

Acute and Chronic Traumatic Injuries of the Sternoclavicular Joint

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Abstract

Acute and chronic traumatic injuries of the sternoclavicular joint require accurate diagnosis and management if complications are to be avoided. Sternoclavicular subluxation or dislocation, medial-clavicle physeal injuries, and degenerative arthritis are the most frequently diagnosed of these relatively uncommon injuries. The medial clavicular epiphysis does not ossify until the 18th to 20th year. Knowledge of its developmental anatomy is essential because most physeal injuries will heal with time without surgical intervention. In contrast, posterior dislocation of the sternoclavicular joint requires prompt closed or open reduction, as posterior displacement of the medial clavicle has been associated with numerous complications, including respiratory distress, venous congestion or arterial insufficiency, brachial plexus compression, and myocardial conduction abnormalities. A myriad of procedures have been recommended for repair or reconstruction of the sternoclavicular joint. On the basis of the authors' experience and review of the literature, they advocate surgical resection of the medial clavicle, with maintenance, repair, or reconstruction of the costoclavicular ligaments, when surgery is indicated. Metallic-pin fixation of the joint should be avoided, as Steinmann pins, Kirschner wires, threaded pins with bent ends, and Hagie pins have all been reported to migrate and cause serious complications, including death.

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Sternoclavicular joint injuries have been classified on the basis of anatomy and etiology. Traumatic posterior sternoclavicular dislocations and posterior physeal fracture-dislocations of the medial clavicle have been found to be the least common types. The serious complications that occur at the time of sternoclavicular joint trauma are primarily limited to posterior sternoclavicular joint injuries and include brachial plexus compression, pneumothorax, respiratory distress, vascular compromise, dysphagia, hoarseness, and death. In a review of the literature on posterior sternoclavicular joint injuries, Worman and Leagus¹

found that 16 of 60 patients suffered complications affecting the trachea, esophagus, or great vessels. Although these complications are generally observed at the time of injury, late-appearing complications have also been noted after nonreduced retrosternal injuries; these have included thoracic outlet syndrome, brachial plexopathy, subclavian artery compression, exertional dyspnea, and fatal sepsis following the development of a tracheoesophageal fistula.

The serious nature of these injuries and the frequency of associated complications give emphasis to the importance of careful evaluation and man-

agement. Our purpose is to review the diagnosis, treatment, and complications of acute and chronic traumatic injuries of the sternoclavicular joint.

Anatomy of the Sternoclavicular Joint

The sternoclavicular joint is a diarthrodial joint and is the only true articulation between the upper extremity and the axial skeleton. The enlarged, bulbous medial end of the clavicle is concave front to back and convex vertically, and therefore creates a saddle-type joint with the clavicular notch of the sternum.^{2,3} The sternoclavicular joint has the distinction of having the least amount of osseous stability of the major joints of the body because less than half of the medial clavicle articulates with the upper angle of the sternum. As Grant noted, "The two [make] an ill fit."³

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Intra-articular Disk Ligament

The intra-articular disk ligament is a very dense, fibrous structure that arises from the synchondral junction of the first rib to the sternum and passes through the sternoclavicular joint, which divides the joint into two separate joint spaces. DePalma⁴ has shown that the disk is perforated only rarely, and that the perforation allows a free communication between the two joint compartments. The disk ligament acts as a checkrein against medial displacement of the inner clavicle.

Costoclavicular Ligament

The costoclavicular ligament, also called the rhomboid ligament, is short and strong and consists of an anterior and a posterior fasciculus. The fibers of the anterior fasciculus arise from the anteromedial surface of the first rib and are directed upward and laterally. The fibers of the posterior fasciculus are shorter and arise lateral to the anterior fibers on the rib and are directed upward and medially. The fibers of the anterior and posterior components cross and provide stability of the joint during rotation and elevation of the clavicle. The configuration of the two-part costoclavicular ligament is in many ways similar to that of the two-part coracoclavicular ligament, which stabilizes the outer end of the clavicle.

Interclavicular Ligament

The interclavicular ligament connects the superomedial aspects of the clavicles with the capsular ligaments and the upper sternum. According to Grant, this band may be comparable to the wishbone of birds.³ The ligament helps the capsular ligaments to produce "shoulder poise" (i.e., to hold up the shoulder).

Capsular Ligament

The capsular ligament covers the anterosuperior and posterior aspects of the joint and represents thickening

of the joint capsule. The clavicular attachment of the ligament is primarily onto the epiphysis of the medial clavicle, with some secondary blending of the fibers into the metaphysis.

According to Bearn,⁵ the capsular ligament is the most important structure in preventing upward displacement of the medial clavicle and inferior drooping of the distal clavicle. In experimental postmortem studies, he evaluated the strength and the role of each of the ligaments at the sternoclavicular joint. Bearn determined, after sectioning the costoclavicular, intra-articular disk, and interclavicular ligaments, that they had no effect on clavicle poise. However, division of the capsular ligament alone resulted in inferior displacement of the distal clavicle.

Mechanisms of Injury

Some of the factors contributing to sternoclavicular joint stability include the particular collagen makeup of the patient's ligaments, the arrangement of the sternoclavicular ligaments and their method of attachment, and the variation in osseous anatomy of this saddle-type joint. Because the sternoclavicular joint is subject to practically every motion of the upper extremity, and because the joint is so small and incongruous, one would think that it would be the most commonly dislocated joint in the body. However, the ligamentous supporting structure is so strong and is designed in such a way that it is actually one of the least commonly dislocated joints in the body.

A traumatic dislocation of the sternoclavicular joint usually occurs only after tremendous forces, either direct or indirect, have been applied to the shoulder. When a dislocation occurs, the direction is usually anterior, which may be partially ex-

plained by the fact that the posterior capsular ligaments are substantially stronger than the other sternoclavicular ligaments. In a retrospective review of nearly 150 traumatic sternoclavicular dislocations reported in three series,⁶⁻⁸ we found that the most common cause of injury was vehicular accidents, with a frequency of 40%. Injury sustained during participation in sports accounted for approximately 21% of sternoclavicular dislocations. The remaining 39% were attributed to falls, miscellaneous trauma, and unspecified industrial accidents.

Direct Force

When a force is applied directly to the anteromedial aspect of the clavicle, the clavicle is pushed posteriorly behind the sternum and into the mediastinum (Fig. 1). This may occur in a variety of ways: for example, when an athlete lying on his back on the ground is jumped on, and the knee of the jumper lands directly on the medial end of the clavicle; when a kick is delivered to the front of the medial clavicle; when a person is run over by a vehicle; or when a person is pinned, front to back, between a vehicle and a wall.

Indirect Force

A force can be applied indirectly to the sternoclavicular joint from a force applied to the anterolateral or posterolateral aspect of the shoulder. If the shoulder is rolled forward during lateral compression, the force applied to the clavicle produces a posterior dislocation of the sternoclavicular joint. If the shoulder is compressed and rolled backward, the laterally applied force produces an anterior dislocation of the sternoclavicular joint as the underlying first rib acts as a fulcrum to lever the sternal end of the clavicle anteriorly.

Indirect force is the most common mechanism of injury to the sternoclavicular joint. Mehta et al⁹ re-

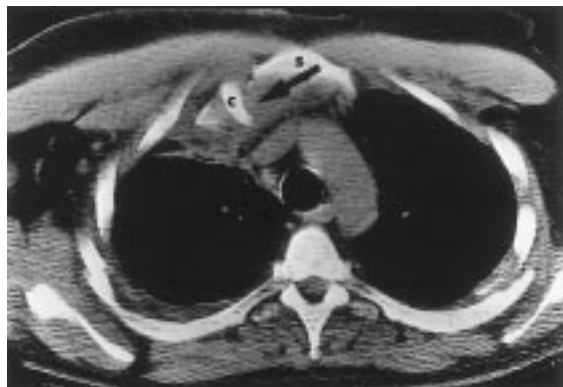


Fig. 1 Computed tomogram of a patient who sustained a right posterior sternoclavicular joint dislocation as a result of impact of the chest against the steering wheel during a motor vehicle accident. Note the degree of displacement of the posterior medial clavicle (arrow). C = medial clavicle; S = sternum.

ported that three of four posterior sternoclavicular dislocations were produced by indirect force, and Heinig¹⁰ reported that indirect force was responsible for eight of nine cases of posterior sternoclavicular dislocation.

Incidence of Injury

Sternoclavicular injuries are rare, and many authors apologize for reporting only three or four cases. Attesting to this rarity is the fact that some orthopaedists have never treated or seen a dislocation of the sternoclavicular joint. In the series of 1,603 injuries of the shoulder girdle reported by Cave,¹¹ only 3% were sternoclavicular dislocations.

Anterior dislocations of the sternoclavicular joint are much more common than posterior ones. In fact, Cave¹¹ reported only one instance of posterior sternoclavicular dislocation in his large series, and our review of the world literature yielded fewer than 110 cases.

The largest series of sternoclavicular dislocations from a single institution treated by multiple authors was reported by Nettles and Linscheid,⁶ who described 60 patients with this injury. Only 3 of these patients had posterior sternoclavicular dislocations. Waskowitz⁸ reviewed

18 cases of sternoclavicular dislocation, none of which were posterior injuries. In our series of 185 traumatic sternoclavicular injuries,² however, there were 135 patients with anterior dislocations and 50 patients with posterior dislocations. Although these injuries are relatively uncommon, in Cave's series¹¹ and in our own experience, dislocation of the sternoclavicular joint was not as rare as posterior dislocation of the glenohumeral joint.

Clinical Presentation

The patient with an acute fracture or dislocation of the sternoclavicular joint has severe pain that is increased with any movement of the arm, particularly when the shoulders are pressed together by a lateral force. The patient usually supports the injured arm across the trunk with the uninjured arm. If the joint is dislocated, the affected shoulder appears to be shortened and thrust forward compared with the normal shoulder. The head may be tilted toward the side of the dislocated joint, and discomfort increases when the patient is placed in the supine position. With an anterior dislocation, the medial end of the clavicle is visibly prominent and can be palpated anterior to the sternum (Fig. 2). It may be

fixed anteriorly, or it may be quite mobile.

In contrast, in a patient with a posterior dislocation, the usually palpable medial end of the clavicle is displaced posteriorly. The anterosuperior fullness of the chest produced by the clavicle is less prominent compared with the normal side. The corner of the sternum is more easily palpated than the normal sternoclavicular joint. Venous congestion may be present in the neck or in the upper extremity. Breathing difficulties, shortness of breath, or a choking sensation may be noted. Circulation to the ipsilateral arm may be decreased. The patient may complain of difficulty in swallowing or a tight feeling in the throat. In severe cases, the patient may be hypotensive and in a state of shock.

We have seen a number of patients who clinically appeared to have an anterior dislocation of the sternoclavicular joint on the basis of prominent anterior swelling, but whose x-ray studies showed complete posterior dislocation. It is important to remember that one cannot always rely on the clinical findings obtained when examining and palpating the joint to make a distinction between anterior and posterior dislocation.



Fig. 2 Photograph of a 37-year-old woman who sustained a traumatic left anterior sternoclavicular dislocation when she was run over by a car.

Radiologic Examination

Radiography

Routine radiographs of the chest occasionally suggest that the sternoclavicular joint or the position of the clavicle is abnormal. It would be ideal to take a view at right angles to the anteroposterior plane, but because of the anatomy of the region, it is impossible to take a true 90-degree cephalocaudal lateral view. Lateral radiographs of the chest are at right angles to the anteroposterior plane, but they cannot be interpreted because of the density of the chest and the overlap of the medial clavicles with the first rib and the sternum. To circumvent these difficulties, several special projections have been advocated.

In 1968, Hobbs¹² recommended a view that approximates a 90-degree cephalocaudal lateral view of the sternoclavicular joints. To obtain this projection, the patient is seated at the x-ray table, high enough to lean forward over the table. The cassette is on the table, and the lower anterior rib cage is against the cassette. The patient leans forward so that the nape of the flexed neck is almost parallel to the table. The x-rays pass through the cervical spine to project an image of the sternoclavicular joints onto the cassette.

In the same year, Heinig¹⁰ recommended an x-ray projection for imaging the sternoclavicular joint that resembles a "swimmer's view" of the cervical spine. With the patient in a supine position, the central ray of the x-ray tube is directed tangential to the joint and parallel to the opposite clavicle.

In the early 1970s, Rockwood developed a 40-degree cephalic-tilt view that is a true caudocephalic view of both of the sternoclavicular joints and the medial clavicles.² If the injured sternoclavicular joint is dislocated anteriorly, the clavicle will appear to be displaced superior

to an imaginary horizontal line when compared with the normal clavicle. If the sternoclavicular joint is dislocated posteriorly, the clavicle will appear to be displaced inferior to an imaginary horizontal plane when compared with the normal clavicle (Fig. 3). This special projection was named the "serendipity view" by the senior author (C.A.R.) because it was discovered purely by accident.

Tomography

In 1959, Baker¹³ recommended the use of tomography, which was developed in the late 1920s. He believed it to be far more valuable than routine films and the fingertips of the examining physician. Before the development of computed tomography (CT), tomography was especially helpful in distinguishing between a sternoclavicular dislocation and a fracture of the medial clavicle.

Computed Tomography

In our experience, CT is the best imaging modality for evaluating acute and chronic traumatic injuries of the sternoclavicular joint. It clearly distinguishes injuries of the joint from fractures of the medial clavicle and defines minor subluxations of the joint.^{2,14-16} Images of both sternoclavicular joints and the medial half of both clavicles must be ob-

tained to compare the injured joint with the normal contralateral joint.

Physcal Injuries

Although the clavicle is the first long bone of the body to ossify (intrauterine week 5), the epiphysis at the medial end of the clavicle is the last epiphysis in the body to appear and the last one to close. The medial clavicular epiphysis does not ossify until the 18th to 20th year, and it fuses with the shaft of the clavicle around the 23rd to 25th year.³

This information about the epiphysis is important, because it is believed that many so-called sternoclavicular joint dislocations are not dislocations at all, but rather injuries to the medial physis of the clavicle (Fig. 4). As with the rare posterior sternoclavicular joint dislocations, the concern for late complications caused by pressure on the hilar structures with posterior physal injuries has led many authors to recommend surgery after failure of closed reduction. However, it is our opinion that the majority of these injuries will heal with time, without surgical intervention,¹³ and that the remodeling process will eliminate most of the bone deformity or displacement.

In our experience, closed reduction should be attempted in all acute



Fig. 3 Posterior dislocation of the right sternoclavicular joint as seen on a 40-degree cephalic-tilt radiograph of a 37-year-old man. The right clavicle is displaced inferior to a horizontal line drawn across the superior border of the normal left clavicle.



Fig. 4 CT scan of a 19-year-old patient who presented after a motor vehicle accident with chest pain and a "choking sensation" that was exacerbated by lying supine. C = medial clavicle; E = epiphyseal fragment; S = sternum. Note physeal injury of medial clavicle and compression of trachea (arrow). (Reprinted with permission from Rockwood CA Jr, Wirth MA: Injuries to the sternoclavicular joint, in Rockwood CA Jr, Green DP, Bucholz RW, et al [eds]: *Rockwood and Green's Fractures in Adults*, 4th ed. Philadelphia: Lippincott-Raven, 1996, vol 2, p 1448.)

posterior physeal injuries that present within 10 days of injury. Beyond this period of time, if a patient is having no symptoms suggesting compromise of the mediastinal structures, we recommend expectant management of these injuries because of their potential to remodel. However, if children and adults younger than 25 years of age have symptoms from the pressure of the posteriorly displaced clavicle into the mediastinum (e.g., dysphagia, dyspnea, upper-extremity swelling, or cyanosis) and closed reduction was unsuccessful, an operative procedure should be performed.

Many authors have observed at the time of surgery that the intra-articular disk ligament stays with the sternum. We have also noted that the epiphyseal disk (either unossified or ossified, depending on the age of the patient) usually stays with the sternum. Anatomically, the epiphysis is lateral to the articular disk ligament and is held in place by the capsular ligament. It is important to recognize these structures so that the epiphysis is not inadvertently excised with the intra-articular disk ligament at the time of surgery.

Sternoclavicular Sprain or Subluxation

Acute sprains of the sternoclavicular joint can be classified as mild or moderate. In a mild sprain, all the ligaments are intact, and the joint is stable. In a moderate sprain, there is subluxation of the sternoclavicular joint. The capsular, intra-articular disk, and costoclavicular ligaments may be partially disrupted.

The mildly sprained sternoclavicular joint is stable and can be painful. Application of ice for the first 12 to 24 hours, followed by heat, is helpful. The upper extremity should be immobilized in a sling for 3 to 4 days. The patient can then gradually regain use of the arm in everyday activities.

Moderate sprains of the sternoclavicular joint are characterized by anterior or posterior sternoclavicular subluxation. These injuries can usually be reduced satisfactorily by drawing the shoulders backward as if reducing and holding a fracture of the clavicle. A clavicle strap can be used to hold the reduction. A sling and swath is used to hold up the shoulder and to prevent motion of the arm. The patient should be protected from further injury for 4 to 6 weeks.

Anterior Sternoclavicular Dislocation

In 1990, de Jong and Sukul¹⁷ reported long-term follow-up results in 10 patients with traumatic anterior sternoclavicular dislocations. All patients were treated nonoperatively with analgesics and immobilization. The results of treatment were good in 7 patients, fair in 2 patients, and poor in 1 patient at follow-up (mean interval, 5 years). There is still controversy regarding the treatment of acute or chronic anterior dislocation of the sternoclavicular joint. Most acute anterior dislocations are unstable after reduction, and many operative procedures have been described to repair or reconstruct the joint.

Method of Closed Reduction

Although in most instances closed reduction is unsuccessful, we nevertheless recommend an attempt at reducing the anterior displacement of the medial clavicle if the patient presents within 7 to 10 days of injury. Closed reduction can be accomplished with local or general anesthesia or, in the case of stoic patients, without anesthesia. Most authors recommend the use of narcotics or muscle relaxants. The patient is placed supine on the table, with a 3- to 4-inch-thick pad between the shoulders. With the patient in this position, the sternoclavicular joint may be reducible with direct gentle pressure over the anteriorly displaced medial clavicle. When the pressure is released, however, the clavicle usually dislocates again.

If the patient is older than 23 to 25 years of age, persistent prominence of the anterior clavicle is to be expected. This does not seem to interfere with usual activities and, in some cases, has not even interfered with heavy manual labor.²

Postreduction Care

If the sternoclavicular joint remains reduced when the shoulders are held back, the shoulders can be stabilized with a soft figure-of-eight dressing, a commercial clavicle-strap harness, or a plaster figure-of-eight cast. Some authors recommend a bulky pressure pad over the anteromedial clavicle, which is held in place with elastic tape. Immobilization should be maintained for at least 6 weeks, and then the arm should be protected for another 2 weeks before strenuous activities are undertaken. If the sternoclavicular joint again dislocates when the reduction pressure is released, as it usually does, a figure-of-eight dressing or a sling can be used until the patient's symptoms subside.

Operative Management

Although some authors have recommended surgical repair of anterior dislocations of the sternoclavicular joint, we believe that the operative complications are too great and the end results are too unsatisfactory to consider open reduction.

Posterior Sternoclavicular Dislocation

Because associated injuries are common with posterior dislocation of the sternoclavicular joint, prompt and careful examination of the patient is extremely important. A very thorough history and physical examination should be done to rule out damage to the pulmonary and vascular systems. The sternoclavicular joint must be carefully evaluated with all available radiologic modalities, including, when indicated, combined aortography-CT for potential vascular injuries (Fig. 5). If associated injuries are present, appropriate consultants should be called in before reduction is performed.

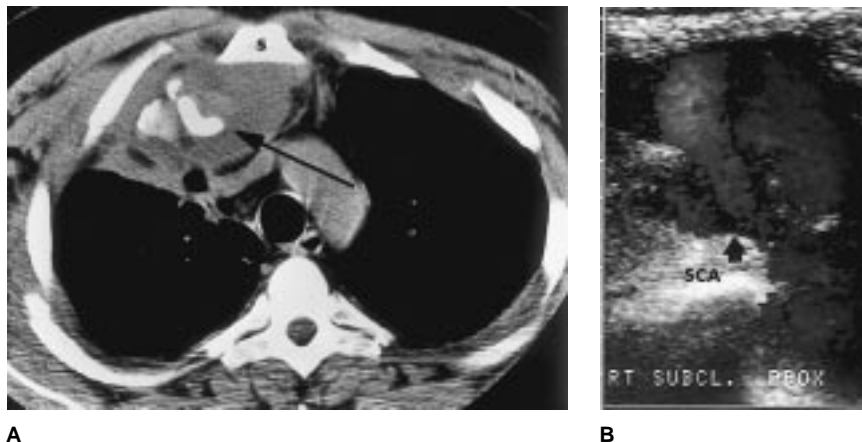


Fig. 5 A, CT scan revealing a posterior fracture-dislocation of the sternoclavicular joint with significant soft-tissue swelling and compromise of the hilar structures. Note the comminuted medial-clavicle fracture (arrow). S = sternum. B, Duplex ultrasound study revealing a large pseudoaneurysm of the right subclavian artery (SCA). Note the large neck of the pseudoaneurysm, which measured approximately 1 cm in diameter (arrow). (Reprinted with permission from Rockwood CA Jr, Wirth MA: Injuries to the sternoclavicular joint, in Rockwood CA Jr, Green DP, Bucholz RW, et al [eds]: *Rockwood and Green's Fractures in Adults*, 4th ed. Philadelphia: Lippincott-Raven, 1996, vol 2, p 1439.)

Worman and Leagus¹ reported a case of posterior dislocation of the sternoclavicular joint in which it was noted at surgery that the displaced clavicle had lacerated the right pulmonary artery. The clavicle had prevented exsanguination, because the vessel was still impaled by the clavicle. Had a closed reduction been performed in the emergency department, the result could have been disastrous.

Cooper et al¹⁸ reported a case in which a posterior sternoclavicular dislocation caused transection of the internal mammary artery and laceration of the brachiocephalic vein. The vascular injuries were associated with fractures of the anterior ends of the first to third ribs and marked posterior instability of the medial end of the clavicle. The brachiocephalic vein was repaired, but the posteriorly displaced medial clavicle impinged on the suture line. The pressure on the vein was alleviated by reducing the medial clavicle and stabilizing the sternoclavicular joint with an external fixator.

From a review of the earlier literature, it appears that the treatment of choice for posterior sternoclavicular dislocation in the past was operative. Since the 1950s, however, the preference has been closed reduction.^{2,19} Some authors who had previously done open reductions reported that they were amazed by how easily the dislocation reduced under direct vision, and thereafter they used closed reductions with complete success.

We advise closed reduction in all posterior sternoclavicular dislocations that present within 7 to 10 days of injury. Once the joint has been reduced closed, it is usually stable.

Methods of Closed Reduction

Many different techniques have been described for closed reduction of a posterior dislocation of the sternoclavicular joint. General anesthesia is usually required for reduction of these injuries because the patient has so much pain and muscle spasm. However, for the stoic patient, some

authors have performed the reduction with the use of intravenous narcotics and muscle relaxants. Heinig¹⁰ has successfully used local anesthesia for closed reduction of these injuries.

Abduction-Traction Technique

With the abduction-traction technique, the patient is placed on his back with the dislocated shoulder near the edge of the table. A 3- to 4-inch-thick sandbag is placed between the shoulders. Lateral traction is applied to the abducted arm, which is then gradually brought back into extension. The clavicle usually reduces with an audible snap or pop, and it is almost always stable. Too much extension can bind the anterior surface of the dislocated medial clavicle on the back of the manubrium. Occasionally, it may be necessary to grasp the medial clavicle with one's fingers to dislodge it from behind the sternum. If this fails, the skin is prepared, and a sterile towel clip is used to grasp the medial clavicle to apply anterior traction while lateral traction is applied to the arm.

Adduction-Traction Technique

With the adduction-traction technique, the patient is supine on the table with a 3- to 4-inch bolster between the shoulders. Traction is then applied to the arm in adduction, while a downward pressure is exerted on the shoulders. The clavicle is levered over the first rib into its normal position.

Other Techniques

Heinig¹⁰ has reported successful reduction by placing the patient supine on the table with three or four folded towels between the shoulders and then applying a posteriorly directed force to both shoulders. Other authors have achieved reduction by putting a knee between the shoulders of the seated patient and then pulling back on both shoulders.

It is important to emphasize that closed reduction should be performed early after injury. Several authors have reported great difficulty in obtaining successful closed reduction after 48 hours.

Postreduction Care

To allow ligament healing after reduction, the shoulders should be held back for 4 to 6 weeks with a figure-of-eight dressing or one of the commercially available figure-of-eight straps used to treat fractures of the clavicle.

Operative Management

Should closed maneuvers fail in the adult, an operative procedure should be performed, because most adult patients cannot tolerate posterior displacement of the clavicle into the mediastinum. In recent years, various authors have recommended open reduction and internal fixation for acute injuries, as well as for chronic problems. Gangahar and Flogaites,²⁰ Holmdahl,²¹ Louw and Louw,²² and Borrero²³ have all reported significant late-appearing complications after nonreduced posterior dislocations in patients who initially demonstrated no significant symptoms related to compression of the mediastinal structures. This has been our experience as well. For this reason, we recommend excision of the medial clavicle and stabilization of the remainder of the clavicle to the first rib in patients with chronic posterior sternoclavicular dislocations.

Several basic procedures have been described to maintain the medial end of the clavicle in its normal articulation with the sternum. Suture, internal fixation across the joint, use of the fascia lata or subclavius tendons, and osteotomy of the medial clavicle have all been advocated. Regardless of the chosen surgical procedure, we recommend that the surgeon become totally familiar with the anatomy that lies im-

mediately above, behind, and around the sternoclavicular joint.

We also suggest that a thoracic surgeon be part of the surgical team in the event that catastrophic bleeding occurs. The risk of this potentially fatal complication is particularly high in patients with chronic nonreduced posterior dislocations.

If the sternoclavicular ligaments are completely disrupted, we advocate medial-clavicle resection with stabilization of the remaining clavicle to the first rib, rather than trying to stabilize the sternoclavicular joint. This ensures that the mediastinal structures have been adequately decompressed from the compromising effect of the posteriorly displaced medial clavicle.

After resection of the medial clavicle, two or three pieces of nonabsorbable suture are passed around the remaining medial end of the clavicle and its periosteal tube and then through the residual stump or scar of the old costoclavicular ligament on the dorsal surface on the first rib. The closure of the periosteal tube will stabilize the medial clavicle. In some cases it may be necessary to pass additional sutures around the first rib for stability. However, care must be taken not to tighten the sutures so much that the medial end of the clavicle is compressed down onto the first rib. If present, the capsular and/or intra-articular disk ligaments can also be used to stabilize the medial clavicle.

In 1993, Grassi et al²⁴ reported the data on a series of 22 patients who had undergone resection of the medial end of the clavicle. Eighteen of these patients were treated for an acute or chronic traumatic injury to the sternoclavicular joint. The patients were divided into two groups. In group I were 15 patients who underwent resection of the medial end of the clavicle with maintenance or reconstruction of the costoclavicular ligament. In group II

were 7 patients who underwent resection of the medial end of the clavicle without maintenance or reconstruction of the costoclavicular ligament.

The outcome in 6 of the patients in group II was poor, with persistence or worsening of preoperative symptoms. The 1 patient with a successful result had suffered a posterior epiphyseal separation in which the costoclavicular ligament remained attached to the periosteum, thus preventing instability.

In group I, the result was rated as excellent in 11 cases, fair in 3, and poor in 1. Of note, all patients in this group who had undergone primary surgical resection of the medial end of the clavicle with maintenance of the costoclavicular ligaments had an excellent result. When the operation was performed as a revision of a previous procedure with reconstruction of the costoclavicular ligaments, the results were less successful, but only 1 of the 7 patients was not satisfied with the outcome of treatment.

Injury of the Intra-articular Disk Ligament

Patients occasionally present with a stable sternoclavicular joint that is associated with a reproducible and painful clicking, grating, or popping sensation reminiscent of a meniscal tear in the knee. Although this injury is uncommon, these symptoms may be consistent with injury to the intra-articular disk ligament, as suggested by Bateman.²⁵ As with a meniscal injury in the knee, a tear of the intra-articular disk ligament can be quite disabling and should be considered in the differential diagnosis of any acute or chronic post-traumatic injury of the sternoclavicular joint.

Duggan²⁶ reported a case in which, several weeks after an injury

to the sternoclavicular joint, the patient still had popping in the joint. Through a small incision, Duggan exposed the capsule, and out through the capsule popped the intra-articular disk, which looked like "an avulsed fingernail." After repair of the capsule, the patient's symptoms resolved.

The combination of CT and arthrography has been advocated as a diagnostic aid in difficult cases. It must be borne in mind, however, that 6% of intra-articular disks are incomplete, and their appearance may be incorrectly interpreted as a positive finding.

In cases that are refractory to conservative management, a local anesthetic can be injected into the joint to confirm the source of pain. If the pain in the joint is obliterated, resection of the disk at the time of arthrotomy may eliminate the pain.

A potential complication of simple disk excision may arise from inadequate understanding of the articular anatomy of the sternoclavicular joint. Failure to recognize and treat degenerative changes at the inferior pole of the medial clavicle (the site of the true articular surface between the clavicle and the upper angle of the sternum) will result in persistent symptoms.

Degenerative Arthritis of the Sternoclavicular Joint

Conservative nonoperative treatment of patients with osteoarthritis of the sternoclavicular joint secondary to a traumatic injury (i.e., heat, anti-inflammatory agents, and rest) is usually successful. If the patient has persistent symptoms of arthritis for 6 to 12 months despite these measures, and if the symptoms can be completely relieved by injection of a local anesthetic agent into the sternoclavicular joint region, resectional arthroplasty of the sternoclavicular joint is indicated (Fig. 6).

If the medial end of the clavicle is to be removed because of degenerative changes, the surgeon should be careful not to damage the costoclavicular ligament and should always evaluate the residual stability of the remaining clavicle. If too much of the clavicle is resected, several complications may ensue. Initially, there will be a decrease in pain and alleviation of crepitation, but this is usually short-lived. Subsequently, a return of mild to moderate symptoms occurs, because the integral stabilizing role of the clavicle has been lost. Functional deficits related to limited shoulder mobility, neurologic symptoms, thoracic outlet syndrome, and fatigue have been reported.^{2,19}

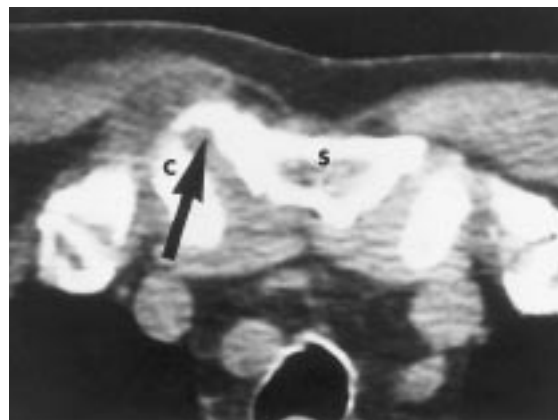


Fig. 6 CT scan of a 63-year-old right hand-dominant man who worked more than 45 years as a landscaper. Image demonstrates a hyper-trophic, degenerative right sternoclavicular joint consistent with osteoarthritis (arrow). C = medial clavicle; S = sternum.

Dislocations of Both Ends of the Clavicle

To our knowledge, the first reported case of dislocation of both ends of the clavicle was by Porral in 1831.² In 1923, Beckman²⁷ reported a single case and reviewed the literature on 15 cases that had been previously reported. With the exception of Beckman's patient, all patients had been treated conservatively with acceptable function. In one patient, brachial plexus neuropathy developed, which was treated by excision of a portion of the clavicle. To our knowledge, only four additional cases have been reported since then.²

In 1990, Sanders et al²⁸ reported the cases of six patients with dislocation of both ends of the clavicle (an anterior dislocation of the sternoclavicular joint and a posterior dislocation of the acromioclavicular joint). The two patients who had fewer demands on the shoulder did well with only minor symptoms after nonoperative management. The other four patients had persistent symptoms that were localized to the acromioclavicular joint. Each of these patients underwent reconstruction of the acromioclavicular joint, which resulted in painless full range of motion and a return to normal activity.

Bilateral Dislocations

Bilateral dislocations have been described relatively infrequently in the literature. In 1896, Hotchkiss²⁹ reported a bilateral traumatic dislocation of the sternoclavicular joint in a 28-year-old man who was run over by a cart and suffered an anterior dislocation of the right sternoclavicular joint and a posterior dislocation of the left one. The senior author has treated four cases of traumatic bilateral sternoclavicular dislocation. Of

the 60 sternoclavicular dislocations reported by Nettles and Linscheid⁶ only 3 were bilateral anterior dislocations. All 3 occurred spontaneously or after a trivial event.

Recurrent Traumatic Dislocations

Recurrent anterior or posterior dislocation of the sternoclavicular joint after an acute injury is extremely rare. The joint is usually stable after reduction, or it remains permanently anteriorly or posteriorly displaced. This entity should not be confused with a traumatic spontaneous subluxation or dislocation.

Complications of Injuries to the Sternoclavicular Joint

Nonoperative Treatment

The serious complications that occur at the time of dislocation of the sternoclavicular joint are primarily limited to posterior injuries. Virtually the only complications that occur with anterior dislocation of the sternoclavicular joint are "cosmetic bumps" and late degenerative changes.¹⁴⁻¹⁶

Many complications have been reported secondary to retrosternal

dislocation. These include pneumothorax and laceration of the superior vena cava, respiratory distress, venous congestion in the neck, rupture of the esophagus with abscess and osteomyelitis of the clavicle, fatal tracheoesophageal fistula, pressure on the subclavian artery in an untreated patient, subsequent occlusion of the subclavian artery in a patient who was not treated, myocardial conduction abnormalities, compression of the right common carotid artery by a fracture-dislocation of the sternoclavicular joint, brachial plexus compression, and hoarseness, onset of snoring, and voice changes from normal to falsetto with movement of the arm.^{2,14-16}

In an excellent review of the complications associated with posterior dislocation of the sternoclavicular joint, Worman and Leagus¹ reported that 16 of 60 patients described in the literature had suffered complications involving the trachea, esophagus, or great vessels (Fig. 7). It is noteworthy that even though the incidence of complications was 25%, only four deaths have been reported as a result of this injury.²

Operative Treatment

A myriad of procedures have been recommended for repair or re-



Fig. 7 Contrast material-enhanced CT scan of 16-year-old boy who presented with left arm swelling and cyanosis 14 months after a wrestling injury. A stenotic lesion of the subclavian vein can be seen adjacent to a posteriorly displaced physeal fracture of the medial clavicle (arrow). Note relationship between posteriorly displaced clavicle (C) and sternum (S).

construction of the sternoclavicular joint. Recommendations in the earlier literature included such unusual materials as kangaroo tendon xenograft and ivory fixation pegs to stabilize the reconstruction. However, no technique has left a more ominous legacy of complications than the use of Kirschner wires or Steinmann pins.

While most orthopaedic surgeons are aware of anecdotal accounts of the grave effects of pin migration, numerous pin-and-wire techniques continue to be used in the surgical management of the sternoclavicular joint. Complications related to pin migration have led to many recommendations by those who continue to use them for sternoclavicular joint surgery. These recommendations include not perforating the medial cortex of the manubrium, using smooth pins, bending the pin ends at acute angles, leaving the pins in a palpably subcutaneous position, instructing patients not to elevate their arms above 90 degrees, and using external supplementary bracing. However, it must be pointed out that smooth pins, threaded Kirschner wires, pins with bent ends, and Hagie pins have all been reported to migrate and cause serious complications, including death.^{2,15,19,28,30}

By 1992, there had been reports of seven deaths and three near-deaths due to complications as a result of transfixing the sternoclavicular joint with Kirschner wires or Steinmann

pins.^{2,19,30} The pins, either intact or broken, migrated into the heart, pulmonary artery, innominate artery, aorta, or spinal cord.³⁰ Tremendous leverage force is applied to pins that cross the sternoclavicular joint, and fatigue breakage of the pins is common.

Some of the more profound complications resulting from the migration of wires and pins from the sternoclavicular joint include the following: Kirschner wires that migrated into the mediastinum; broken pins that had to be removed from windows in the sternum; a pin that penetrated the back of the sternum and entered the right pulmonary artery; a pin that migrated to the opposite breast; pins that migrated into the heart, the aorta, or the pulmonary artery; and a pin that lacerated the subclavian artery.^{2,14-16} In addition, the senior author has treated patients in whom the pin migrated into the chest and up into the base of the neck.

In 1990, Lyons and Rockwood³⁰ reported on the complications of pin use in shoulder surgery. In 45 instances, pins that were used in the fixation of the acromioclavicular joint, the sternoclavicular joint, or a fracture of the proximal humerus or in arthrodesis of the shoulder had migrated to various sites in the body—the heart, lungs, spinal cord, trachea, spleen, mammary gland, and even into the orbit. Eight deaths occurred, all of them associated with migration of pins from the sternoclavicular

joint. On the basis of a review of the literature, we consider the risk of serious complications after pin fixation of the sternoclavicular joint to be so grave as to contraindicate this practice.

Summary

Although acute and chronic traumatic injuries of the sternoclavicular joint are relatively uncommon, the potential for serious complications, including respiratory distress, venous congestion, arterial insufficiency, brachial plexus compression, and myocardial conduction abnormalities, necessitates diagnostic vigilance and judicious management. Most physal injuries will heal with time without surgical intervention, but posterior dislocation of the sternoclavicular joint requires prompt closed or open reduction. Many procedures have been recommended for repair or reconstruction of the sternoclavicular joint. We recommend surgical resection of the medial clavicle, with maintenance, repair, or reconstruction of the costoclavicular ligaments, when surgery is indicated. It is of paramount importance that metallic-pin fixation of the joint be avoided, as Steinmann pins, Kirschner wires, threaded pins with bent ends, and Hagie pins have all been reported to migrate and cause serious complications, including death.

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