing these injuries (Table I)[1]. A Type-I injury is a sprain (stretching) of the acromioclavicular ligament. Type-II injuries tear the acromioclavicular ligament, leaving the coracoclavicular ligament intact. When the coracoclavicular and acromioclavicular ligaments are both torn and the acromioclavicular separation is reducible with gentle upward pressure under the elbow, the injury is classified as Type III. A Type-IV acromioclavicular separation occurs when the coracoclavicular and acromioclavicular ligaments are torn and the scapula is displaced inferiorly and anteriorly, resulting in a relative posterior displacement of the distal part of the clavicle through a tear in the deltotrapezial fascia. The distal part of the clavicle lies directly subcutaneously in these injuries. A Type-V injury is characterized by a wide coracoclavicular separation. The distal part of the clavicle is herniated through a rent in the deltotrapezial fascia with the scapula displaced inferiorly. Type-IV and V injuries are not reducible with upward pressure beneath the elbow, indicating interposition of soft tissue (deltotrapezial fascia) between the distal part of the clavicle and the acromioclavicular joint. Type VI is an exceedingly rare, high-energy injury characterized by inferior displacement of the clavicle beneath the coracoid. Most surgeons never encounter this injury, and it is not discussed in detail in this review.

Neviaser developed a simpler classification system, also emphasizing the reducibility of the joint in determining the diagnosis and classification[2]. Type I is a sprain of the acromioclavicular ligament, and Type II is a tear of this ligament. Type III is subclassified as Type IIIA if the injury is reducible and as Type IIIB (corresponding to Rockwood Types IV and V) if the injury is not reducible.

Diagnosis

Type I

Type-I injuries, according to the Rockwood system, are sprains of the acro-

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TABLE I Modified Rockwood System for Classification of Acromioclavicular Separations

Type	Acromioclavicular Ligament	Coracoclavicular Ligament	Deltotrapezial Fascia
I	Sprained	Intact	—
II	Torn	Intact	—
III	Torn	Torn	Intact
IV	Torn	Torn	Torn
V	Torn	Torn	Torn

mioclavicular ligament with no displacement. Radiographic findings are usually normal if the injury occurs in isolation. The diagnosis is based on the history and the findings of the physical examination. There is tenderness directly at the acromioclavicular joint. It is unusual for an inspection of the shoulder to reveal a deformity, with the exception of ecchymosis or abrasion on the superior aspect of the shoulder in the acute phase after the injury.

Type II

Type-II injuries are tears of the acromioclavicular ligament with an intact coracoclavicular ligament. Physical examination reveals tenderness to palpation at the acromioclavicular joint. The acromion may be slightly displaced inferiorly relative to the distal part of the clavicle, but it continues to be at least partially in contact with the distal part of the clavicle. The joint is unstable in the anteroposterior plane. The distance between the coracoid and clavicle remains normal, but the acromion is subluxated relative to the distal part of the clavicle.

Type III

When the acromioclavicular and coracoclavicular ligaments are both torn, the distal part of the clavicle is prominent as an obvious visible deformity. The distal part of the clavicle is usually tender to palpation, and the joint is reducible with upward pressure under the elbow. Chronic separations are less reducible because of scar formation around the joint. Nevertheless, the deltotrapezial aponeurosis is intact. The acromioclavicular joint is unstable in both the vertical and the horizontal plane. Complete separation of the acromioclavicular joint and an increase in the coracoclavicular distance are seen on radiographs.

Type IV

The clavicle is driven in a posterior direction in a Type-IV separation. This results in a distinct visible deformity with extreme prominence of the clavicle over the scapular spine. The clavicle is herniated through the trapezius and is subcutaneous. Although the acromioclavicular joint is unstable, because it is impaled over the scapula, it does not move on physical examination. Posterior displacement of the clavicle is seen on the axillary radiograph, whereas the dislocated acromioclavicular joint and a widened coracoclavicular distance are seen on the anteroposterior radiograph.

Type V

Displacement of the distal part of the clavicle occurs predominantly in the vertical plane. The injury results in obvious visible deformity of the distal part of the clavicle associated with downward and slightly anterior displacement of the scapula. The separation is not completely reducible because the distal part of the clavicle is herniated through the deltotrapezial fascia. There is usually substantial tenderness and swelling in the acute phase after the injury. An increase in the coracoclavicular distance (of up to 300%) and superior displacement of the distal part of the clavicle are seen on the anteroposterior radiograph.

Treatment

Treatment varies depending on the severity of the injury and the soft-tissue involvement. There is very little controversy regarding the treatment of Type-I and II injuries or Type-IV and V injuries. However, treatment of Type-III injuries is controversial, and there is no general consensus[3-6].

Type I

Sling immobilization and symptomatic treatment of pain are usually all that are necessary for these injuries. Activities are resumed as tolerated.

Type II

These injuries are usually successfully managed with the methods used for Type I. Occasionally, pain persists at the acromioclavicular joint and additional treatment is indicated. Nonoperative measures such as cortisone injections and nonsteroidal anti-inflammatory medication can be administered. An excision of the distal part of the clavicle alone is insufficient treatment; it results in a short, unstable distal part of the clavicle, continued pain, and disability. If surgery is selected because of the persistence of pain after nonoperative treatment, the distal aspect of the clavicle should be removed and a capsular plication with ligament reconstruction should be performed.

Type III

Type-III injuries should initially be treated without surgery[1,3,6]. Most patients recover and regain normal shoulder function, although the visible deformity is permanent. Early surgical treatment can be considered for individuals with high sports or vocational demands, although this is controversial as many high-demand

TABLE II Injuries Associated with Fracture of the Medial Aspect of the Clavicle*

Associated Injury	Percent of Patients
Pneumothorax and/or hemothorax	42
Pulmonary contusion/respiratory failure	55
Rib fracture	73
Vascular injury	2
Facial fracture	31
Head injury	36
Cervical spine injury	25
Visceral injury	29
Upper-extremity injury	45
Lower-extremity injury	31

*Reproduced, with modification, from: Throckmorton T, Kuhn JE. Fractures of the medial end of the clavicle. J Shoulder Elbow Surg. 2007;16:49-54; with permission from Elsevier.

individuals do well with nonoperative treatment[4]. Surgical treatment for patients with a high risk of recurrent injury, such as hockey or football players, is especially controversial as a surgical repair does not restore normal strength to the ligaments of the acromioclavicular joint and reinjury is common.

Surgical reconstruction of the ligaments is indicated for patients for whom nonoperative treatment has failed[1,3,7]. Many different methods are available, and detailed descriptions are beyond the scope of this article[1,5-8]. There are common basic principles for

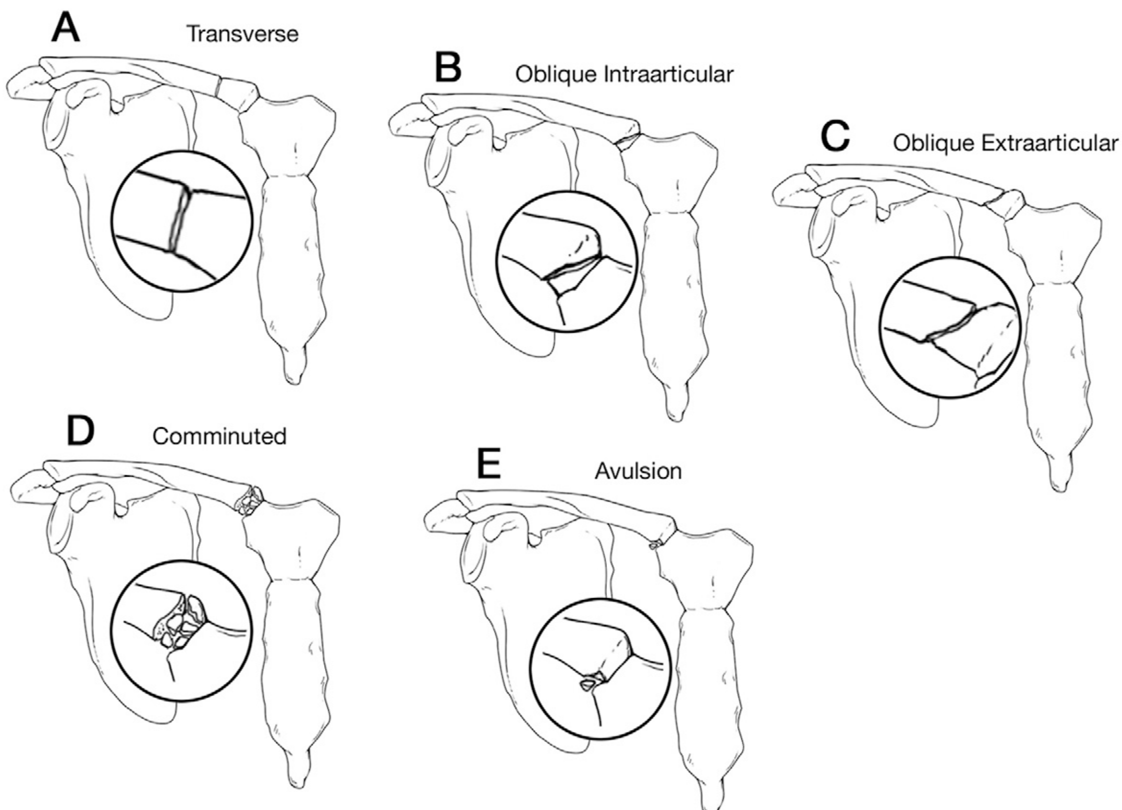

Fig. 1

Classification of medial clavicular fractures. (Reprinted, with permission, from: Throckmorton T, Kuhn JE. Fractures of the medial end of the clavicle. J Shoulder Elbow Surg. 2007;16:49-54.)

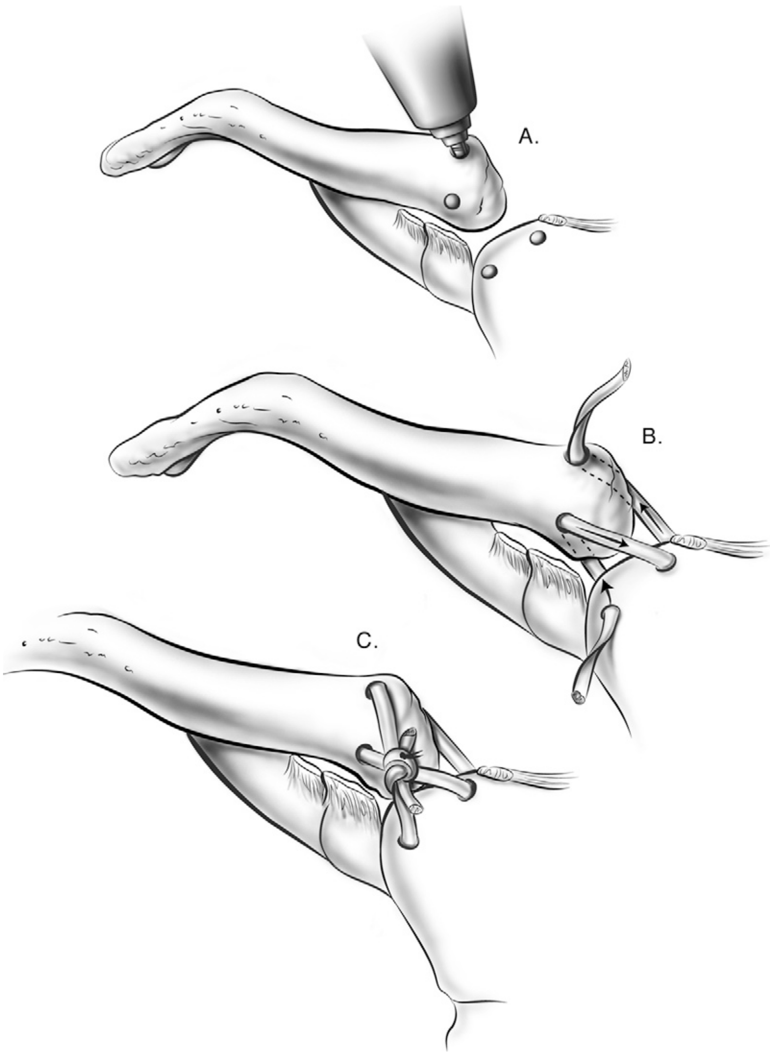

Fig. 2
Figure-of-eight reconstruction of the sternoclavicular joint. (Reprinted from: Spencer EE Jr, Kuhn JE. Biomechanical analysis of reconstructions for sternoclavicular joint instability. J Bone Joint Surg Am. 2004;86:98-105.)

all reconstructive methods. The coracoclavicular ligament is reconstructed with use of sutures based in anchors at the base of the coracoid or around the coracoid. The sutures are usually brought through drill-holes in the clavicle. Transfer of the coracoacromial ligament to the distal part of the clavicle augments the strength and biologic healing of the reconstruction and is advocated as part of the Weaver-Dunn procedure, the most common procedure performed for treatment of these injuries[9]. Autograft or allograft augmentation has been advocated for coracoclavicular ligament reconstruction, to improve the strength and facilitate healing, but long-term results are not yet available[5,8].

Types IV and V
Surgical treatment of Types IV and V is not controversial as early surgery improves the results following these injuries[1]. Ligament reconstruction is performed in the same way as it is for Type-III injuries. Careful attention is paid to the repair of the torn deltotrapezial aponeurosis, as this is a critical aspect of the repair and reconstruction in patients with an acromioclavicular joint separation.

Arthroscopic Treatment
Arthroscopic treatment of Type-III injuries has been reported, but its role in the treatment of acromioclavicular separations has not been studied sufficiently for it to be recommended as an option[10-12]. The instrumentation has been developed but is still under investigation. Arthroscopy may be used as an adjunct to the treatment of Type-IV and V injuries, but the distal part of the clavicle must be exposed to reduce it through the torn deltotrapezial fascia, which is then repaired.

Fractures and Dislocations of the Medial Part of the Clavicle and the Sternoclavicular Joint

Anatomy and Clinical Assessment
The sternoclavicular joint is not commonly injured but, when it is, the injury is usually due to high-energy trauma and may be associated with potentially life-threatening complications.

Fig. 3

Left: Markedly displaced midshaft clavicular fracture with comminution. *Right:* Healed fracture after open reduction and internal fixation with use of a precontoured clavicular plate and supplemental interfragmentary fixation.

The sternoclavicular joint is saddle-shaped with a very large clavicular head relative to the small fossa on the manubrium. This construct has little osseous constraint, and its stability is derived from the strong ligaments. The anterior and posterior aspects of the capsule provide the major stabilizing tissue[13]. The interclavicular ligament, which is important for the poise of the shoulder girdle, and the costoclavicular ligament have secondary roles[14].

The subclavian vessels, esophagus, and trachea are behind the sternoclavicular joint and are at risk when this area is subjected to trauma. A thorough clinical and radiographic evaluation is recommended to assess these structures. Posterior displacement of the medial aspect of the clavicle relative to the sternum is associated with the greatest risk of associated injuries[15].

While a variety of radiographic views have been described to image the sternoclavicular joint and medial aspect of the clavicle (the Hobbs view, Heinig lateral view, and serendipity view)[15], computed tomography and magnetic resonance imaging increase the likelihood that a fracture will be diagnosed[16] and help to determine whether the medial aspect of the clavicle is displaced anteriorly or posteriorly.

Fractures of the Medial Aspect of the Clavicle

Fractures of the medial third of the clavicle are rare, accounting for between 2% and 9.3% of all clavicular fractures. These fractures are often sustained in high-speed motor-vehicle collisions, and seat belt use, while life-saving, may have a role in the production of these injuries[16].

Typically, patients with a fracture of the medial third of the clavicle also have severe thoracic injuries, including pneumothorax and/or pulmonary contusion, with respiratory failure occurring in nearly half of the patients. Other injuries include rib fractures, head injuries, and cervical spine and other upper-extremity injuries (Table II). The mortality rate is as high as 19% for patients with these fractures[16]. The fractures are classified according to their configuration (Fig. 1), with transverse and comminuted fractures presenting most commonly[16].

Nonoperative treatment is most often recommended, but an open fracture is an indication for operative fixation[16]. Many patients have residual pain[16], and the nonunion rate may approach 15%[17]. Some authors have reported success with surgical reduction and internal fixation[18].

Dislocations of the Sternoclavicular Joint

Dislocations of the sternoclavicular joint are rare, accounting for approximately 3% of all shoulder injuries[19], and they can be life-threatening. The epiphysis of the medial end of the clavicle does not close until a person is in his or her mid-twenties[15]. As such,

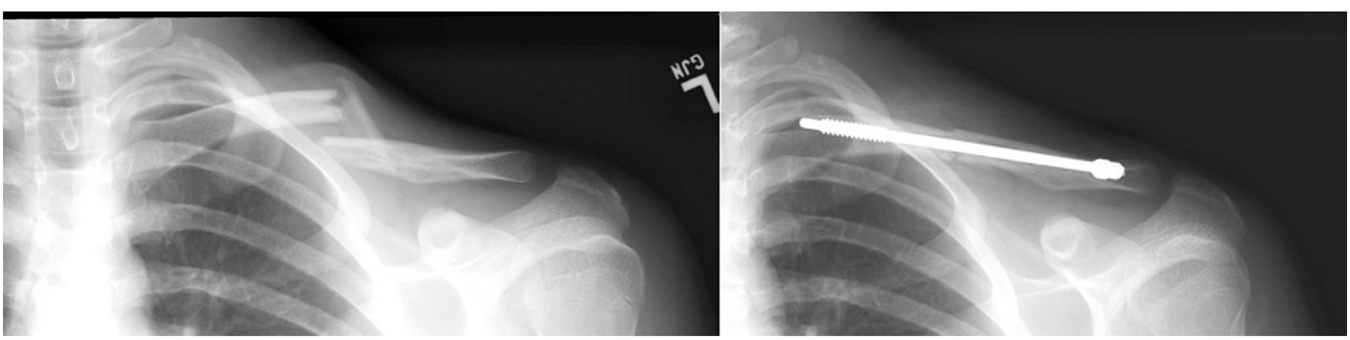

Fig. 4

Left: Markedly displaced midshaft clavicular fracture with a vertical comminuted fragment (a ''zed'' fracture). *Right:* Immediate postoperative radiograph after intramedullary fixation.

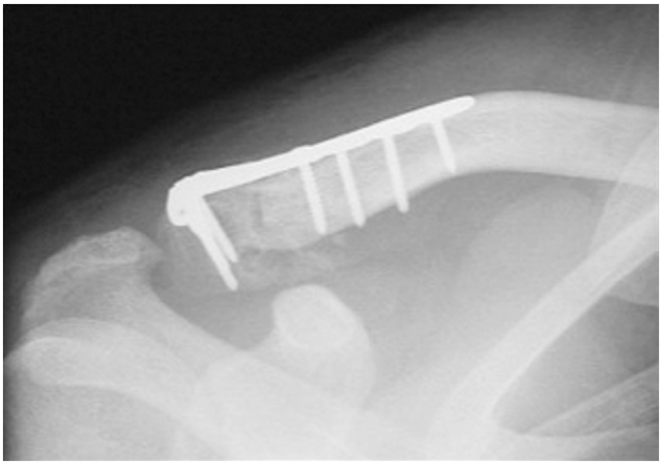

Fig. 5
A distal clavicular plate was used to treat this Type-II distal clavicular fracture. The repair was augmented with coracoclavicular sling fixation.

what is initially perceived as a dislocation in a young adult may in fact be a Salter-Harris Type-I or II physeal fracture; however, reduction and immobilization remain the treatment of choice. Anterior dislocations are two to three times more common than posterior dislocations, and fortunately they are less dangerous. Posterior dislocations have been associated with a variety of life or limb-threatening injuries including tracheal compression, injury to the great vessels[20], mediastinal compression[21], and compression of the innominate vein[22]. Untreated dislocations have been associated with late complications[23], including erosion into the great vessels, tracheoesophageal fistulas, compression of the subclavian artery[24], thoracic outlet syndrome[25], and compression of the brachial plexus[26].

The mechanisms of injury for sternoclavicular dislocation include motor-vehicle collisions, falls, and sports. Most dislocations occur as a result of an indirect force. As the shoulder girdle is pushed back, the clavicle pivots on the first rib and the medial aspect of the clavicle is pushed forward, producing an anterior dislocation. Conversely, when the shoulder girdle is pushed forward, a posterior dislocation may be produced.

These injuries are classified by the direction of the dislocation (anterior or posterior), by their chronicity (acute, subacute, or chronic), and by their severity (ranging from capsular sprains to subluxation events that reduce spontaneously to dislocations that require assistance with reduction).

Acute traumatic instability is usually treated with an acute reduction of the sternoclavicular joint. Closed reduction is recommended for both acute anterior and acute posterior dislocations, and several techniques have been described. Closed reduction is generally successful if it is done early[27]. The reduction of a posterior dislocation of the sternoclavicular joint must be performed carefully as the sternal head could be providing a tamponade of a torn vessel[28]. It is advisable to reduce posterior dislocations of the sternoclavicular joint with the patient under general anesthesia, with thoracic surgery available as a back-up.

Irreducible anterior dislocations are commonly left unreduced, and many patients do well without the need for further intervention[29,30]. Posterior dislocations should not be left unreduced as late sequelae such as erosion into the great vessels or tracheoesophageal fistulas can occur[31]. Open reduction and reconstruction of the sternoclavicular joint ligaments is indicated for both an acute irreducible posterior dislocation and a chronic posterior dislocation. Patients with a chronic anterior dislocation and sufficiently bothersome symptoms may benefit from reconstruction of the sternoclavicular joint.

Surgery is contraindicated for patients who have atraumatic, voluntary instability of the sternoclavicular joint. A connective-tissue disorder such as Ehlers-Danlos syndrome is a relative contraindication.

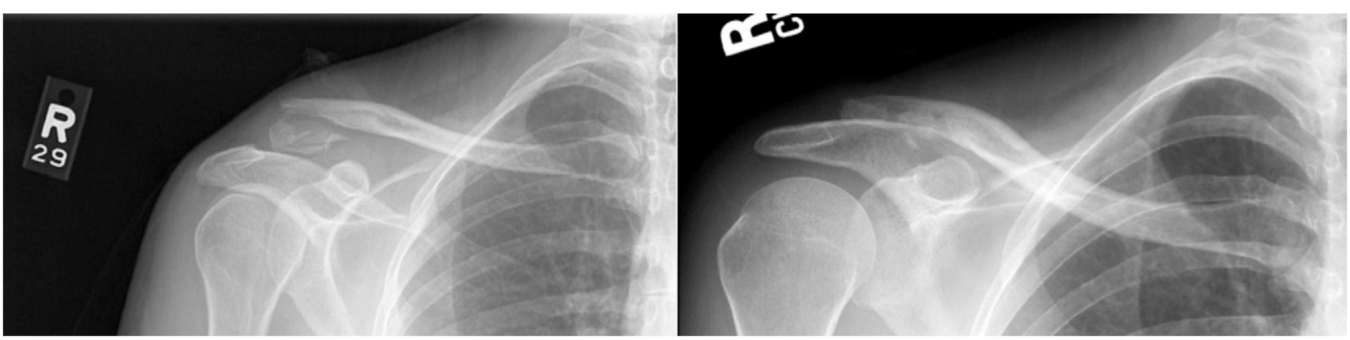

Fig. 6
Left: A displaced Type-II distal clavicular fracture with comminution of the distal fracture fragment. *Right:* Utilization of isolated coracoclavicular fixation led to successful healing and an excellent clinical result.

A variety of surgical techniques has been described for treatment of an unstable sternoclavicular joint. Resection of the sternal head of the clavicle yields poor results[32-34]. Spencer and Kuhn[35] reviewed the biomechanical properties of three of the most popular procedures: transfer of the subclavius tendon[36], transfer of the intra-articular disk and ligament into the resected end of the clavicle[34], and reconstruction of the anterior and posterior aspects of the capsule with use of a figure-of-eight semitendinosus autograft. The figure-of-eight reconstruction with the semitendinosus was found to have significantly better mechanical properties than the reconstructions performed with the other techniques[35] (Fig. 2). Because of pin breakage and migration into vital structures with disastrous complications, the use of Steinmann pins, Kirschner wires, threaded pins with bent ends, and Hagie pins is contraindicated for the treatment of sternoclavicular joint instability[37-42].

Midshaft Clavicular Fractures

Acute midshaft fractures of the clavicle have historically been treated with benign neglect, with the clinical perception that the vast majority of these fractures heal and patients have successful clinical outcomes. In addition, historic reviews showed the prevalence of nonunion after surgical management to be higher than that after nonoperative treatment[43]. However, the current literature reveals that not all patients with this injury do well with nonoperative treatment. In a recent review of 2144 clavicular fractures, Zlowodzki et al.[44] reported a 15.1% prevalence of nonunion of fractures treated without surgery and a 2.2% rate of nonunion of fractures treated with plate fixation. In a study of 242 consecutive clavicular fractures, Hill et al.[45] found that 31% of fifty-two patients in whom a completely displaced middle-third clavicular fracture had been treated with nonoperative means had an unsatisfactory clinical result. In a similar study, of 245 consecutive clavicular fractures, Nowak et al.[46] found that 46% of the patients continued to have clinical sequelae up to nine years after the injury. Robinson et al.[17] showed that the prevalence of clavicular nonunion following nonoperative treatment increased with advancing age, female sex, complete displacement of the fracture ends, and the presence of comminution in their study of 281 diaphyseal clavicular fractures. Although the overall prevalence of clavicular fracture nonunion was found to be 4.5% in their series, the prevalence of nonunion following nonoperative treatment of completely displaced and comminuted fractures ranged from 20% to 47% in patients between twenty-five and sixty-five years of age. McKee et al.[47,48] suggested that utilization of a patient-based outcome measurement (i.e., the Disabilities of the Arm, Shoulder and Hand [DASH] score)[49] may reveal more residual clinical impairment following nonoperative management of displaced clavicular fractures than is demonstrated by surgeon-based or radiographic measures. Thus, the evolution of management of these injuries has included efforts to define which fractures are most likely to progress to symptomatic nonunion or malunion if they are treated initially without surgery and to determine whether primary surgical treatment of these specific fractures may improve the clinical results.

Indications for operative treatment of acute midshaft clavicular fractures include open fractures, fractures with compromised skin due to severe fracture displacement ("tented skin"), and fractures associated with a vascular or neurological injury. On the basis of several studies that have defined the clinical outcome of the nonoperative management of midshaft clavicular fractures[17,44-47,50], evolving indications for acute surgical management include midshaft clavicular fractures with complete displacement (i.e., no osseous contact), initial clavicular shortening of ≥2 cm, and comminuted fractures with a displaced transverse "zed" (or z-shaped) fragment. As female sex and

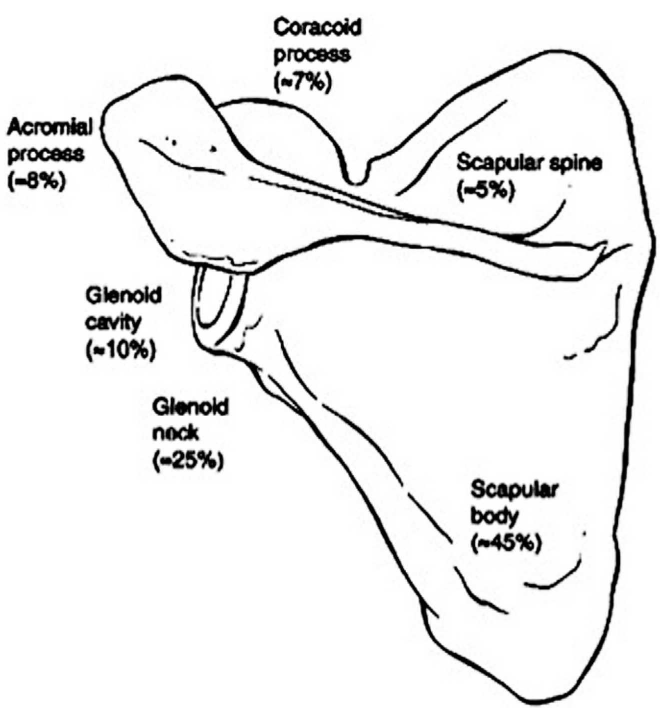

Fig. 7

Frequency of scapular fractures. (Reprinted from: Goss TP. Fractures of the scapula. In: Rockwood CA, Matsen FA, Wirth MA, Lippitt SB, editors. The shoulder. 3rd ed. Philadelphia: Saunders; 2004. p 413-54; with permission from Elsevier.)

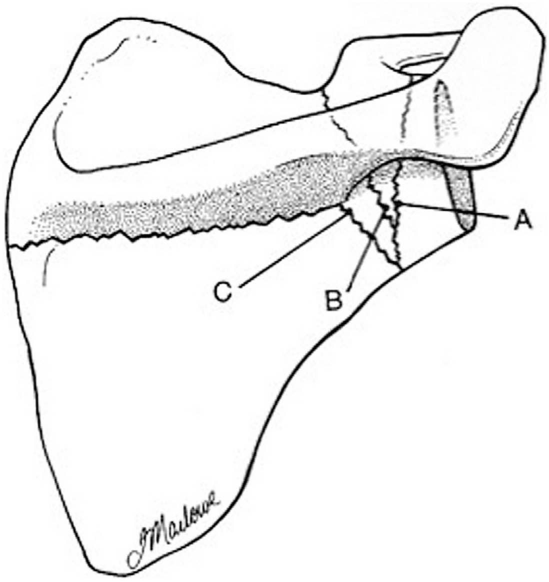

Fig. 8
Scapular neck fractures most commonly occur medial to the coracoid (line B) and uncommonly lateral to the coracoid (line A). (Reprinted, with permission, from: Goss TP. Fractures of the glenoid neck. J Shoulder Elbow Surg. 1994;3:42-52.)

increasing patient age have been associated with increased rates of nonunion[17], these confounding variables should also be taken into consideration when choosing operative or nonoperative treatment.

The Canadian Orthopaedic Trauma Society performed a multicenter, randomized clinical trial comparing nonoperative treatment and plate fixation of displaced midshaft clavicular fractures in 132 patients[50]. Acute operative fixation led to statistically better results with regard to Constant and DASH scores, return to activities, time to union, nonunions, symptomatic malunions, and patient satisfaction. Although hardware removal was the most common reason for repeat intervention in the operatively treated group, only two of sixty-seven patients required removal of symptomatic hardware after the fracture had healed. Three patients with a postoperative infection were managed with antibiotics and local wound care and ultimately had the plate removed after bone-healing, and one broken plate was removed after the patient was involved in an all-terrain-vehicle accident six weeks postoperatively. There were no catastrophic complications related to surgical management. In addition to this prospective randomized clinical trial, there have been multiple other cohort studies showing success with operative management of displaced midshaft clavicular fractures[51-56].

Although the literature contains anecdotal reports of many complications of plate fixation (hardware prominence requiring removal, nonunion, malunion, hardware failure, infection, supraclavicular neuroma, subclavian vein injury, and pneumothorax), these complications can be avoided through meticulous surgical technique (Fig. 3). The supraclavicular nerves, which traverse the clavicle from a superomedial to an inferolateral direction, should be identified and protected throughout the procedure. It is important to be precise about creating a full-thickness deltotrapezial fascial approach that can be meticulously repaired at the conclusion of the procedure. This thick “watertight” deltotrapezial fascial repair will augment the vascular supply to the fracture; minimize dead space and the potential for a postoperative hematoma; and provide a physiologic barrier to the plate and screws, thereby playing an important role in avoiding hardware prominence. It is important to achieve anatomic reduction of the fracture fragments and stable, compressive fixation with use of either a limited-contact dynamic compression plate (or its equivalent) or one of the newer anatomic plates. The use of a tubular plate is not recommended[52,57,58]. It has been shown that placing the plate on the superior (tension) side of the clavicle creates the most stable construct[59], and ensuring that the plate does not protrude off the medial aspect of the clavicle anteriorly will help to avoid painful hardware. The periosteum and soft-tissue attachments of the fracture fragments should be saved, and bone-grafting should be considered in acute cases with severe comminution and in all cases of nonunion.

Intramedullary fixation is another option for the surgical management of a displaced midshaft clavicular fracture (Fig. 4). Use of this technique makes it possible to avoid the larger approach necessary for plate fixation and, if the implant is later removed through a small posterior approach as is typically recommended, the issue of persistent or painful hardware is eliminated. The primary disadvantage of intramedullary fixation is that it does not provide axial or rotational stability when used for nontransverse and comminuted fractures[60]. In addition, smooth Kirschner wires and other nonstable intramedullary fixation methods have had an unacceptably variable complication rate (range, 5% to 50%)[61,62], the most notable of which is hardware migration into the vital structures near the shoulder girdle[63]. Methods of intramedullary fixation that provide more stability while minimizing the complications of loss of fixation and hardware migration have been devised. Successful outcomes have been reported after use of these techniques[61,62,64,65], although no prospective randomized studies comparing intra-

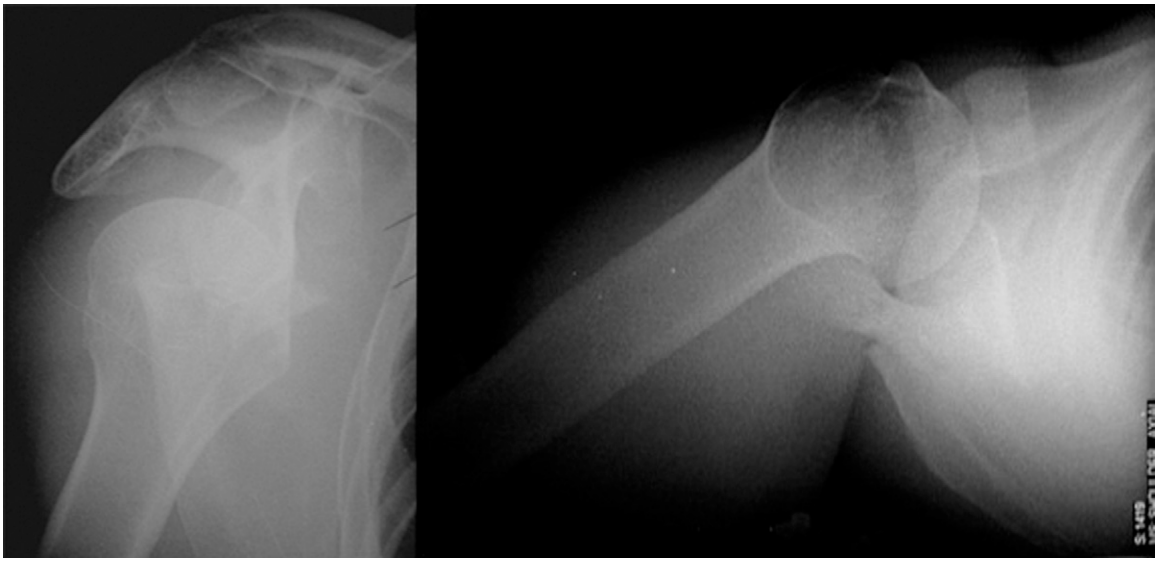

Fig. 9-A

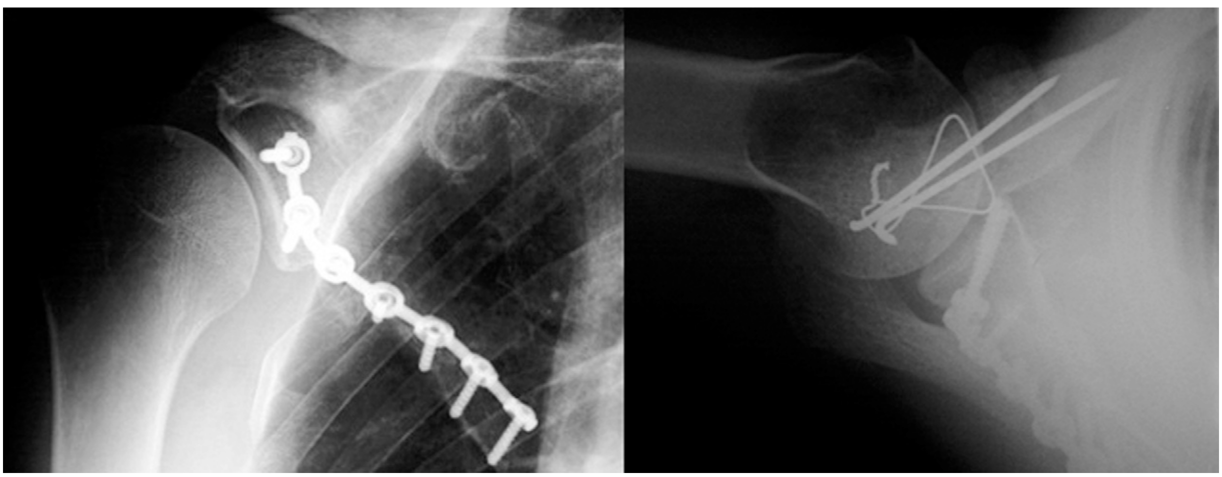

Fig. 9-B

Fig. 9-A Radiographs of a distal clavicular fracture and a displaced scapular neck fracture. **Fig. 9-B** The distal clavicular fracture has been reduced and has been fixed with tension-band and Kirschner wires (right) while the displaced scapular neck fracture has been reduced and has been fixed posteriorly with a plate that curves inferiorly along the lateral border (left). (Reprinted, with permission, from: Getz C, Deutsch A, Williams GR Jr. Scapular and glenoid fractures. In: Warner JJP, Iannotti JP, Flatow EL, editors. Complex and revision problems in shoulder surgery. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2005. p 365-94.)

medullary and plate fixation are available to our knowledge.

As is the case with plate fixation, complications following intramedullary fixation of displaced midshaft clavicular fractures can often be minimized through meticulous surgical technique. Only a minimal incision over the fracture site is necessary to reduce the fracture fragments; the soft-tissue and periosteal attachments to osseous fragments should be maintained. The largest-diameter device that will traverse the medullary canal is recommended to enhance fracture stability (particularly for nontransverse fractures and those with comminution), and the threads of the implant should not lie at the level of the fracture site. It is important to completely reduce the fracture prior to placement of the intramedullary device; this requires superior translation of the lateral part of the shoulder girdle, which prevents the creation of an “A-frame” malalignment of the clavicle. In addition, there is a tendency for the intramedullary device to exit the distal part of the clavicle too superiorly; care should be taken to ensure that the device exits the posterior part of the clavicle as far distally and inferiorly as possible. At the conclusion of the procedure, comminuted fragments are reapproximated with cerclage suture and the deltotrapezial fascia is closed over the fracture site.

An important issue regarding recommendations for the treatment of

TABLE III Results of Treatment of Glenoid Neck Fractures[81,92-99]*

Author(s)	Year	No. of Patients	Mean Duration of Follow-up (Range)	Treatment	Results
Herscovici et al.[92]	1992	7	Not available	Clavicle operatively fixed	All excellent
Nordqvist and Petersson[81]	1992	68	14 yr	Nonoperative	51 good, 15 fair, 2 poor. Residual deformity associated with pain
Leung and Lam[93]	1993	15	25 mo (14-47)	Operative fixation	14 good to excellent, 1 fair; no stratification by displacement
Edwards et al.[94]	2000	20	28 mo (9-79)	Nonoperative	17 excellent, 3 good. Less displacement associated with better results
Low and Lam[95]	2000	4	3.3 yr (2-4)	Clavicle operatively fixed	3 excellent, 1 good. No stratification by displacement
Egol et al.[96]	2001	19	Not available	7 operative, 12 nonoperative	More flexion in operative group; no difference in shoulder outcome scores
Van Noort et al.[97]	2001	35	35 mo	31 nonoperative, 4 operative	3 late reconstructions; no difference between groups except that severe displacement resulted in caudal dislocation.
Hashiguchi and Ito[98]	2003	5	57.4 mo	Clavicle operatively fixed	5 good; average UCLA score, 34.2 points
Labler et al.[99]	2004	17	Not available	8 nonoperative, 9 operative	5 good to excellent in each group; associated injures affected outcome; displacement poor prognostic indicator

*Although the patient groups and treatment methods are variable, patient satisfaction seemed to be related to residual displacement or angulation in nonoperatively treated patients and surgical management was most successful when anatomic reduction and healing were achieved.

displaced midshaft clavicular fractures is the timing of surgical management. In a study to address this issue, Potter et al.[66] compared fifteen patients who had had immediate fixation of this injury with fifteen who had undergone delayed fixation of a clavicular nonunion or symptomatic malunion after failure of nonoperative care. Although no significant differences in fracture-healing, in strength of shoulder flexion, abduction, or rotation, or in DASH scores were noted between the groups, the Constant scores and endurance strength were marginally better after the acute fracture repair. These authors pointed out that these data should not be used in isolation to recommend primary operative fixation of this injury but rather could be used in counseling patients on the relative advantages and disadvantages of immediate operative repair compared with potentially delayed reconstruction for the treatment of displaced midshaft fractures[66].

Lateral Clavicular Fractures

There is general agreement that lateral clavicular fractures, which account for 10% to 15% of all clavicular fractures, with complete displacement are associated with a higher prevalence of nonunion than are midshaft clavicular fractures[17,43,67]; this is likely due to a combination of bone and ligamentous injury. Nordqvist et al.[67] found that 25% of Type-II lateral clavicular fractures (fractures that occur between the

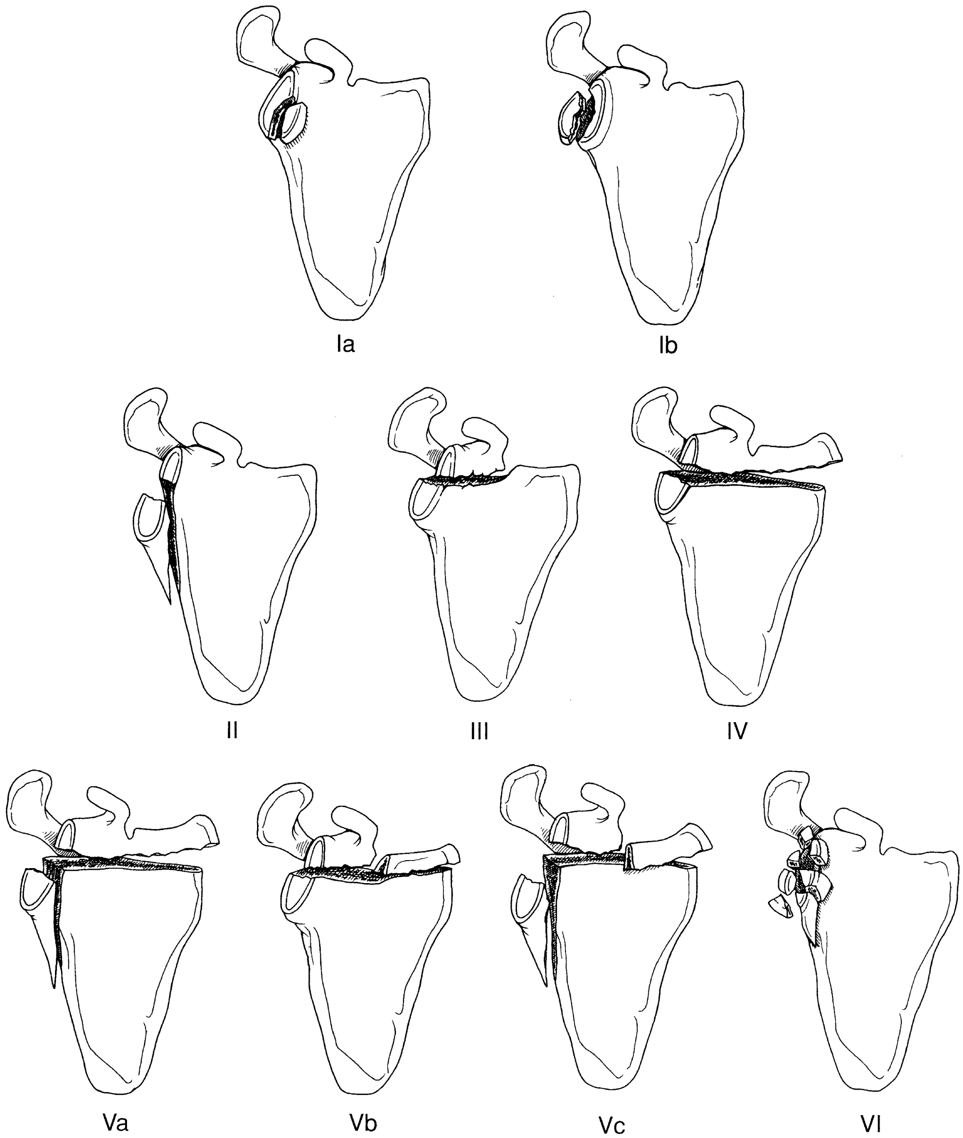

Fig. 10

Types I through VI glenoid fossa fractures. (Reprinted, with permission, from: Goss TP. Scapular fractures and dislocations: diagnosis and treatment. J Am Acad Orthop Surg. 1995;3:22-33.)

conoid and trapezoid coracoclavicular ligaments) progressed to nonunion or caused chronic pain, and Robinson et al.[17] showed that 21% of patients with this injury required surgery. Although the proportion of lateral clavicular fractures that progress to nonunion, particularly in elderly patients, may be higher than the proportion of midshaft clavicular fractures that do so, many of the nonunions are asymptomatic and do not require further treatment[17].

We are not aware of any prospective studies comparing operative and nonoperative treatment for fractures of the lateral third of the clavicle. When these fractures are managed operatively, the remaining part of the clavicle that is lateral to the fracture site is often either substantially comminuted or of insufficient quantity to enable rigid fixation with traditional plates or intramedullary implants. An array of different technical procedures to address this problem, with use of screws, pins, and plates, have been described in multiple small case series[60,68-73]. Newer, precontoured anatomic plates that enable locking screw fixation into the lateral fracture fragment have been created; however, even these may be of insufficient strength to withstand the traction forces of the lateral part of the shoulder girdle. Thus, it has been recommended that coracoclavicular fixation or reconstruction be used to supplement the osseous fixation[74]. This is typically provided through suture or allograft ligament sling fixation around the base of the coracoid and the reduced clavicle to augment or reconstruct the injured coracoclavicular ligament (Fig. 5).

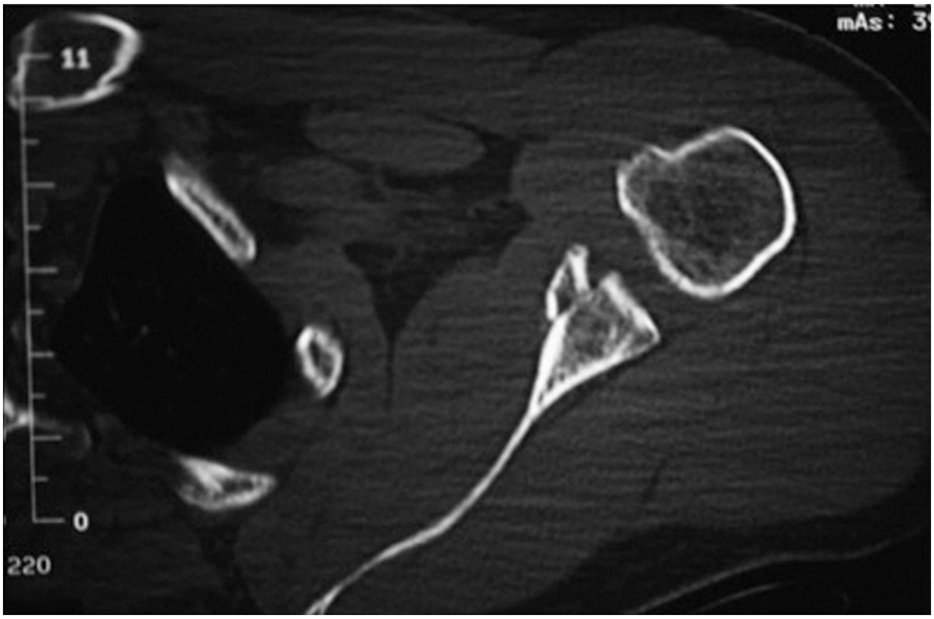

Fig. 11-A

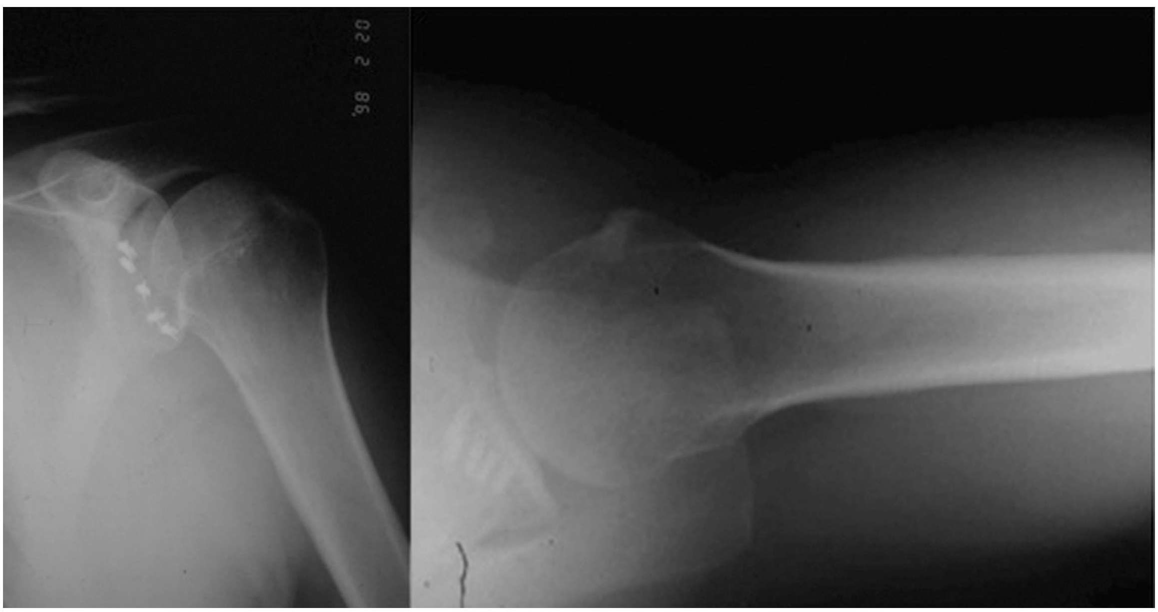

Fig. 11-B

Fig. 11-A A Type-Ia glenoid rim fracture. **Fig. 11-B** Suture anchors have been placed in the fracture bed, and sutures have been passed through the fragment and tied extra-articularly. (Reprinted, with permission, from: Getz C, Deutsch A, Williams GR Jr. Scapular and glenoid fractures. In: Warner JJP, Iannotti JP, Flatow EL, editors. Complex and revision problems in shoulder surgery. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2005. p 365-94.)

Occasionally, if the lateral-distal part of the clavicular bone has been determined, qualitatively or quantitatively, to be unable to accept osseous fixation, isolated coracoclavicular fixation can be used successfully to treat these injuries (Fig. 6). Utilization of a hook plate[70,71,75] has also been described for this particular injury. Although isolated series have shown successful results with this implant, the prevalence and magnitude of complications preclude its universal recommendation. If it is used, it should always be removed approximately three months postoperatively because of the high prevalence of acromial erosion and rotator cuff damage from the hook.

Glenoid and Scapular Fractures

Fractures of the glenoid and scapula account for 1% of all fractures and 5% of all shoulder fractures[76-79].

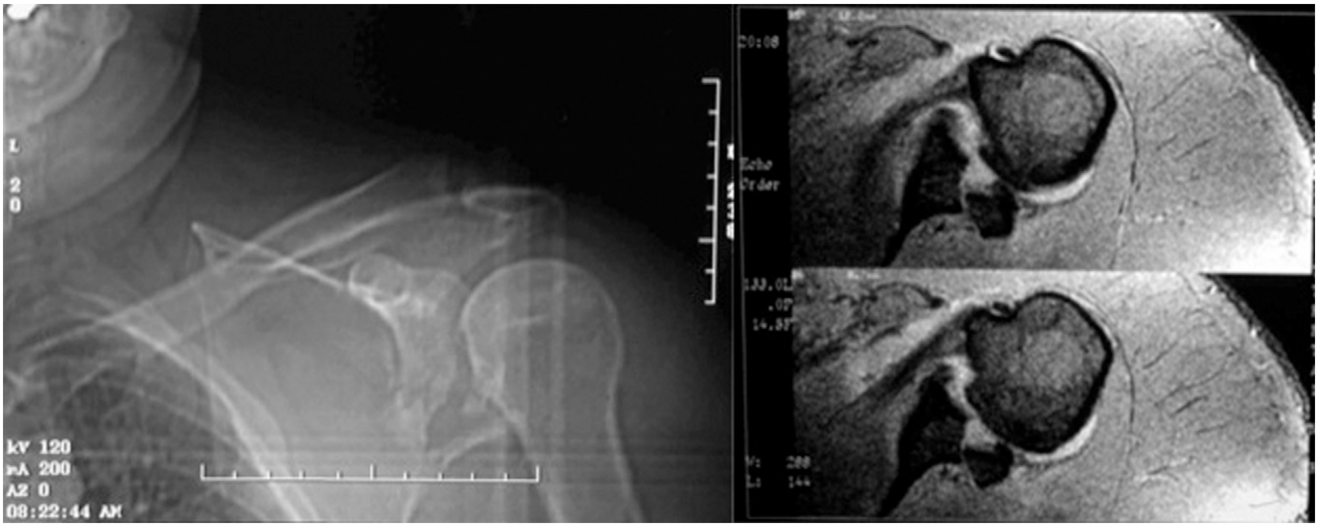

Fig. 12-A

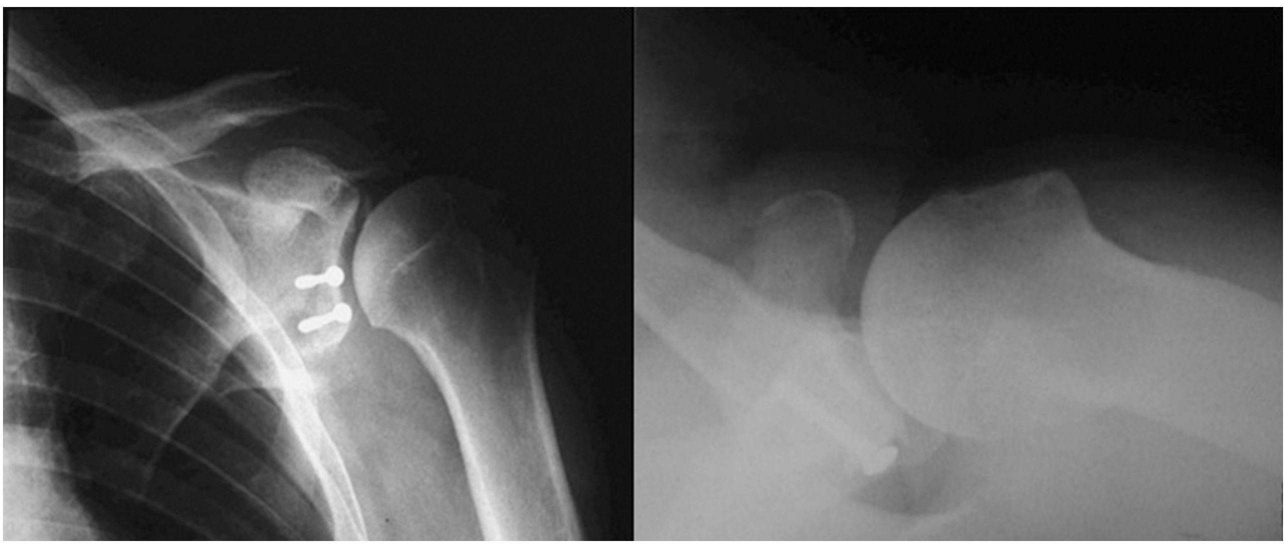

Fig. 12-B

Fig. 12-A A Type-Ib glenoid rim fracture. **Fig. 12-B** The posterior fragment has been fixed with two screws. (Reprinted, with permission, from: Getz C, Deutsch A, Williams GR Jr. Scapular and glenoid fractures. In: Warner JJP, Iannotti JP, Flatow EL, editors. Complex and revision problems in shoulder surgery. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2005. p 365-94.)

These fractures most commonly involve the scapular body (45%), the glenoid neck (25%), and the glenoid cavity (10%). Fractures affecting the acromion process (8%), coracoid process (7%), and scapular spine (5%) are less common[76,80] (Fig. 7). Management varies according to the fracture location and displacement.

Scapular Body Fractures

Fractures of the scapular body are often associated with concomitant injuries, which are sometimes life-threatening[76-78,81,82]. These injuries include rib fractures, hemothorax or pneumothorax, a ruptured viscus, closed head injury, and long-bone fracture. Management of a scapular body fracture may be deferred because of these other injuries, especially in patients who have sustained polytrauma. In 90% of cases, the scapular body fracture is treated nonoperatively with a sling for comfort for seven to ten days, followed by pendulum exercises and passive range-of-motion exercises for four to six weeks. An overhead pulley exercise program can usually be added by six weeks postinjury. Rotator cuff and scapular muscle strengthening is initiated at six to eight weeks and is continued for two to three months. Improvement occurs for nine to twelve months. Successful fracture union, minimal pain, and good function are expected in most cases[76,81,82]. However, nonunion and symptomatic malunion have been reported[76,83-85].

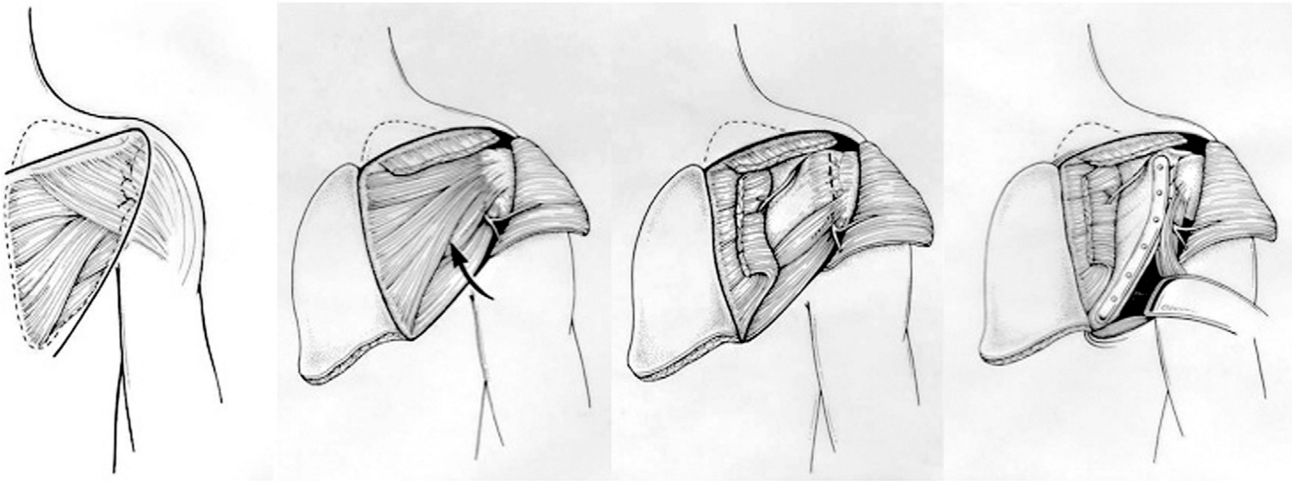

Fig. 13
An extended posterior approach is utilized to expose the glenoid, glenoid neck, and lateral border of the scapula. (Reprinted, with permission, from: Getz C, Deutsch A, Williams GR Jr. Scapular and glenoid fractures. In: Warner JJP, Iannotti JP, Flatow EL, editors. Complex and revision problems in shoulder surgery. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2005. p 365-94.)

Glenoid Neck Fractures

Glenoid neck fractures exit the superior part of the scapula either medial or lateral to the base of the coracoid[76,86] (Fig. 8). Those that exit laterally are inherently unstable and often require operative stabilization. However, they are very uncommon. Glenoid neck fractures that exit medial to the base of the coracoid divide the scapula into a medial fragment (consisting of the scapular body, scapular spine, and acromion) and a lateral fragment (the glenoid and the coracoid process). The lateral fragment is attached to the medial fragment by the coracoacromial ligament and to the axial skeleton by the coracoclavicular and acromioclavicular ligaments and the clavicle[87].

Goss described the superior shoulder suspensory complex as a lateral osseous and soft-tissue ring (the glenoid process, coracoid process, coracoclavicular ligament, distal part of the clavicle, acromioclavicular joint, and acromion process) supported by superior and inferior osseous struts (the clavicular shaft and the lateral scapular body and spine)[76,82,86,88]. Together with the coracoacromial ligament, the remaining intact portions of the superior shoulder suspensory complex resist displacement and angulation of glenoid neck fractures.

Glenoid neck fractures can be classified according to the amount of displacement and angulation[86]. Type-I glenoid neck fractures are displaced <1 cm, are angulated <40°, and account for 90% of cases. Type-II fractures are displaced >1 cm, are angulated >40°, and represent only 10% of glenoid neck fractures[76,89-91]. In the absence of an additional fracture or ligamentous injury, most glenoid neck fractures are inherently stable[87] and can be managed nonoperatively with a protocol similar to the one described above for scapular body fractures.

Displaced or angulated fractures in young active patients are treated operatively[76,91]. The type of operative treatment depends on the associated injuries to the superior shoulder suspensory complex and the time from the injury. For example, an acute (less than seven-day-old) displaced glenoid neck fracture combined with an ipsilateral clavicular shaft fracture and disruption of the coracoacromial and acromioclavicular ligaments can be managed with open reduction and internal fixation of the clavicle. The glenoid neck will be reduced by the intact coracoclavicular ligament (i.e., by ligamentotaxis). Likewise, an acute displaced glenoid neck fracture combined with displaced ipsilateral clavicular shaft and scapular spine fractures can be treated with open reduction and internal fixation of the clavicular shaft and the scapular spine. The glenoid neck will be reduced by ligamentotaxis through the intact coracoclavicular and/or coracoacromial ligaments. In patients with a subacute fracture, or a fracture pattern that is not amenable to ligamentotaxis, the glenoid neck must be reduced and stabilized directly through a posterior approach deep to the posterior border of the posterior part of the deltoid through the internervous plane between the teres minor and the infraspinatus. A plate is placed along the posterior aspect of the glenoid and curves down the lateral angle of the scapula (Figs. 9-A and 9-B).

Reported results of the treatment of glenoid neck fractures are sparse and difficult to interpret. Patients with and without combined injuries to the superior shoulder suspensory complex have been included in studies of the treatment of glenoid neck fractures, and results have been rarely stratified according to displacement or angulation. However, patient satisfaction after nonoperative treatment seems to be related to residual displacement or angulation, and surgical management is most successful when anatomic reduction and healing are achieved. The results of several

Fig. 14-A

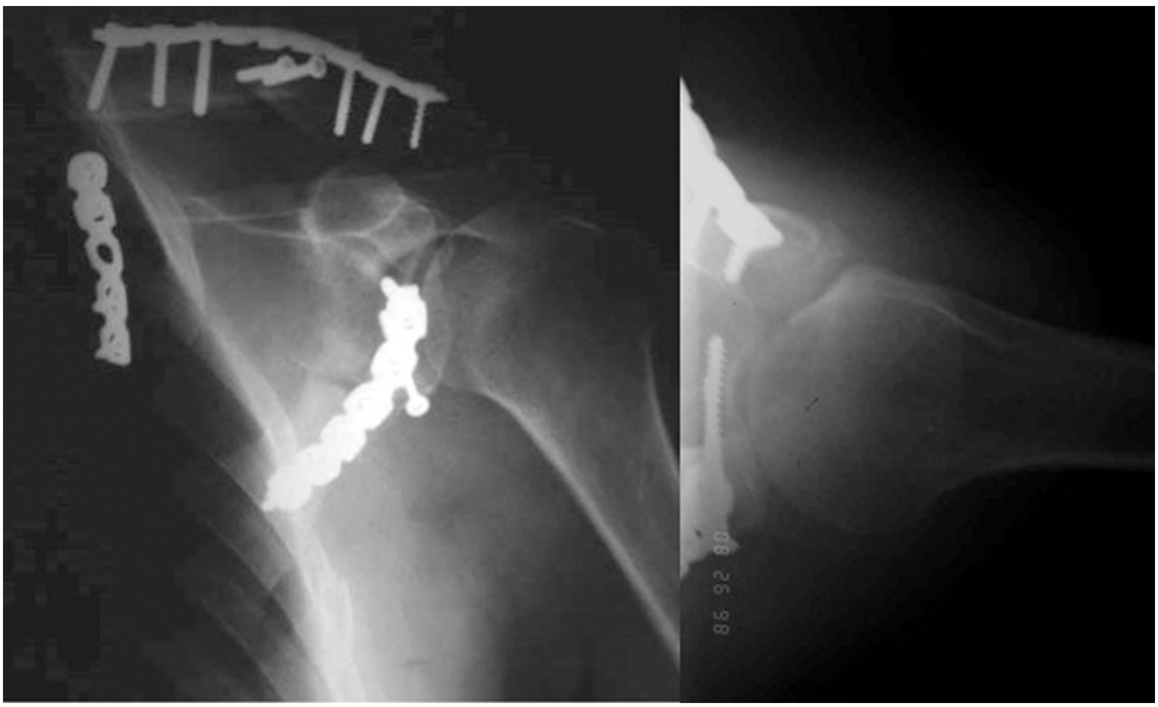

Fig. 14-B

Fig. 14-A A Type-Va glenoid fossa fracture with an associated midshaft clavicular fracture. **Fig. 14-B** An extended posterior approach was used to fix the glenoid with supplementation by a medial border plate. (Reprinted, with permission, from: Getz C, Deutsch A, Williams GR Jr. Scapular and glenoid fractures. In: Warner JJP, Iannotti JP, Flatow EL, editors. Complex and revision problems in shoulder surgery. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2005. p 365-94.)

reported series[81,92-99] are summarized in Table III.

Glenoid Cavity Fractures

Glenoid cavity fractures involve the glenoid rim and are usually associated with instability or are fractures of the glenoid fossa causing incongruity of the articular surface. They are classified, according to their location and severity, into six types[76,88,100,101] (Fig. 10).

Type-I fractures involve the anterior (Ia) or posterior (Ib) aspect of the glenoid rim. Type-II through IV fractures start with a transverse fracture between the superior and inferior halves of the glenoid and exit inferiorly through the lateral scapular border (II), superiorly through or near the superior scapular notch (III), or medially through the medial scapular border (IV). Type-V fractures are more complex and are a combination of Type-II through IV fractures. Type-VI fractures are severely comminuted and often not reconstructible.

Most glenoid fractures can be treated nonoperatively in a manner similar to what is used for scapular body fractures. Nonoperative treatment is also indicated for Type-VI fractures that are too comminuted to support stable fixation. Operative treatment is reserved for Type-I fractures associated with an unstable glenohumeral joint or any fracture (other than Type VI) with intra-articular displacement exceeding 5 mm[102].

Surgery for Type-I fractures is often done arthroscopically[103], especially if it is performed acutely. When the rim fragment contains the labrum, which it often does, it can be used for fixation. In many cases, the most inferior portion of the osseous fragment is still attached to the native glenoid through an intact labral connection. The superior part of the fragment usually contains a portion of the labrum superior to it that can be reattached to the glenoid with suture anchors.

Open treatment of Type-Ia fractures is performed through a standard deltopectoral or anterior axillary approach. The displaced fragment is stabilized with interfragmentary screws (if it is large enough) or suture anchors. The anchors are placed in the native glenoid inferior and superior to the fragment, with the labrum used for fixation. Alternatively, the anchors are placed in the fracture bed and the sutures are passed through the fragment and tied extra-articularly (Figs. 11-A and 11-B).

Type-Ib fractures that are associated with an unstable glenohumeral joint are usually fixed with interfragmentary screws through a limited posterior axillary approach. With the patient in the lateral decubitus position and the arm abducted, the posterior part of the deltoid is retracted superolaterally without detaching any of its origin or insertion. The interval between the infraspinatus and the teres minor is split, and the infraspinatus is retracted superiorly while the teres minor is retracted inferiorly. The infraspinatus insertion does not require detachment in most cases. The capsule is incised to visualize the articular surface. The fragment is then reduced and fixed with two screws (Figs. 12-A and 12-B).

Type-II fractures are also approached through a posterior axillary incision, through the same interval without detachment of the infraspinatus. If a plate is required to obtain adequate fixation, the inferior limb of the posterior axillary incision is extended inferiorly and medially over the lateral scapular margin. The infraspinatus origin and the dorsal portions of the origins of the teres minor and teres major are reflected off the scapula to expose the lateral border and the fracture line. The fracture is reduced, held provisionally with pins, and stabilized with a plate that starts below the fracture line on the lateral scapular border and extends superiorly onto the posterior surface of the glenoid. Care must be taken to avoid damage to the suprascapular nerve by the plate and to avoid placing screws into the joint.

Type-III fractures are often best approached anteriorly. The strongest deforming force is the conjoined tendon of the short head of the biceps and the coracobrachialis. Control of the fragment is easiest when the coracoid can be used to lever the fragment. A neutralization plate can be placed anteriorly and supplemented with a lag screw placed percutaneously from superior to inferior, between the clavicle and the scapular spine or acromion.

The treatment of Type-IV fractures is similar to that of Type-II fractures. In some cases, even after a plate has been applied laterally, the fracture is rotationally unstable. Under these circumstances, the medial border of the scapula is exposed and a plate is placed across the medial extent of the fracture.

The most important aspect of operative management of Type-V fractures is to be sure that there are enough large fragments for stable and anatomic fixation of the articular surface. An extensile posterior approach is used in most cases[79,104]. Combining anterior and posterior approaches is rarely required but may be necessary for Type-Vb and Vc fractures when the superior glenoid fragment is severely rotated by the conjoined tendon.

The extensile posterior approach is performed with the patient lying in the lateral decubitus position. The skin incision starts at the medial extent of the scapular spine, courses laterally to the posterior corner of the acromion, and then curves inferiorly and medially to follow the lateral scapular border (Fig. 13). The posterior deltoid origin is released from the scapular spine and retracted laterally. The interval between the infraspinatus and the teres minor is split, and the infraspinatus is detached from the humerus and reflected medially. Care is taken to prevent traction on the suprascapular nerve. The capsule is then incised to expose the joint surface. The teres minor and teres major origins are partially reflected off the lateral scapular margin, and the fracture is reduced. The articular surface is reconstructed and is fixed provisionally with pins. The remaining fractures are reduced, and a plate is placed from the lateral scapular border to the posterior surface of the glenoid. Cannulated screws can be passed over the pins that were used for provisional fixation. After the plate has been secured, fracture stability is assessed. In some cases, a medial plate may also be required (Figs. 14-A and 14-B).

The results of surgical management of glenoid cavity fractures depend on the quality of the reduction. When residual joint incongruity is <2 mm, results are good or excellent in 80% to 90% of cases and posttraumatic arthritis is minimal after four years of follow-up[79,102].

Overview

Collectively, fractures and dislocations of the acromioclavicular joint, sternoclavicular joint, clavicle, and scapula account for a large percentage of shoulder girdle injuries. Treatment recommendations vary according to the severity and location of the injury. Most acromioclavicular injuries are treated nonoperatively unless the displacement is severe or irreducible. Sternoclavicular dislocations are treated with closed reduction. Anterior dislocations often are unstable after reduction and are subsequently treated nonoperatively. Unstable or irreducible posterior dislocations are reduced and stabilized with open means because of the potential for mediastinal injury. Markedly displaced medial and lateral clavicular fractures are associated with a high prevalence of symptomatic nonunion; therefore, operative reduction and fixation are often recommended. Traditionally, midshaft clavicular fractures have been treated nonoperatively in most cases. Recently, high prevalences of symptomatic nonunion and malunion have been identified. Hence, operative management with a plate or intramedullary pin has been advocated for displaced fractures. Scapular fractures are most often treated nonoperatively. Operative reduction and internal fixation is reserved for displaced or angulated glenoid neck fractures, glenoid rim fractures associated with instability, and glenoid fossa fractures with articular displacement of >5 mm.

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