Scapulothoracic dissociation: Evaluation and Management

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Abstract

Scapulothoracic dissociation is a rare, potentially limb- and life-threatening injury of the shoulder girdle. The injury is characterized by lateral displacement of the scapula resulting from traumatic disruption of the scapulothoracic articulation. The typical physical examination findings consist of substantial swelling of the shoulder girdle, along with weakness, numbness, and pulselessness in the ipsilateral upper extremity. Radiographic evaluation includes measurement of the scapular index on a nonrotated chest radiograph and assessment for either a distracted clavicle fracture or a disrupted acromioclavicular or sternoclavicular joint. Although vascular injury occurs in most patients, emergent surgery is performed only in patients with either limb-threatening ischemia or active arterial hemorrhage. Management of neurologic injury can be delayed if necessary. The location and severity of neurologic injury determine whether observation, nerve grafting, nerve transfer, or above-elbow amputation is performed. Skeletal stabilization procedures include plate fixation of clavicle fractures and reduction of distracted acromioclavicular or sternoclavicular joints. The extent of neurologic injury determines clinical outcomes. Medical Outcomes Study 36-Item Short Form scores are significantly lower in patients with complete brachial plexus avulsion injury than in patients with postganglionic injury.

Scapulothoracic dissociation is a devastating injury of the shoulder girdle. The condition involves a spectrum of osseous, muscular, vascular, and neurologic injuries resulting from traumatic disruption of the relationship of the scapula and upper extremity with the thorax. Scapulothoracic dissociation was originally described by Oreck et al as consisting of a laterally displaced scapula with separation of the ipsilateral acromioclavicular (AC) joint, disruption of the brachial plexus and subclavian vessels, and intact overlying skin. In subsequent case reports, two other variations of the same overall injury pattern were identified, consisting of either distracted clavicle fracture or sternoclavicular (SC) joint disruption. The clavicular fracture variant was found to be the most common injury type, followed by disruption of the AC joint and the SC joint.

More recently, the diagnostic definition of scapulothoracic dissociation has been expanded to include less severe injuries, including incomplete vascular and neurologic injuries. Therefore, the physician must be vigilant and maintain suspicion for scapulothoracic dissociation in all patients in whom shoulder girdle injury is caused by a high-energy mechanism of injury. The presence of intact overlying skin can divert the physician’s attention...
toward other, more obvious injuries, with dire consequences for some patients. Recognition, diagnosis, and management of scapulothoracic dissociation has improved over the past 30 years.

**Anatomy**

The scapula overlies the posterolateral thorax. The scapula is important for both positioning the glenohumeral articulation in space and providing the origin for muscles that are integral to shoulder motion. The scapulothoracic articulation has none of the typical characteristics of a synovial, cartilaginous, or fibrous joint. Instead, the close relationship between the scapula and the thorax is mediated by bursae (eg, infraserratus, supraserratus). Additionally, the scapula has no direct osseous attachment to the axial skeleton. Instead, the clavicle and the AC and SC joints provide an indirect link for axial skeletal stabilization. For lateralization of the scapula and disruption of the normal scapulothoracic relationship to occur, distraction forces applied to the upper extremity must result in disruption of at least one of the anterior shoulder structures.

The vascular anatomy of the upper extremity has redundant collateral arterial flow. The subclavian artery originates from the aortic arch for the left upper extremity and the brachiocephalic artery for the right upper extremity. The subclavian artery travels from its origin in the thorax to the lateral border of the first rib before becoming the axillary artery. The subclavian artery has five main branches, including the thyrocervical trunk. The axillary artery is closely associated with the brachial plexus and is the landmark by which the brachial plexus cords are identified. The axillary artery has six main branches, including the subscapular and dorsal scapular arteries. The axillary artery is called the brachial artery after passing the inferior margin of the teres major muscle.

Sensation and muscular innervation of the upper extremity are provided by the C5-T1 nerve roots, mostly via the terminal branches of the brachial plexus. Each nerve root has an efferent and an afferent component. Injury to the nerve roots is characterized based on whether the injury occurs proximal or distal to the dorsal root ganglion. Preganglionic nerve injuries have limited healing potential, whereas postganglionic nerve disruptions have a greater regenerative capability (Figure 1). Determining the nerve injury location is important for making treatment decisions and in the overall prognosis for neurologic recovery.

**Mechanism of Injury**

Scapulothoracic dissociation occurs as a result of a high-energy distraction force. Most patients who sustain scapulothoracic dissociation are involved in high-speed collisions. The authors of a retrospective review of all such injuries reported in the literature found that 44% and 35% of injuries occur as a result of a motor-cycle or motor vehicle accident, respectively.

Other reported mechanisms of injury include a fall from a height and industrial machine accidents. Numerous theories have been proposed regarding the likely mode of injury. The distraction force necessary to cause scapulothoracic dissociation occurs via either a distracting direct blunt force or a sudden deceleration while the injured extremity remains gripped to a handlebar or steering wheel. As the distraction force increases, so does the severity of injury. It is believed that the musculoskeletal and vascular structures are injured first. The anterior shoulder yields via a clavicle fracture or separation of the AC or
SC joint, with partial or complete rupture of the trapezius, deltoid, pectoralis minor, latissimus dorsi, rhomboid, and levator scapulae muscles. Traction injury to the brachial plexus is thought to be the final injury incurred. Some injuries do not follow this stepwise progression; thus, the physician must conduct a thorough physical examination of each patient and order additional diagnostic testing as necessary to determine the extent of injury and necessity for surgical intervention.

**Evaluation and Diagnosis**

**Physical Examination**

The initial evaluation of all patients with suspected scapulothoracic dissociation begins with basic Advanced Trauma Life Support protocols. A shoulder girdle injury may be apparent only on careful scrutiny of the chest radiograph or secondary assessment of the upper extremity. Because of the likelihood of ipsilateral upper extremity fractures or other distracting injuries, the physician must maintain a high index of suspicion for scapulothoracic dissociation in every patient.

Patients with scapulothoracic dissociation commonly exhibit noticeable asymmetric swelling of the injured shoulder compared with the contralateral side as a result of hematoma formation and edema. Intact skin is the distinguishing feature between scapulothoracic dissociation and a traumatic forequarter amputation. After visual inspection is complete, a focused musculoskeletal examination is performed that should include palpation of the chest and shoulder. On this physical examination, the physician typically can identify any accompanying shoulder girdle injuries, such as a disrupted AC joint or a clavicle fracture. The injured upper extremity should also be evaluated for other fractures. Early case reports described ipsilateral extremity fractures, which were often open, in all patients with scapulothoracic dissociation. An analysis of multiple case series indicated that ipsilateral fractures of the humerus, radius, ulna, or hand occur in 41% of patients with scapulothoracic dissociation.

Vascular examination may reveal pulselessness as well as pallor and appreciable coolness compared with the contralateral upper extremity. Pulses are assessed at the wrist and in the antecubital fossa and arm. A pulseless upper extremity was noted on presentation in 71 of 72 cases of scapulothoracic dissociation reported between 1984 and 1996. In that study, the main determinant of limb-threatening ischemia was the presence of any of these injuries. In one series, all 11 patients with scapulothoracic dissociation had an absent radial pulse, but only 1 patient had limb-threatening ischemia. In that study, the main determinant of limb-threatening ischemia was a cold extremity with a “mottled blue color.” Limb-threatening ischemia has been reported to occur in approximately 10% of patients with scapulothoracic dissociation.

Differentiating ischemic from non-ischemic limbs should be done in consultation with a vascular surgeon after obtaining additional information to confirm collateral blood flow, such as via upper extremity angiography or CT angiography.

In patients who are not obtunded, a thorough neurologic examination should be performed to accurately document distal motor strength and sensation to determine the presence, extent, and location of nerve injury (eg, preganglionic lesion, postganglionic lesion). The physician should note examination findings consistent with Horner syndrome, including miosis, ptosis, anhidrosis, and enophthalmus, because injury to the sympathetic trunk can be indicative of a preganglionic nerve lesion.

**Radiographic Evaluation**

A nonrotated chest radiograph is the initial modality used to diagnose scapulothoracic dissociation. Numerous signs of scapulothoracic dissociation can be identified radiographically. Increased soft-tissue density may be seen in the vicinity of the scapula, which can indicate a hematoma resulting from muscular and vascular injury. Substantial distraction of a clavicle fracture or an AC or SC joint disruption are among the best initial indications that a scapulothoracic dissociation may have occurred, and the presence of any of these injuries warrants further investigation. The degree of scapular lateralization should be assessed via calculation of the scapular index (Figure 2).

Oreick et al introduced the idea of measuring and comparing the lateral displacement of both scapulae...
The authors recommended measuring the distance between a midline thoracic spinous process and the medial border of the scapula of both the injured and uninjured upper extremities at the same level. Kelbel et al\textsuperscript{10} further developed this radiographic assessment by calculating a ratio of the distances on the injured and uninjured sides and comparing the results from patients with and without scapulothoracic dissociation. The mean scapular index was 1.07 in 50 uninjured patients, compared with 1.5 in the 1 patient with scapulothoracic dissociation. A subsequent case series of 25 patients reported a mean scapular index of 1.29.\textsuperscript{12} No strict cut-off for a positive scapular index exists; however, any value >1.29 is consistent with scapulothoracic dissociation until proven otherwise. Alternatively, the distance from the midline to the medial scapular border on the injured and uninjured sides can be measured radiographically and compared. A difference >1 cm is considered consistent with scapulothoracic dissociation.\textsuperscript{8,13} The drawback with both of these methods is that they rely on an uninjured side for comparison as well as perfect radiographic technique. Bilateral scapulothoracic dissociation has been reported,\textsuperscript{13} and asymmetric positioning of either upper extremity, resulting in scapular protraction or retraction, could result in false-positive or false-negative results. Therefore, although radiographic measurements should be used to confirm clinical suspicion of scapulothoracic dissociation, an equivocal radiographic result cannot rule out dissociation. No technique for measuring scapulothoracic dissociation using CT has been described.

Orthogonal radiographs of any suspected ipsilateral upper extremity fractures should be obtained. The physician also should obtain dedicated radiographs of the clavicle fracture or AC or SC joint separation to better characterize injury severity and aid in preoperative planning.

**Angiography**

Conventional angiography is the standard modality for assessing vascular injury. This procedure is typically performed by a vascular or general trauma surgeon using a common femoral arteriotomy, contrast dye, and fluoroscopy. Other modalities, such as CT angiography and MR angiography, are gaining in popularity. Recently, CT angiography was found to provide equivalent diagnostic information and facilitate a faster time to surgery for definitive treatment compared with conventional angiography.\textsuperscript{14} In our experience, CT angiography is helpful preoperatively to identify vascular injury; the injury is confirmed using conventional angiography before performing an arterial repair. The method of addressing arterial injury in a patient with scapulothoracic dissociation is dictated by the available personnel, equipment, and institutional preferences.

**Additional Imaging Studies**

MRI and CT myelography can be used to evaluate the extent of neurologic injury if surgical dissection of the brachial plexus is not performed at the time of an open vascular repair. Currently, CT myelography is the preferred method for identifying a pseudomeningocele and diagnosing a preganglionic nerve injury.\textsuperscript{13} CT myelography should be done no sooner than 3 weeks after injury to allow time for a potentially dye-displacing hematoma to resorb and the pseudomeningocele to form.\textsuperscript{6,10} MRI can be used to diagnose a pseudomeningocele. Spinal cord edema, which is typically seen with root-level injuries, can be identified on MRI. In addition, MRI can accurately identify the location of a peripheral nerve lesion, and it can confirm a postganglionic brachial plexus injury. MRI is most effective in confirming suspected postganglionic nerve injury.\textsuperscript{16}

**Electrodiagnostic Testing**

Electrodiagnostic testing includes electromyography and nerve conduction velocity studies. In patients in whom surgical exploration of the brachial plexus was not performed and advanced imaging was not obtained, electrodiagnostic testing can help identify the location of injury and the severity of nerve damage, as well as monitor the patient for progression of postinjury recovery. Additionally, electrodiagnostic testing can evaluate the function of donor nerves in patients in whom a nerve transfer procedure is being considered. Typically, electrodiagnostic testing is first performed 3 to 4 weeks postinjury to allow for wallerian degeneration and thereby provide an accurate assessment of the extent of injury. Testing of the paraspinal muscles can be especially helpful for distinguishing between preganglionic and postganglionic injuries. Electrodiagnostic testing can be repeated every 6 weeks after the initial assessment to monitor the status and progression of neurologic recovery.\textsuperscript{17}

**Classification**

Numerous classification systems have been proposed to help guide treatment and predict clinical outcome in patients with scapulothoracic dissociation. The Zelle et al\textsuperscript{12} modification of the Dam-schen et al\textsuperscript{7} classification is most often cited. Although this classification is mostly used in the research setting, it has some utility as a
predictive tool. The classification divides scapulothoracic dissociation injuries into four types (Table 1). Types 1 through 3 vary in severity and patterns of osseous, vascular, and incomplete brachial plexus injury. Type 4, which involves complete brachial plexus avulsion injury, is the most severe. Patients with a type 4 injury historically have had poor clinical outcomes.

**Management**

**Initial Management**

Currently, there is no universally agreed upon treatment algorithm for scapulothoracic dissociation because of the rarity and variation of the injury pattern and the presence of concomitant systemic injuries. As noted earlier in this article, neurologic injury typically can be managed in a delayed manner, if at all. The urgency of surgical intervention is determined by vascular injury and the need to prevent ischemic complications. Little evidence exists to guide the timing of musculoskeletal reconstruction, but we feel that a progressive neurologic deficit or the need for stabilization after a vascular repair is an indication for urgent orthopaedic intervention. Otherwise, we prefer to proceed with osseous fixation as soon as the patient’s condition and hospital resources safely allow.

**Vascular Repair**

Initially, lateral thoracotomy or median sternotomy was performed to control subclavian bleeding in patients with scapulothoracic dissociation who were hemodynamically unstable. However, on surgical exploration of a patient with scapulothoracic dissociation and hemodynamic instability, the treating physicians found subclavian artery and vein thrombosis and blood loss resulting from a “torrential hemorrhage issuing from myriad perforating arteries and veins of the chest wall.” An analysis of published case series detailing findings in 61 patients reported that subclavian or axillary artery hemorrhage is exceedingly rare, with 100% of angiography results demonstrating arterial occlusion with collateral flow but no active hemorrhage. Therefore, active arterial hemorrhage requiring urgent thoracotomy or sternotomy for access and control is the exception, not the rule.

Angiography of the injured extremity is recommended for all hemodynamically stable patients to determine the presence and location of a vascular lesion. If a vascular injury is identified, then either an autogenous vein or synthetic graft is used to repair it. Recently, interest in endovascular repair has increased. However, the necessity of vascular repair has been questioned. Sampson et al reviewed the results of 11 patients with scapulothoracic dissociation and vascular injury. Angiography revealed that all patients had arterial occlusion with no evidence of contrast extravasation. Six patients subsequently underwent arterial repair with an interpositional saphenous vein graft, and the other five patients did not undergo repair. The five patients who did not undergo arterial repair had no long-term ischemic complications and did not experience delayed hemorrhage. The authors of that study concluded that scapulothoracic dissociation injuries without active arterial hemorrhage or limb-threatening ischemia could be managed with close observation alone.

We recommend the use of advanced vascular testing, such as CT angiography or conventional angiography, to confirm the presence of arterial injury and to determine the location, ensure the presence of collateral flow, and rule out active arterial hemorrhage. The orthopaedic, vascular, and general surgeons should confer and decide together whether to repair a subclavian, axillary, or brachial arterial occlusion without contrast extravasation based on confidence of adequate collateral flow and concomitant injuries. For patients who undergo vascular repair to manage limb-threatening ischemia, upper extremity fasciotomies should be performed and consideration should be given to performing skeletal stabilization in the form of clavicle fracture open reduction and internal fixation or stabilization of an AC or SC joint separation. Skeletal stabilization will protect the vascular repair and allow for a more accurate determination of vascular graft length. If the clavicle fracture or the AC or SC joint disruption cannot be managed at the time of vascular repair because of the patient’s overall condition or the need to address other more life-threatening injuries, then the upper extremity is immobilized in a sling until skeletal stabilization occurs. If a vascular repair is performed, some surgeons advocate exploring the brachial plexus at that time to determine the location and severity of neurologic injury.
However, as discussed earlier, non-surgical modalities, such as CT myelography, MRI, or electromyography testing, may be used to characterize the extent of brachial plexus injury.

Subclavian, axillary, or brachial vein injuries are most commonly occluded and therefore are not repaired. Ligation of the occluded vein typically is performed during an open arterial repair.

**Osseous Stabilization**

No study has compared the results of surgical fixation of clavicle fracture, AC or SC joint disruption, or ipsilateral extremity fractures in patients with scapulothoracic dissociation with the results of surgical management of patients with isolated injuries. Therefore, it is unknown whether patients with scapulothoracic dissociation have a higher rate of nonunion or failed repair and thereby require treatment with an alternative surgical stabilization technique. In 2008, Merk et al summarized several AC joint stabilization constructs used in treating patients with scapulothoracic dissociation and described their preferred fixation technique. They reported a successful outcome in one patient who underwent fixation using a locking plate that spanned the AC joint and placement of a single coracoclavicular screw and a transarticular AC joint screw. The authors’ justification for redundant points of fixation was the severe soft-tissue destabilizing nature of the injury.

All clavicle fractures and AC or SC joint injuries should be reduced and stabilized regardless of the extent of neurologic injury or the need for vascular repair. The extensive disruption of the surrounding soft tissue necessitates repair of at least one point of fixation of the extremity to the axial skeleton. Osseous stabilization may improve a patient’s clinical outcome or at least provide a stable shoulder for better prosthesis support. In addition, osseous stabilization may restore appropriate length and prevent further traction to the surrounding soft tissues, including neurovascular structures. Our preferred surgical technique includes orthogonal plating of midshaft clavicle fractures and hook plating with a coracoclavicular screw for AC joint disruptions with a separate anterior spanning plate across the AC joint for added stabilization (Figures 3 and 4). SC joint disruptions are reconstructed with allograft or autograft tendon fixation via osseous tunnels in the medial clavicle and sternum (Figure 5). Plate fixation of fractures of the ipsilateral humerus, ulna, or radius also should be performed to maximize future options for functional salvage procedures. Further research in this area is needed to provide more evidence-based guidelines for surgical management of the musculoskeletal component of a scapulothoracic dissociation injury.

**Neurologic Management**

Differentiating a partial from a complete and a postganglionic from a preganglionic brachial plexus injury is of utmost importance because the injury type determines the expected chance of spontaneous neurologic recovery and responsiveness to surgical intervention. Patients with a subclavian artery injury are significantly more likely to have a complete preganglionic nerve injury compared with patients with axillary or brachial artery injuries. Management options for nerve injury include observation, neurolysis, nerve repair, nerve grafting, nerve transfer, neurotization, tendon or muscle transfers, and amputation.

Historically, complete preganglionic injury was managed with immediate above-elbow amputation with or without shoulder arthrodesis. Recently, interest has increased in nerve transfer with adjacent uninjured donor nerves or neurotization in patients in whom the innervating nerve has been avulsed from the muscle. In order of functional importance, the main goals of nerve reconstruction are to restore elbow function, shoulder stability, hand grasp, and sensation. However, the results of delayed surgical procedures to address neurologic injury historically have been poor. Masmejean et al performed delayed nerve transfer in five patients with scapulothoracic dissociation and brachial plexus injury. Elbow flexion was achieved in only two patients. The mean time to nerve transfer was 11 months in the three patients in whom the procedure failed. Typically, surgical intervention no later than 6 months after injury is advocated if no neurologic recovery is evident. Shorter time to surgery may have resulted in improved functional outcomes in the patients treated by Masmejean et al.

Dodakundi et al reported positive outcomes after performing double free muscle transfers. A double free muscle transfer is a staged transfer of two free muscles (eg, bilateral gracilis muscles) that includes the innervating motor nerve that can be neurorotized with the spinal accessory and intercostal nerves to potentially provide prehension as well as shoulder and elbow stability. Clinical success has been reported after double free muscle transfers, using collateral arteries as recipient vessels, in patients with subclavian or axillary artery injury. The use of collateral arteries as recipient vessels opens the possibility of extending this procedure to patients with scapulothoracic dissociation who did not undergo an arterial repair. Additional studies...
are needed on double free muscle transfer in patients with scapulothoracic dissociation. A complete description and review of the current state-of-the-art neurologic repair techniques is beyond the scope of this article. We recommend consulting a peripheral nerve surgeon to assist in treatment.
to maximize functional recovery of the injured upper extremity.

**Outcomes**

The mortality rate after scapulothoracic dissociation is approximately 10%.\(^7,25\) However, an unknown number of patients who sustain scapulothoracic dissociation likely die from the severity of their injuries without even undergoing evaluation and diagnosis. Of the patients who survive to hospital evaluation and diagnosis, 52% will have a flail extremity and another 21% will undergo an early above-elbow amputation because of the poor potential for neurologic recovery.\(^7\) The clinical outcome of patients with scapulothoracic dissociation is determined largely by the severity of neurologic injury.

Few studies have quantitatively evaluated postinjury outcomes of patients who sustain scapulothoracic injury and the factors that are most important for predicting a clinically acceptable result. Zelle et al\(^12\) obtained Medical Outcomes Study 36-Item Short Form and the Subjective Shoulder Rating System scores at a mean follow-up of 12.6 years after patients experienced scapulothoracic dissociation. No significant difference in outcome scores existed based on patients’ injury severity scores, the presence of a vascular injury, an increased scapular index, or Damshen classification type. The presence of a complete brachial plexus avulsion injury did have a notable clinical impact, with such patients either undergoing above-elbow amputation during their initial hospitalization or having poor shoulder function at the time of mean follow-up. Patients with a complete brachial plexus avulsion had significantly lower Subjective Shoulder Rating System scores and Medical Outcomes Study 36-Item Short Form physical and mental component summary scores (\(P < 0.05\)). Based on their findings, Zelle et al\(^12\) modified the Damshen classification system to include scapulothoracic dissociation injuries with complete brachial plexus avulsion as a separate and the most severe injury type (Table 1).

No study has evaluated whether a flail extremity, an above-elbow amputation, or nerve reconstruction results in increased patient satisfaction. More studies are needed to definitively answer which method of treating patients with scapulothoracic dissociation and a complete brachial plexus avulsion provides the most acceptable clinical outcome.

**Summary**

In treating patients with scapulothoracic dissociation, it is important for the surgeon to recognize and diagnose the injury based on physical examination and radiographic findings, facilitate any urgently needed acute interventions to preserve the life and limb of the patient, and coordinate the timing of and perform skeletal stabilization or amputation when medically feasible and indicated. Additional studies are needed to establish evidence-based guidelines for managing scapulothoracic dissociation to maximize clinical outcomes.

**References**

References printed in bold type are those published within the past 5 years.


