

Sternoclavicular Joint Instability and Reconstruction

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ABSTRACT

Chronic instability or degenerative arthritis of the sternoclavicular (SC) joint may occur after traumatic or spontaneous dislocation of the SC joint. Most commonly, chronic instability of the SC joint occurs anteriorly; however, posterior instability has an increased risk of serious complications because of proximity to mediastinal structures. Although chronic anterior instability of the SC joint does not resolve with nonsurgical treatment, patients often have mild symptoms that do not impair activities of daily living; however, chronic anterior SC joint instability may be functionally limiting in more active individuals. In these cases, surgical treatment with either (1) SC joint reconstruction or (2) medial clavicle resection, or both, can be done. Recurrent posterior instability of the SC joint also requires surgical treatment due to risk of injury to mediastinal structures. Recent literature describes various reconstruction techniques which generally show improved patient-reported outcomes and low complication rates.

Dislocations of the sternoclavicular (SC) joint are relatively rare; however, these dislocations can be accompanied by catastrophic complications due to the proximity of the SC joint to mediastinal structures, particularly when the clavicle dislocates posteriorly. Although anterior SC joint dislocations do not carry the same risk of catastrophic complication, they may result in persistent SC joint instability, which can be functionally limiting in active patients. Most commonly, SC joint dislocations occur because of trauma; however, there are some patients who present with spontaneous atraumatic subluxation or dislocation. Although standard teaching regarding anterior dislocations of the SC joint often advocated nonsurgical management even in the face of recurrent/persistent instability,¹ more recent data have shown that surgical reconstruction of the SC joint is a viable treatment option, with low complication rates and good patient outcomes.^{2,3}

Epidemiology/Incidence

Dislocations of the SC joint are relatively rare injuries, accounting for 3% of all injuries of the shoulder girdle and less than 1% of all joint dislocations.^{4,5} These epidemiological figures are based on data that are more than 50 years

old; however, although there are no recent epidemiological studies reporting the incidence of SC joint dislocations, more recent case series have been able to accrue larger patient groups in shorter periods of time compared with these previous studies.^{3,6,7} This may be due to better detection of SC joint dislocations and chronic instability, may be due to an increased use of CT scan surveys for trauma patients, or could be due to increased survivorship or incidence of patients involved in high-energy motor vehicle accidents or contact sports, although there are no existing data in the literature to support these potential causes. For acute SC joint dislocations, anterior dislocations occur with greater frequency than posterior dislocations, with posterior dislocations reported as comprising 5% to 27% of SC joint dislocations.^{4,8,9}

The rate of chronic instability after an initial SC joint dislocation has not been well studied, but chronic instability has been suggested to increase the risk of degenerative arthritis of the SC joint,^{10,11} as having a history of manual labor or being a postmenopausal woman.¹² Arthritic change of the SC joint is very common with increasing age, with 53% of the specimen over the age of 60 years demonstrating moderate-to-severe arthritic change in one cadaveric study¹³; however, despite this high incidence, SC joint arthritis is rarely symptomatic.¹²

Anatomy and Biomechanics

The SC joint is a diarthrodial joint between the sternum at the manubrium and the medial clavicle, serving as the connection for the clavicle to the axial skeleton. The articulation of the SC joint is unique in that only the inferior 2/3 of the medial clavicle is covered with articular cartilage.¹⁴ Another unique feature of the SC joint is that the medial clavicle is the last ossification center to fuse in the human body, typically between the ages of 23 to 25 years and potentially as old as 31 years.¹¹ This late closure of the medial clavicular epiphysis must be considered in young adults who can sustain physeal injuries that may mimic an SC joint dislocation.

Owing to its articular incongruity and lack of osseous constraint, the SC joint has free passive motion in all planes in addition to being able to rotate about the long axis of the clavicle.¹⁵ The SC joint has its greatest range of motion in the anterior-to-posterior plane where it can either protract or retract about 35° in either direction followed by elevation where 30° to 35° of motion can occur.¹⁵ The other major motion of the SC joint is anterior or posterior rotation about the lateral axis of the

clavicle.¹⁶ When the arm is raised overhead in forward elevation or abduction, elevation, retraction, and posterior rotation of the medial clavicle occur at the SC joint.¹⁶

The SC joint has minimal inherent osseous stability because the joint surfaces have little congruence with a convex shape to the manubrial articular surface and a saddle shape to the medial clavicle, with the articular surface being convex in the coronal plane and concave in the axial plane.¹¹ Despite little osseous stability, the SC joint remains one of the most stable joints in the body because of a strong ligamentous complex and the presence of a fibrocartilage intra-articular disk. The ligamentous complex of the SC joint includes the anterior and posterior capsular ligaments, the interclavicular ligament, the costoclavicular ligament, and the intra-articular disk ligament, although the intra-articular disk ligament contributes to little stability and is believed to primarily add in preserving the articular cartilage surfaces of the medial clavicle and manubrium in the face of their incongruity and to add in diminishing force transmitted to these surfaces.^{17,18}

The anterior and posterior capsular ligaments are thickenings of the capsule, with the posterior capsular ligament being thicker and playing a greater role in stability compared with the anterior capsular ligament.¹⁹ Although the posterior capsular ligament restrains both anterior and posterior displacement of the medial clavicle in addition to superior displacement of the clavicle, the anterior capsular ligament serves only as a secondary restraint to anterior translation. Previous studies^{19,20} have suggested that the posterior capsular ligament is the most important ligament for the stability of the SC joint; however, there have been more recent studies^{14,21} suggesting that the costoclavicular ligament is the most important ligament for stability. The costoclavicular ligament is a short, stout ligament that originates on the first rib and attaches to the costoclavicular tubercle on the superior aspect of the medial clavicle.¹⁴ The importance of the costoclavicular ligament is highlighted by the finding of Rockwood that the success of an SC resection is dependent on the preservation of the costoclavicular ligament.²² For this reason, it is important to understand its ligamentous attachment site on the clavicle well, particularly that it inserts between 10 and 12.3 mm lateral to the SC joint line.^{14,23,24} The subclavius muscle has also been shown to play a role in joint stability as well²⁵; thus, care should be taken to preserve this muscle during surgical treatment of the SC joint.

When performing SC joint reconstruction, the knowledge of anatomic safe zones for dissection posterior to the SC joint is necessary. Reconstruction

techniques using bony tunnels require dissection posterior to the manubrium and medial clavicle to allow for retractor placement for safe drilling. When dissecting posterior to the manubrium, an avascular safe zone exists between the SC joint and the sternothyroid muscle belly.¹⁴ If referencing from the posterosuperior-most aspect of manubrial articular cartilage, the safe zone extends 9.5 mm inferiorly and 19.8 mm laterally along the border of the first rib while the medial extent of the safe zone crosses midline.¹⁴ An additional surgically relevant landmark is the clavicular ridge on the medial face of the clavicle which is located anteriorly at the 9:30 clock position on a right clavicle, which can be used to guide appropriate anatomic orientation when performing a surgical reconstruction of an SC joint which is rotationally unstable.¹⁴

Mechanism of Injury and Classification

Because of the strength of the SC joint ligamentous complex, a large force is required to cause a dislocation event, although no previous biomechanical studies have been done to determine the exact magnitude of this force. Trauma is the most common cause of SC joint dislocations, with high-energy motor vehicle collisions and contact sports being the most common culprits.^{9,11,26–28} These dislocations can occur from either direct or indirect trauma. Indirect trauma occurs more often and can result in either anterior or posterior dislocations. If a posteromedially directed force is applied to the anterolateral aspect of the shoulder girdle, an anterior SC dislocation may result, whereas an anteromedially directed force applied to the posterolateral aspect of the shoulder girdle can result in an anterior SC joint dislocation. These indirect traumas can occur with a forceful fall landing on the shoulder or with lateral compression, such as when an athlete is tackled and driven down onto one's shoulder.^{1,9} Direct trauma is less common and results in posterior dislocation because an external anterior-to-posterior force drives the medial clavicle posterior to the sternum. Atraumatic SC joint dislocations have been described but are very rare in occurrence.²⁹ Trapezius palsy or generalized hyperlaxity can contribute to atraumatic SC joint dislocation.⁵

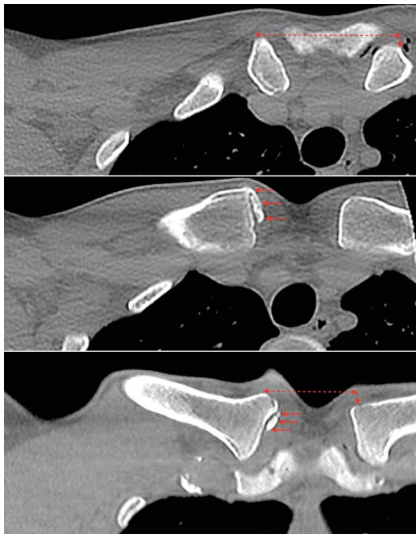
Classification of SC joint injuries has been previously described by Allman et al³⁰ with classification dependent on the extent of injury. A type 1 injury is one in which SC joint ligaments and capsule are sprained without full rupture, type 2 injury involves tearing of SC joint ligaments and/or capsule with joint subluxation, and type

3 injury denotes tearing of SC joint ligaments and capsule with frank dislocation.³⁰ The most clinically important classification of treatment considerations is whether the medial clavicle is dislocated anteriorly versus posteriorly because posterior dislocations are accompanied by substantial risk to mediastinal structures. SC joint dislocations may also be classified as acute or chronic, which is also an important consideration for clinical management.

Clinical Presentation and Initial Management

Most often, patients suffering an SC joint dislocation or injury present with pain at the SC joint, which increases with most movements of the ipsilateral shoulder girdle.¹⁵ Often patients support the injured arm with the contralateral arm and sometimes will tilt their head to the side of the injury.^{9,27} Pain at the SC joint in patients with dislocations often increases when laying supine.¹⁵ Because SC joint injuries often occur as part of high-energy polytraumatic injuries, pain may not be initially reported at the SC joint because of distracting injuries or alterations in patient mental status. Inspection of the SC joint can be particularly useful in these situations. In anterior dislocations, the medial clavicle will be displaced anteriorly and the asymmetry can be palpated on examination. Posterior dislocation can be harder to detect on examination; however, there may be less fullness of the chest overlying the affected SC joint, although increased swelling from the traumatic injury can give the illusion of an anterior dislocation in some cases of posterior dislocation.¹

Appropriate initial management and diagnosis of an SC joint dislocation with emphasis on recognizing posterior dislocations have been well described.¹ In the setting of posterior dislocation, symptoms such as venous congestion in the neck or ipsilateral arm, hoarseness, cough, dysphagia, or shortness of breath require prompt recognition if present as mediastinal compromise is present in as many as 25% to 30% of posterior dislocations.⁵ When suspected, imaging should be done expeditiously to confirm diagnosis. Although serendipity view radiographs can be used to differentiate anterior from posterior SC joint dislocation, ultimately the CT scan and MRI have greater diagnostic capability, with CT being the preferred advanced imaging modality to allow for better assessment of mediastinal structures (Figure 1).^{1,11} If advanced imaging is obtained, bilateral SC joints should be included in the scan to allow for comparison.

Figure 1

Preoperative CT scans of a 30-year-old patient presenting with posttraumatic anterior instability and significant osteoarthritis of the right sternoclavicular joint. This is demonstrated by the notable anterior displacement (red dashed arrows) of the medial aspect of the right clavicle (top) and large intraarticular bony fragment (solid red arrows) due to degenerative osteoarthritis (middle).

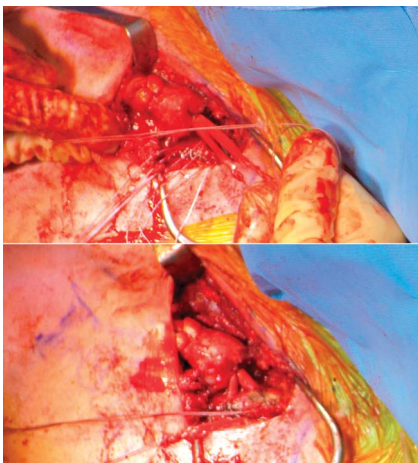
Management of a posterior dislocation of the SC joint should be addressed in the operating room with either a closed reduction under anesthesia or an open reduction with a thoracic surgeon on standby.¹ If closed reduction is successful, the SC joint is usually stable without additional intervention; however, if open reduction is required, SC joint reconstruction should be done, particularly if there is injury to the SC ligaments and capsule.^{1,5} In cases of an acute anterior dislocation, the literature supports initial treatment with closed reduction either under local anesthesia or sedation, although persistent instability after a closed reduction is common.¹ To reduce an anterior dislocation, the provider can place a small bump or rolled blanket between the scapulae of the patient while patient is lying supine and then apply a posterolaterally directed force over the anteriorly displaced medial clavicle.³¹ To reduce a posterior dislocation, the same technique of placing a bump between scapulae of a supine patient is used, but then, the provider should abduct the shoulder to 90° followed by the application of simultaneous traction and extension of the shoulder. Ultimately, if this is unsuccessful, it may be necessary to grip the medial clavicle percutaneously with a tool such as a towel clip to allow for the manipulation of the medial clavicle.³¹

For patients with chronic SC joint instability or with degenerative arthritis of the SC joint, patients often

complain of discomfort, clicking, and pain with overhead motions, reaching behind the back, and reaching across the body.⁶ Patients with these symptoms often have difficulty with sports and with activities of daily living.⁶ There are some targeted examination maneuvers, which can aid in the diagnosis of chronic instability or arthritic change of the SC joint. Palpation of the SC joint can be used to assess for asymmetric deformity, presence of osteophytic change, or pain. With anterior instability, the anterior prominence of the medial clavicle at the SC joint can be increased by abducting the shoulder above 90° or by moving the upper extremity behind the frontal plane of the body.⁶ Pain with application of a posteriorly directed force over the medial clavicle at the SC joint, also known as the push-down test, pain with cross body adduction, and pain with resisted arm abduction can produce pain in patients with SC joint arthritis or instability.¹¹ There has been little investigation into the sensitivity and specificity of examination maneuvers for SC joint pathology; however, one recent study identified pain with palpation of the SC joint and pain with active shoulder protraction as the most sensitive examination maneuvers with a sensitivity of 93% and 86%, respectively.³²

Surgical Treatment of Persistent Anterior Sternoclavicular Joint Instability or Sternoclavicular Joint Arthritis

Previously, recommendations had been made to avoid surgical intervention in patients with anterior SC instability, citing the complication rates with surgical intervention and the outcomes of nonoperative treatment^{1,9}; however, the cited study which demonstrated good long-term outcomes patients treated nonoperatively for anterior SC joint dislocation included only 10 patients and showed 7 with good results and the remaining 3 with fair or poor outcome assessed at an average of 53 months after injury.²⁶ These patients who fail to have acceptable outcomes with nonoperative treatment should be considered for surgical treatment. There have been an increasing number of case series demonstrating good outcomes with low complication rates over the past decade.^{3,6,7,33–36} Nonetheless, initial management for most SC joint injuries remains nonoperative treatment. With type I injuries, only a short period of immobilization in a sling is required, approximately 1 week or less with return to activity okay as symptoms improve. Type II injuries are often treated with immobilization with either sling or figure-of-eight brace for 4

Figure 2

Photographs showing that a shuttling suture is passed through the clavicular intramedullary canal and is used to pass the two ends of a semitendinosus allograft through the anterior clavicle hole in a luggage loop fashion (top). The allograft is passed in a similar fashion through the sternum, and once it is secured, it will reduce the clavicle medially toward the sternum and restore stable sternoclavicular joint anatomy.

to 6 weeks. Type III injuries should be treated with closed reduction as outlined previously in this text. Surgical treatment of SC joint pathology should be reserved for patients who continue to have pain with either symptomatic instability or arthrosis that has not responded to appropriate conservative treatment.³¹

There are a variety of different surgical techniques which have been described for the treatment of persistent SC joint pathology. These techniques can largely be classified as either an SC joint resection or SC joint reconstruction or a combination of both of these procedures. Open reduction and internal fixation types of procedures have been described previously but are accompanied by risk of potential severe complications with implant migration, especially with the use of pins or wires.⁵ In addition, fusion of the SC joint should not routinely be considered as a treatment option because it substantially limits functional glenohumeral motion on the ipsilateral side.⁵

In cases of persistent symptomatic SC joint instability, an SC joint reconstruction procedure should be included in the surgical treatment plan, whereas patients with posttraumatic arthritis of the SC joint without persistent instability should be considered for an SC joint resection alone without reconstruction.^{3,37,38} Persistent symptomatic SC joint instability can be diagnosed based on physical examination for either dislocation or subluxation of the SC joint or by the radiograph or CT scan for persistent dislocation.

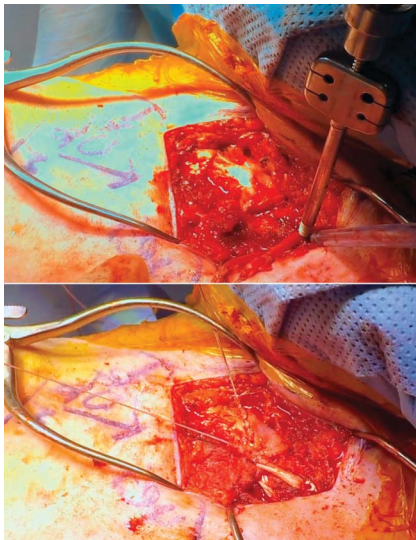
Sternoclavicular Joint Resection Arthroplasty

SC joint resection arthroplasty is a good treatment option for patients with SC joint arthritis or posttraumatic pain without instability that has failed conservative treatment. SC joint resection has been previously advocated as treatment for SC instability; however, we would caution the use of an SC joint resection alone without concomitant SC joint reconstruction if instability is present. In one case series, Eskola et al¹⁰ demonstrated poor outcomes with SC joint resection in patients with chronic anterior SC instability while demonstrating good outcomes in those patients with the same diagnosis for whom they conducted an SC joint reconstruction. Multiple studies have shown good outcomes with SC joint medial clavicle resections when conducted strictly for SC joint osteoarthritis without instability.^{39–41} These three studies all did limit medial clavicle resection to less than 10 mm to preserve the costoclavicular ligament, which is an essential surgical consideration.^{14,22,39} To achieve successful decompression of the SC joint while preserving adequate medial clavicle, it has been demonstrated biomechanically that a resection parallel to the SC joint is able to better decompress with lesser resection when compared with an oblique osteotomy.³⁷ In addition, during SC joint resection, care should be taken to preserve the SC joint capsule and perform a stout repair at closure to prevent iatrogenic instability postoperatively, given the significance of the capsular ligaments on joint stability. Care should also be taken to preserve the subclavius muscle during this procedure as well because it also contributes to SC joint stability.

Sternoclavicular Joint Reconstruction

A variety of SC joint reconstruction techniques have been described in the literature including allograft or autograft figure-of-eight reconstruction, intramedullary graft reconstruction, synthetic reconstruction using suture, and tenodesis using either the sternal head of the sternocleidomastoid or the subclavius. Overall, there is considerable variability in outcomes of the various reconstruction techniques reported in the literature, possibly because of small case series size or variance in surgical indications or techniques.⁸

The authors' preferred technique is a figure-of-eight reconstruction technique using either semitendinosus allograft³⁸ or gracilis autograft.³⁹ Within the literature, figure-of-eight techniques have been more frequently used within more recent case series of SC joint

Figure 3

Photographs showing that tension is applied to both limbs of the semitendinosus allograft, and two biocomposite interference screws are advanced into each sternal bone tunnel to secure the figure-of-eight construct (top). The excess ends of the allograft are crossed back laterally over the sternoclavicular joint and secured with suture tapes in a locking fashion (bottom).

resections.^{3,6,33–36,42} The figure-of-eight technique rose to prominence after a biomechanical analysis of different SC joint reconstruction techniques by Spencer and Kuhn⁴³ in 2004 where they showed biomechanical superiority of figure-of-eight reconstructions, with a load to failure nearly 3 times greater than the other techniques studied.

Briefly, to perform figure-of-eight reconstruction of the SC joint, dissection is carried down to the capsule and a horizontal incision is made in the joint capsule with the capsule being elevated from the medial clavicle and the sternum to allow access 2 cm medially on the sternum and 4 cm laterally from the clavicle. If there is an injury to the articular disk, then it is removed and the joint is also débrided of excess synovium and osteophytes if present. Next, drill tunnels must be made to pass the reconstruction graft (Figure 2). There are a variety of techniques described for drill holes, but generally, drill holes should be established at the superior and inferior aspects of the medial clavicle and articular portion of the manubrium. These drill holes should be spaced 1 to 1.5 cm apart to allow for adequate bone bridge and should be positioned 1 to 2 cm away from the end of the clavicle. The size of the drill hole is dictated by the size of the reconstruction graft, with 3.5 to 4.5 mm tunnels recommended for the use of a gracilis or semitendinosus graft and 2.5 mm recommended for the use of a palmaris

graft. Drill tunnels may be drilled anterior to posterior; however, great care must be taken to avoid over-penetration of the drill posteriorly by the use of an appropriate retractor or finger palpation. Alternatively, some recommend drilling unicortical tunnels from anterior to posterior which angle toward the joint and are then subsequently connected by drilling from the medial surface of the clavicle or the lateral surface of the sternum to complete the tunnel. After drill holes are complete, the tendon graft is passed through the tunnels in a figure-of-eight configuration with graft limbs running along both the anterior and posterior aspects of the SC joint. The graft can then be knotted on itself and secured in place with suture (Figure 3). In one series, a single anchor is inserted into the lateral articular surface of the sternum (angled 20° to 50° anterior to posterior), with one end of the graft secured to the sternum by the anchor before being looped through clavicular tunnels and then the other end of the tunnel is also secured to the anchor.³⁶

Of the case series in which the figure-of-eight technique was used, the gracilis autograft was most commonly used (49/72), followed by the semitendinosus autograft (11/72) and palmaris autograft (6/72), with the remaining (6/72) being the allograft tendon.^{3,6,33,34,36} The revision surgery rate for recurrent or persistent instability or pain after figure-of-eight technique SC joint reconstruction was 8.3% (6/72) in this series. All case series showed the overall good outcomes postoperatively with high rates of return to activity.

Postoperatively, it has been recommended that patients wear a sling for 6 weeks and perform gentle pendulums with no scapular protraction or retraction for 6 weeks. There should be no weight-bearing of the surgical extremity during these initial 6 weeks as well. Active-assist range of motion can be initiated at 6 weeks followed by active range of motion and strengthening of the shoulder and scapular stabilizers to begin at 8 weeks. Return to sport can occur when patients have no pain with sport-specific exercise, have full, painless range of motion of the surgical extremity, and have strength within 10% of the contralateral extremity.¹⁵

Summary

Although SC instability is a rare clinical entity, knowledge of this diagnosis is necessary because of the possible severe concomitant mediastinal pathology, which can accompany posterior SC joint dislocations. Although anterior SC joint instability and SC joint osteoarthritis

can typically be managed nonoperatively, occasionally, these patients have poor outcomes with conservative management. Surgical management of these problems has been shown to have low complication rates and good outcomes and should consist of SC joint resection arthroplasty for SC joint arthritis or posttraumatic pain and SC joint reconstruction for persistent anterior instability.

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