Sternoclavicular Joint Reconstruction: Contemporary Stabilization Procedures and Rehabilitative Care with Case Report

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Abstract

Background: Acute and chronic sternoclavicular (SC) dislocations are rare. Due to the rarity, consistent assessment and treatment experience among medical providers is lacking. Recognizing the type and extent of injury to the SC joint requires a high index of suspicion, a comprehensive evaluation, and proper imaging studies. Many disorders of the SC joint can be treated non-operatively. However, surgical treatment may be indicated for irreducible dislocations and symptomatic, chronic instability that fails non-operative physical therapy. The purpose of this paper is to provide a comprehensive update on the current surgical techniques supported by anatomic, biomechanical, and outcome data that a rehabilitation specialist can expect to encounter.

Case Description: This case details the physician assessment, surgical procedure, physical therapy treatment, and outcome of an active, 15 year-old male with atraumatic SC joint instability. A criterion-based rehabilitation guideline, in conjunction with the author's clinical decision making, manual therapy intervention, and an understanding of the surgical technique, served as the framework for the patient's post-operative progression. The patient returned to full-participation in sports at 7 months and he remained symptom free without functional limitations at 1 year following surgery.

Discussion: The rarity of SC joint instability may create a gap in a physical therapists ability to recognize, treat, and post-operatively manage these patients successfully. The figure-of-8 graft reconstruction technique may be recommended more frequently due to recent favorable biomechanical and outcome research. Additional biomechanical research and stratified outcome studies will be needed to better understand adaptations in the shoulder girdle that a physical therapist may expect to find when working with these patients.

Background

Sternoclavicular joint dislocations are rare injuries, representing only 2-3% of the injuries of the upper limb.[1] Although rare, such injuries deserve rapid diagnosis and effective treatment to avoid future complications. Motor vehicle collisions and sports participation are the top two causes of traumatic SC joint injury.[2,3,4] The injury can be classified on the basis of anatomy in posterior or anterior dislocation, etiology into direct trauma, indirect trauma, or atraumatic injuries, and to the degree of ligamentous injury.[2,5] In 1967, Allman classified SC joint injuries based on the degree of ligamentous disruption. Type 1 describes a simple sprain of the SC ligaments and capsule without subluxation or dislocation. Type 2 injuries involve a disruption of the SC ligaments and capsule and result in a subluxation of the medial clavicle without dislocation. Type 3 injuries entail a rupture of all supporting ligaments with complete anterior or posterior dislocation.[6]

Anatomy and Biomechanics of the SC Joint

The development of the clavicle is unique compared to other bones in the body. Although it is the first long bone to ossify in the womb during the fifth gestational week, its physis is the last to close at nearly 25 years of age. As such, many SC joint dislocations in younger patients may be the result of injury to a non-united epiphysis rather than ligamentous disruption.[7,8,9]

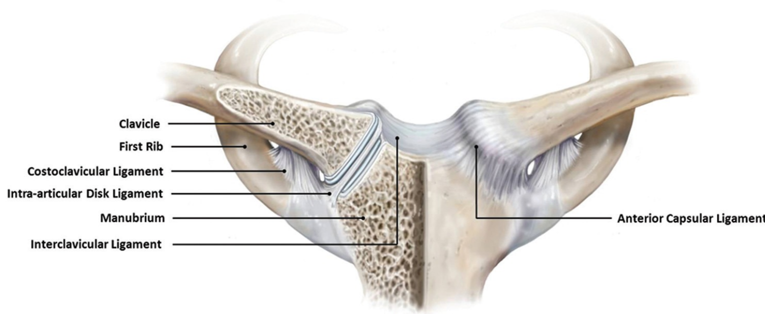

Figure 1. Osseoligamentous anatomy of the sternoclavicular joint.

The SC joint is an incongruous, diathrodial saddle joint composed of the medial clavicle, sternum, and first rib.[10] The surfaces of the SC joint are covered with fibrocartilage and are highly incongruent. Osseous stability of the SC joint is among the lowest of the major joints in the body because less than half of the medial clavicle articulates with the superior angle of the sternum.[11] As a result, this incongruity requires stability from its surrounding ligamentous supports. The SC joint articulation is held in place by the SC capsular ligaments, the costoclavicular ligament, and the interclavicular ligament (**Figure 1**). A fibrocartilaginous disc acts primarily as a restraint against medial displacement of the proximal clavicle and blends with the fibers of the capsular ligament anteriorly and posteriorly.[10]

The anatomy of the joint surfaces and ligaments dictates the functional movement at the SC joint. The arthrokinematic motion is similar whether the shoulder girdle moves actively or passively. During scapular elevation, the medial clavicle glides inferiorly on the sternum. Depression of the scapula elicits a superior glide of the medial clavicle on the sternum. The medial clavicle moves posteriorly with scapular protraction and anteriorly with scapular retraction. When the clavicle moves in one direction, the capsular ligaments on the side of the motion become lax. Ligaments on the opposite side of the joint become taut, limiting the movement.[12] The axis of motion lies lateral to the joint at the costoclavicular ligament. The location of the axis so far from the joint accentuates the intra-articular motion with elevation-depression and protraction-retraction.[13]

Elevation and depression occur between the clavicle and SC disk, whereas protraction and retraction occur between the disk and the manubrium.[14] The ligaments that stabilize the SC joint are essential for its 50° of clavicular rotation, 35° of elevation, and 35° of anterior-posterior glide. The anterosuperior and posterior aspects of the capsular ligament provide the primary support for the SC joint, with greater strength provided by the posterior component. In 1967, Bearn demonstrated that the capsular ligament is the most important structure preventing superior displacement of the medial clavicle and inferior descent of the distal clavicle.[15] More recently Spencer et al. performed a cadaveric biomechanical study to demonstrate that the posterior SC joint capsule is the most important structure for preventing both anterior and posterior translation of the SC joint, with the anterior capsule acting as an important secondary stabilizer.[16] Dennis et al. also found that it took 50% more force to dislocate the clavicle posteriorly, compared to anteriorly, in cadavers.[17]

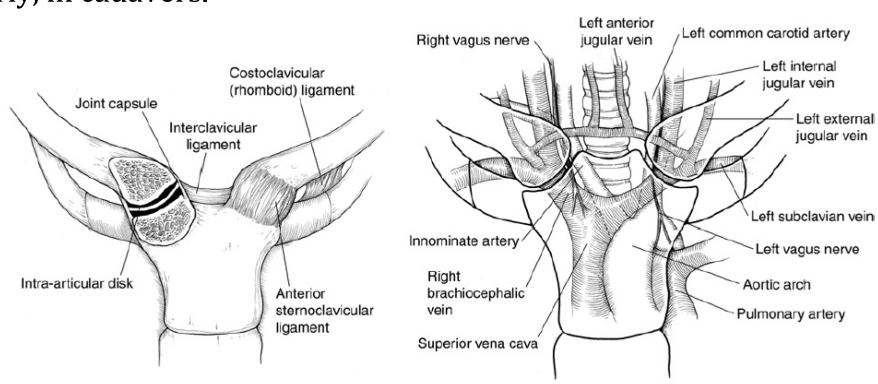

Figure 2. Sternoclavicular joint and adjacent blood vessels.

Mechanism of Injury

Anterior dislocation is three to twenty times more common than posterior dislocation.[2,18] Posterior dislocation, which is rare, may cause serious complications due to compression of prime central structures by the medial clavicle (**Figure 2**). Respiratory discomfort, lesions of the brachial plexus, and arterial insufficiency are some of the harmful consequences of this type of dislocation.[19,20,21,22] The high rate of complications and their severity emphasize the importance of an accurate diagnosis and treatment plan.

Some of the factors contributing to SC joint stability include the particular collagen makeup of the patient's ligaments, the arrangement of the SC ligaments and their method of attachment, and the variation in osseous anatomy of this saddle-type joint. This small, incongruous joint is subject to practically every motion of the upper extremity, however the ligamentous support and design make it one of the least dislocated in the body.[10]

The direction of direct force to the clavicle often determines the type of dislocation. 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. This may occur in a variety of ways: for example, when an athlete is jumped on while lying on their back, the contact is 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 between a vehicle and a wall or the ground.

An indirect force can be applied to the SC joint from either the anterolateral or posterolateral aspect of the shoulder. If the shoulder is compressed and rolled backward, the anterolateral applied force produces an anterior dislocation of the SC joint as the underlying first rib acts as a fulcrum to lever the sternal end of the clavicle anteriorly.[10] By contrast, a posterolateral compression on the shoulder moves it forward and the force directed toward the clavicle produces a posterior dislocation.[23]

Spontaneous atraumatic anterior subluxation of the SC joint is less likely to occur compared to indirect or direct trauma of the clavicle. When it does occur, it is most commonly seen in teenagers and young adults who have ligamentous laxity. The subluxation often occurs either during routine overhead activities or during overhead sports activities.[5]

Clinical Presentation

The patient with an acute dislocation of the SC joint has severe pain that is increased with any movement of the arm, particularly when the shoulders are approximated together by a lateral force. The patient often supports the injured arm across their trunk with the uninvolved arm. With the shirt removed, the shoulder may appear to be shortened and thrust forward compared to the uninvolved shoulder. Their head may be seen tilted or rotated toward the side of the dislocation to slacken the sternocleidomastoid and reduce the muscular pull across the joint. With an anterior dislocation, the patient may have difficulty lying supine and the medial end of the clavicle can be visibly prominent and palpated anterior to the sternum (**Figure 3**).

Figure 3. Patient with right anterior sternoclavicular joint dislocation.

In contrast, a patient with a traumatic posterior dislocation may have a less prominent medial clavicle, and the corner of the sternum may be easily palpated (**Figure 4**). In severe cases, venous congestion, breathing difficulties, shortness of breath, or a choking sensation may be noted. The individual may demonstrate a tendency to hold the shoulder girdle in a retracted posture to produce an anterior arthrokinematic glide of the medial clavicle on the sternum and decrease pressure from the mediastinum.

A

Figure 4. Patient with left posterior sternoclavicular dislocation.

The clinical presentation of the patient is crucial for the diagnosis, as conventional x-rays do not always allow a definitive evaluation of the position of the clavicle.[24,25] The "serendipity view" x-ray, described by Wirth and Rockwood,[26] is one of the first images taken of a suspected SC joint instability. It is an oblique view of the SC joint that allows visualization of both clavicles for comparative purposes. To obtain this view, the x-ray beam is centered on the SC joint and tilted 40° in the cephalad-oblique direction (**Figure 5**).

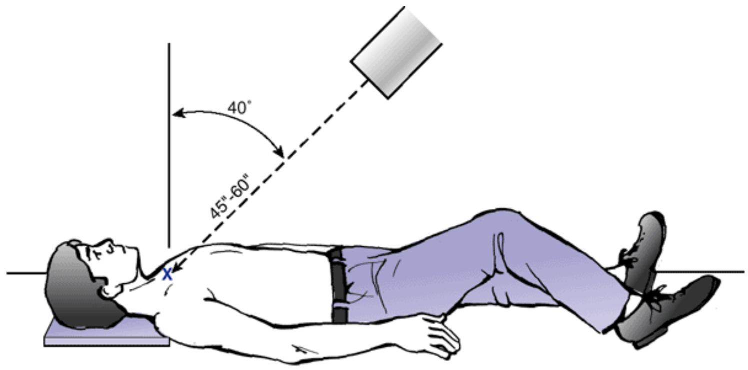

Figure 5. X-ray Serendipity View

If the clinician desires a more detailed image of the SC orientation, the x-ray is followed up with a computed tomography (CT) scan. A CT scan is reported to be the best imaging modality for evaluation of acute and chronic traumatic injuries of the SC joint.[27] CT is preferred and often indicated in the trauma patient to search for associated mediastinal injuries, to identify occult medial clavicular fractures, and to determine the degree of dislocation relative to the contralateral clavicle[28,29] Because injuries to the SC joint often involve high-energy mechanisms, injuries to this joint can easily be missed without specific imaging because of the presence of other more dramatic injuries.[30] For additional clarification during the diagnostic process, multi-planar CT scans may be obtained showing the structures of interest without superposition of surrounding tissues. By obtaining such scans, one can more precisely distinguish between medial clavicle fractures, epiphyseal lesions, and SC joint dislocations.

SC Instability Management

Instability at the SC joint can reduce the shoulder girdle's functional capacity, create compensatory impairments along the upper extremity kinetic chain, and/or pose a risk to vascular, respiratory, and neural structures. The specific course of treatment of acute and chronic anterior SC joint dislocation remains controversial. Treatment interventions reported in the literature range from rest and reassurance,[5] immobilization,[31] physical therapy,[23] closed reduction,[32] and open reduction with reconstruction.[33] The specific course of medical management of an unstable SC joint is influenced by the degree of instability, the functional limitations of the shoulder girdle, the duration of the instability, and if there are any retro-sternal structures compromised by the instability.

The mildly sprained, painful, yet stable SC joint (Allman type 1) is best treated with ice within 48 hours of injury followed by immobilization in a sling for less than a week along with anti-inflammatory pain medication. After this period of immobilization, the patient may resume activities of daily living.[28]

Moderate sprains of the SC joint (Allman type 2) typically involve subluxation without dislocation. This injury is also best treated with ice within the first 48 hours, but immobilization and stabilization with a figure-of-8 dressing and/or sling should be advocated for approximately 4-6 weeks to enhance healing of the disrupted ligaments and to protect the joint from further injury.[28] After 4-6 weeks of immobilization, it is recommended that the patient begin physical therapy to assist their return to previous activities of daily living and help to safely restore strength.

An attempt at closed reduction is typically performed for the anteriorly or posteriorly dislocated SC joint.[28,34,35] After reduction, the shoulder should be immobilized in a sling for approximately 6 weeks to promote healing of the disrupted SC ligaments. It is generally accepted that contact sports and high-risk activities should be prohibited for at least 3-4 months to avoid recurrent injury and chronic instability. In contrast to anterior dislocations, which tend to re-dislocate, posterior dislocations are usually stable after initial reduction.[31] After conducting a survey of orthopedic surgeons, Van Tongel et al. concluded that 52% of surgeons first attempted a closed reduction for a traumatically dislocated SC joint.[36] However, 80% of the same practitioners reported that the reduction was not maintained in more than half of the cases. Recurrent subluxation and/or dislocation may lead to chronic, painful instability, and finally, surgical treatment.

According to Thomas et al., indications for surgical stabilization of the sternoclavicular joint include 1) chronic symptomatic anterior instability and 2) recurrent or irreducible posterior dislocation.[33] Given the benign course of chronic anterior instability and the rarity of recurrent posterior instability, reconstruction of the sternoclavicular joint is a rare procedure.[37] Despite the rare need for SC reconstruction, evolving surgical stabilization techniques have shown improved preliminary success and functional outcomes in the literature. The satisfactory outcomes may prompt a trend in the number of surgeons recommending this surgery to patients who have chronic or acute SC joint instability. It is critical that the orthopedic physical therapist have a sound understanding of the relationship of the SC joint to the functional shoulder girdle, the most current reconstruction surgical techniques, and keys to successful post-operative rehabilitation.

SC Joint Reconstruction Procedures

Over the last 25 years, there have been a variety of stabilization procedures developed and studied. In 2011, Thut et al. published the first systematic review of SC joint reconstruction techniques, outcomes, and biomechanical strength.[38] The clinical studies are summarized in **Table 1**. Each study represents level IV clinical evidence. Inclusion criteria required at least six patients, each receiving the same reconstruction and with at least 1 year follow-up. Due to the limited number of studies in the literature, the quality of the outcome measures was inconsistent among the studies and there was no stratification for mechanism of injury.

Table 1. Overview of Clinical Studies

Author(s)	No. Shoulders	Follow-Up	Procedure	Results	Complications
Ferrandez et al.,[39] 1988	6 acute	2.5 yrs	Capsule repair with K-wire fixation	4-residual deformity, 5-normal motion, 1-moderate limitation	Two cheloid scars. One mediastinal K-wire migration.
Franck et al.,[40] 2003	10 acute	>1 yrs	Balser plate, removed at 3 months	Mean Constant score 90.2 +-6.6. One SC arthritis (100 max)	One seroma
Rockwood et al.,[41] 1997	6 chronic	5.7 yrs	Resect 1.5 cm medial clavicle, tie capsule and disc into medullary canal, repair capsule	Six excellent results on their scale	None
Bae et al.,[42] 2006	9 chronic	55 months	Figure-8 graft woven through two drill holes in manubrium and two in clavicle (8 semitendinosus, 1 SCM fascia)	Mean SST score, 11.4 (12 max)	None
Abiddin et al.,[43] 2006	2 acute, 6 chronic	4.5 years	Two suture anchors in manubrium, sutures in clavicle, repair capsule	Mean Oxford score 15.75 (12 max, 60 worst). Mean Constant Score 74.88 (100 max)	Two reoperations, one after fall from horse, one after failure at 1 year, revision failed at 3 yrs.
Armstrong and Dias,[44] 2007	7 chronic	39.7 mos	Use medial SCM as graft, leave attached to manubrium, through drill	2 stable, 4 transient subluxation, 1 instability limiting	Two transient scar sensitivity

			hole in clavicle. Repair capsule.	sports	

Two biomechanical studies investigating the strength of various SC joint reconstruction procedures have been published over the last two decades. **Table 2** summarizes the biomechanical reports. Thomas et al.[44] studied the surgical technique most similar to the kind used in the Abiddin et al.[43] case study. Spencer and Kuhn compared the strength of three different reconstruction techniques in cadavers.[45] The Spencer and Kuhn biomechanical findings have become a hallmark study that supports the figure-of-8 surgical technique to repair an unstable SC joint over the last decade.

Table 2. Overview of Biomechanical Studies

Author	Technique	Results
Thomas et al.,[45] 2000	"Safe" repair with two sutures passed through drill holes in manubrium and clavicle Suture around clavicle and first rib	50 kg anterior force caused 50% subluxation of joint 50 kg anterior force caused 75% subluxation of joint
Spencer and Kuhn,[46] 2004	Subclavian tendon through drill holes in medial clavicle Capsule and disc into medullary canal Figure-of-8 semitendinosus graft through two drill holes in clavicle and two in manubrium	Peak load 75.6 +- 19.0 N anterior, 51.5 +- 28.9 N posterior Peak load 84.6 +- 45.7 N anterior, 85.0 +- 22.8 N posterior Peak load 230.3 +- 146.1 N anterior, 241.4 +- 49.7 N posterior

The systematic review of both clinical and biomechanical data conducted by Thut et al. in 2011,[38] led them to recommend the figure-of-8 approach using a tendon graft through drill holes in the clavicle and manubrium as discussed by Spencer and Kuhn.[45] In 2013, Martetschlager et al.[47] conducted a current concepts review and also found the figure-of-8 surgical technique to be the most recommended method when reconstruction is indicated for stability of the SC joint. The figure-of-8 tendon graft reconstruction has been shown to be safe while also providing effective preliminary results.[48,49,50,51,52] Because of its biomechanical advantages and satisfactory preliminary outcomes, figure-of-8 reconstruction of the unstable SC joint is currently in favor (**Figure 6**).

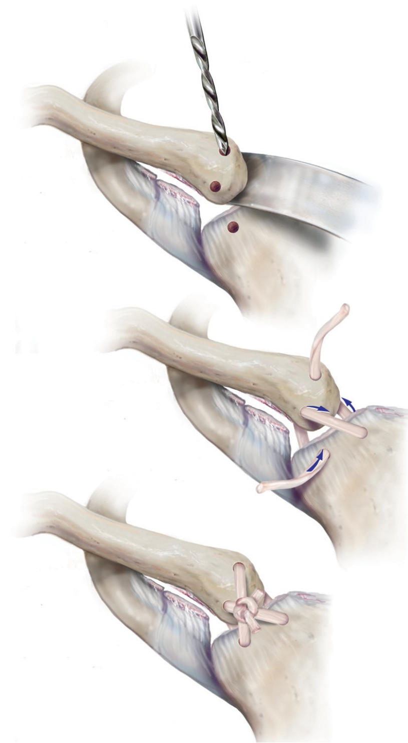

Figure 6. Illustration of figure-of-8 reconstruction technique.

In the following pages, the author describes the presentation, surgical repair, and rehabilitation of a patient treated following an SC joint reconstruction. To fully appreciate the rehabilitation timeline following surgery, the physical therapist must have sound understanding of the surgical technique to assist their clinical decision making throughout each phase of healing. The author will provide clinical commentary on the specific rehabilitation considerations of the patient in the case report. Finally, the author will discuss rehabilitation implications and identify areas for further study.

Case Report

History

A 15-year-old male competitive lacrosse player reported an 8-month history of right SC joint pain and popping with overhead shoulder motions. He did not recall a specific injury or trauma to his SC joint that triggered the symptoms. However, he was repetitively exposed to contact and trauma due to the physical nature of lacrosse. The patient stated that approximately 5 months after he first noticed symptoms, he fell on an outstretched hand during lacrosse practice and was aware of a significant increase in instability of his right shoulder. He became limited in his ability to use his right shoulder girdle. As a result, he became fearful of exacerbation from contact and falling and withdrew from sports participation. It was the patient's goal to return to sports such as lacrosse, soccer, skiing, and sailing. His SC joint pain eventually became significant and unrelenting enough that he and his parents, both physicians, decided to consult with an orthopedic surgeon to discuss his treatment options.

The patient and his family met with an orthopedic surgeon at the Steadman Clinic in Vail, Colorado. Clinical exam and imaging studies were consistent with a right shoulder chronic SC joint anterior instability. The patient had a palpable bony prominence over his right SC area with range of motion, specifically abduction and extension. There was an obvious anterior SC dislocation with combined flexion/external rotation/abduction, popping, and 2/10 pain in the SC joint on the Visual Analog Scale (VAS). Scapular winging, atrophy, or dyskinesia was not observed. The muscle strength of his external rotators, internal rotators, supraspinatus, and deltoid was 5/5 and comparable to his uninvolved side. The patient had negative provocative tests for rotator cuff, labrum, biceps instability, and acromioclavicular pathology.

During the initial consultation with the orthopedic surgeon, both conservative management and operative interventions were discussed with the patient and family. Conservative management, which the patient had not performed, would have consisted of a trial of physical therapy and avoiding all activities that cause the SC joint to dislocate. The surgeon informed the patient that a significant risk of waiting for the surgery could be the development of SC joint arthrosis that may complicate a future reconstruction. Because the patient wanted to continue to be very active in sports and activities, it was decided that the patient undergo a right open SC joint reconstruction with excision of the intra-articular disc using the contralateral harvest of the left gracilis tendon for reconstruction.

Description of Surgical Technique

The patient underwent general anesthesia and was placed supine on the operating room table. The right SC joint was approached using a longitudinal incision carried through the skin and subcutaneous tissues. The sternocleidomastoid muscle and tendon and the platysma tendon were elevated and a subperiosteal dissection around the medial end of the clavicle was performed. The intra-articular disc was identified to have some tearing in it and was removed. Next, two 4 mm bone tunnels were each drilled in the sternum and medial clavicle.

At this point, an incision was made medial of the left knee. The sartorius fascia was elevated and the gracilis tendon was identified and was harvested with a tendon strip. The harvest site was closed and the 4mm gracilis graft was prepared. The graft was passed through the sternum and the clavicle creating two horizontal limbs posteriorly and a crossing limb anteriorly, consistent with the figure-of-8 method described by Spencer and Kuhn.[46] Lastly, the graft was tensioned, the joint reduced, and the graft was secured to itself with #2 Ethibond sutures and #1 Vicryl sutures (**Figure 7**).

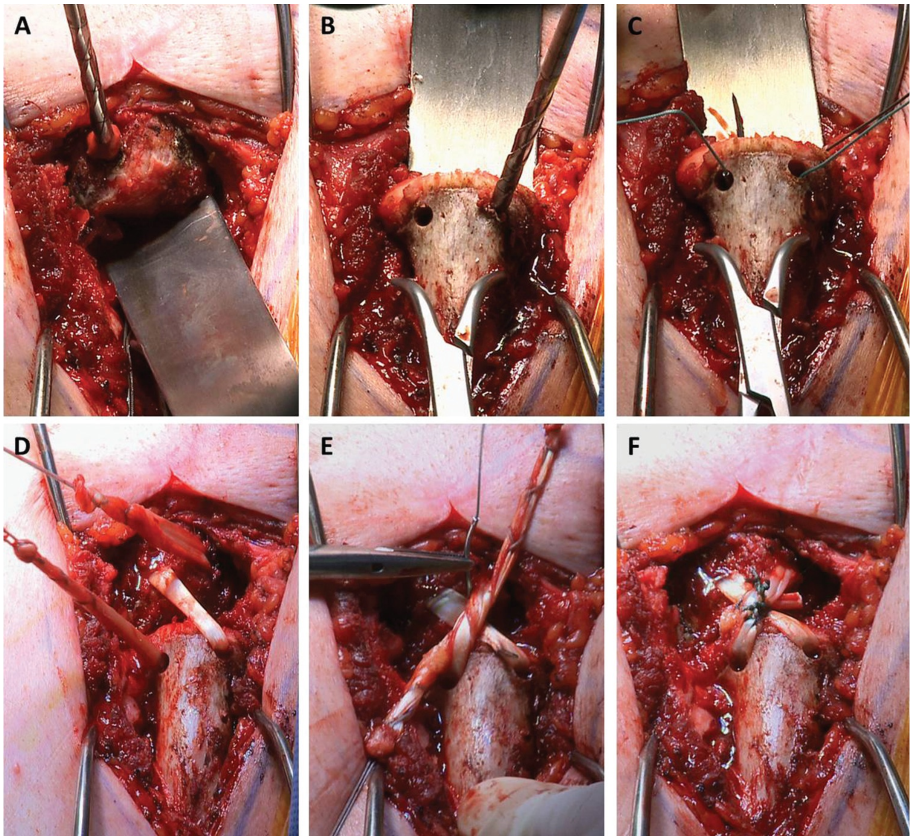

Figure 7. (A) Bone tunnels in the sternum are created. (B) Two 4-mm bone tunnels are created in the medial clavicle. (C) Sutures are passed through the tunnels for graft shuttling. (D) The graft is shuttled in a figure-of-8 manner. (E) The graft ends are tied together and subsequently secured with sutures. (F) The free ends of the graft are removed with a scalpel. Courtesy of Martetschlager, et al.[46]

When the figure-of-8 graft was in place, the surgeon performed a capsulorrhaphy of the SC joint with a #1 Vicryl suture and a pants-over-vest configuration to provide additional stability. The wound was irrigated and demineralized bone matrix was used in and around the bone tunnels to facilitate additional healing. Finally, the sternocleidomastoid tendon and platysma tendon were closed with #1 Vicryl and the skin was sutured.[53]

Post-Operative Physical Therapy

Immediately following surgery, the patient was placed in a right arm sling with instructions to keep his right shoulder girdle completely immobile for 6 weeks. He was allowed early active hand, wrist, and elbow motion. Independent rehabilitation of his graft site was encouraged through active ROM of his left lower extremity. The patient was instructed to avoid resisted knee flexion for 4 weeks following surgery to allow the graft to heal.

The patient was instructed to begin physical therapy at eight weeks post-surgery with a frequency of two visits per week. At the time of his physical therapy evaluation, the patient completed a TAOS Functional Index intake form, which is a clinical outcome tool used to benchmark a patient's functional limitations.[54] He reported his ability to reach was 80% impaired ("I cannot reach up to a lower shelf without increased symptoms, but I can reach counter height to place an empty cup"). He also reported that he was 40% impaired in his functional ability at school ("I can do most of my usual work, but no more"). The patient described his pain as achy and rated his pain at 1/10 on the VAS.

The patient's PROM at the time of his initial evaluation was 90° of abduction, 70° of external rotation, 30° of internal rotation, and 80° of flexion. His PROM was limited by soft tissue restriction with pain. He was able to attain passive scapular retraction to neutral, limited by anterior chest tightness with pain. There was observable atrophy of his rhomboids and trapezius on the involved side.

Post-operative instructions included goals of attaining full PROM and AROM. Per physician guidelines, the patient began weaning out of the sling at week 8 and was finished by week 10. Internal and external rotation strengthening was allowed at 10 weeks post-op with careful attention not to load the clavicle or SC joint until 12 weeks post-op. The patient's rehab consisted of five, criterion-based phases. The goals in each phase and a more detailed description of the rehabilitation guidelines are included in **Table 3**.

Table 3. Rehabilitation Guidelines for Sternoclavicular Joint Reconstruction w/ Hamstring Autograft. Adapted from Howard Head Sports Medicine Center, Vail, CO.

Week

Phase I- Maximal Protection PROM	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
Scapular Retraction-Depression	◆	◆	◆	◆							
Pendulums	◆	◆	◆	◆							
Aqua Therapy for Gentle AAROM	◆	◆	◆	◆							
PASSIVE ROM											
External Rotation	◆	◆	◆	◆	◆	◆	◆	◆	◆	Continue PROM until full ROM is achieved.	
Forward Elevation & Scaption	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Abduction	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Internal Rotation to Belt Line	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Internal Rotation	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Phase II- Minimal Protection AROM	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
ACTIVE ASSISTED ROM											
Internal & External ROM		◆	◆	◆	◆	◆	◆	◆	◆	◆	
Forward Elevation & Scaption		◆	◆	◆	◆	◆	◆	◆	◆	◆	
ISOMETRICS—LIGHT											
Internal/External Rotation			◆	◆	◆	◆	◆				
Biceps/Triceps			◆	◆	◆	◆	◆				
ACTIVE ROM											
Side lying External Rotation			◆	◆	◆	◆	◆	◆	◆	◆	◆
Forward Elevation & Scaption			◆	◆	◆	◆	◆	◆	◆	◆	◆
Salutes			◆	◆	◆	◆	◆	◆	◆	◆	◆
Prone Horizontal Abduction w/ ER			◆	◆	◆	◆	◆	◆	◆	◆	◆
Prone Lower Traps to 60°			◆	◆	◆	◆	◆	◆	◆	◆	◆
Prone Extensions with ER			◆	◆	◆	◆	◆	◆	◆	◆	◆
Open Chain Proprioception			◆	◆	◆	◆	◆	◆	◆	◆	◆

LOW LOAD PROLONGED STRETCHES											
Door Jam Series			♦	♦	♦	♦	♦	♦	♦	♦	♦
Towel Internal Rotation						♦	♦	♦	♦	♦	♦
Cross Arm Stretch						♦	♦	♦	♦	♦	♦
Sleeper Stretch			♦	♦	♦	♦	♦	♦	♦	♦	♦
TV Watching Stretch			♦	♦	♦	♦	♦	♦	♦	♦	♦
90/90 External Rotation Stretch						♦	♦	♦	♦	♦	♦
ACTIVITIES OF DAILY LIVING (ADLs)	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
Eating/Drinking (elbow motion ok)	Use uninvolved arm only.						♦	♦	♦	♦	♦
Dressing							♦	♦	♦	♦	♦
Washing/Showering							♦	♦	♦	♦	♦
Computer with supported arm	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Driving			♦	♦	♦	♦	♦	♦	♦	♦	♦
Lifting up to 5 lbs.			♦	♦	♦	♦	♦	♦	♦	♦	♦
Overhead Activity			♦	♦	♦	♦	♦	♦	♦	♦	♦
Lifting greater than 5 lbs.							♦	♦	♦	♦	♦
Phase III- Initial Resistance, Strengthening, & Proprioception	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
External Rotation			♦	♦	♦	♦	♦	♦	♦	♦	♦
Internal Rotation			♦	♦	♦	♦	♦	♦	♦	♦	♦
Punches with a Plus			♦	♦	♦	♦	♦	♦	♦	♦	♦
Sport Cord Rows			♦	♦	♦	♦	♦	♦	♦	♦	♦
Prone Lower Trap			♦	♦	♦	♦	♦	♦	♦	♦	♦
Bicep Curls			♦	♦	♦	♦	♦	♦	♦	♦	♦
Triceps Extensions			♦	♦	♦	♦	♦	♦	♦	♦	♦
Initial Push-up Plus						♦	♦	♦	♦	♦	♦
Initial Closed Chain Stability						♦	♦	♦	♦	♦	♦
Phase IV- Advanced Resistance, Strengthening, & Proprioception	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
External Rotation at 45°						♦	♦	♦	♦	♦	♦
Bear Hugs						♦	♦	♦	♦	♦	♦
External Rotation at 90°						♦	♦	♦	♦	♦	♦
Statue of Liberty						♦	♦	♦	♦	♦	♦
Advanced Push-up Plus									♦	♦	♦
Advanced Closed Chain Stability									♦	♦	♦
PNF with Resistance						♦	♦	♦	♦	♦	♦
Decelerations						♦	♦	♦	♦	♦	♦
Plyometric External Rotations								♦	♦	♦	♦
Phase V- Weight Lifting, Gym, & Return To Sports	**8**	**9**	**10**	**11**	**12**	**13**	**17**	**21**	**25**	**28**	**33**
Criteria: Full pain-free motion and full rotator cuff strength restored. No lat pulls behind back or wide grip bench press.											
Skiing							♦	♦	♦	♦	♦
Throwing Progression							♦	♦	♦	♦	♦
Overhead and Serving Sports (Tennis, Vball, Golf)								♦	♦	♦	♦
Contact Sports (Football, Hockey, Lacrosse)							Check with MD.				
Swimming							♦	♦	♦	♦	♦

The post-operative protocol served as a guideline for rehabilitation progression. The intent was not to substitute for clinical decision-making. The progression through each phase of rehab was based on clinical criteria and time frames as appropriate. It was important that each phase of rehab be mastered prior to initiating the next phase to insure proper healing of repaired tissue. Following any surgery, an appreciation of the soft tissue and bone healing timeframes are critical.

Manual Therapy

Although the post-operative guideline did not include the use of manual therapy, the author recognized the need for soft tissue and joint mobilization through the administration of selective tissue tension testing of the shoulder girdle. The patient was found to have regional joint hypomobility of the shoulder girdle and mid thoracic spine due to compensation, abnormal movement patterns, and immobilization. This was consistent with what the author expected to find following 8 months of SC joint pain and 2 months of post-operative mobility precautions.

The acromioclavicular joint demonstrated generalized hypomobility in anterior, posterior, and inferior clavicular arthrokinematic glides. This was likely due to 6 weeks of shoulder girdle mobility restrictions in the sling. The patient responded well to Grade II, III, and eventually Grade IV and V mobilizations between weeks ten and fourteen.[55] When the acromioclavicular mobility was restored in all planes, acromioclavicular joint mobilization as part of the plan of care was discontinued.

Restoration of the patient's upper thoracic segmental extension, right side bending, and right rotation restriction was addressed through manual therapy techniques. The patient's avoidance of end range flexion and abduction of his right arm for nearly 8 months led to regional stiffness of his upper thoracic spine into this combined, functional movement pattern. The improvement in upper thoracic joint mobility through the use of manual therapy led to greater functional shoulder flexion within several visits.

The patient had moderate difficulty attaining combined glenohumeral external rotation and abduction. This was due to a combination of factors including the glenohumeral capsule, muscle length restrictions, anterior SC joint capsular stress, and fear avoidance. The anterior and inferior glenohumeral capsular hypomobility developed from being immobilized in a sling for 8 weeks. The patient also had fascial restrictions, likely developed from post-operative scarring and immobilization, across the clavicle, pectorals, and sternum that resulted in loss of motion into external rotation and abduction of the humerus. With the patient's arm held against his stomach in internal rotation for 6 weeks following surgery, his subscapularis, latissimus dorsi, and pectoralis major developed muscle length restrictions and also contributed to difficulty attaining end range active external rotation and abduction. Prior to the surgery, glenohumeral motion into external rotation and abduction exacerbated anterior SC joint instability and was avoided due to aggravation of symptoms. Between weeks 8 and 12, the patient continued to demonstrate moderate fear-avoidance and muscle guarding in end range passive and active combined external rotation and abduction. To overcome the muscle guarding, gradual, pain-free repetition into greater PROM, AAROM, and AROM was emphasized to build his confidence in the SC joint stability.

Transverse friction and scar massage was an integral part of the plan of care. Cyriax reported the benefits of scar massage to improve tissue mobility and elasticity.[56] Post-operative scarring can result in a disorganized collagen matrix and impair the tissues ability to broaden. Transverse friction massage allows the muscle and connective tissue to broaden passively. The added mobility can be maintained through active muscle contraction into the osteokinematic end range immediately following transverse friction massage.[56] Treatment included gentle, and then more aggressive scar massage followed by AROM between the 8th and 12th week post-surgery. The patient made considerable gains in ROM while adhering to this sequence of treatment. The multi-modal approach of skilled manual therapy consisting of joint mobilization and soft tissue friction massage, static and dynamic stretching, and functional ROM patterns enabled the patient to achieve full AROM in all planes by week 12.

Therapeutic Exercise

By week 10, the patient was making consistent ROM progress and the treatment plan was expanded to include strength and proprioceptive control, outlined in Phase III. Attention was given to protecting the SC joint by performing controlled, mid-range strengthening. The exercise prescription consisted of high repetition and minimal resistance to slowly stress and strengthen the shoulder girdle. Over several weeks, closed kinetic chain movements were slowly introduced and progressed to include greater amounts of body weight and larger amplitudes of motion.

By week 13, advanced strengthening and proprioception were progressed in Phase IV. The author integrated the patient's own sport-specific movements within the protocol guidelines. Particular attention was given to neuromuscular control throughout the cocking phase of throwing. The shoulder girdle was challenged with plyometric, acceleration, and deceleration specific movement patterns in combinations of flexion, external rotation, and abduction. In addition, mobility, fluidity, and power through the entire kinetic chain were emphasized with regard to throwing, pushing, and pulling to ensure that the newly reconstructed SC joint was not being excessively stressed through functional movements.

Based on the patient's functional mobility, strength, and stability at the SC joint, the patient transitioned from physical therapy to return to sport at seven months post-surgery. The AROM of the patient's shoulder girdle was 180° of abduction, 93° of external rotation, 60° of internal rotation, and 180° of flexion. Manual muscle testing of his deltoid, infraspinatus, supraspinatus, pectoralis major, rhomboid, and trapezius were 5/5, without pain. TAOS Functional Index at discharge measured 0% impairment in reaching, work, recreation/sports, and lifting. The patient reported that he was experiencing no pain and he recorded his global rating of change compared to his first physical therapy treatment as 'completely recovered.' A follow-up phone call was given to the patient by the author at 1 year post-surgery and he reported that he was having no problems with his shoulder and he had returned to lacrosse without any discomfort or functional limitations from the SC joint. In total, the patient attended 25 visits over the course of 6 months of physical therapy.

Clinical Commentary and Discussion

Numerous techniques have been proposed for reconstruction of the unstable SC joint. According to Spencer and Kuhn, the figure-of-8 reconstruction with hamstring tendon graft appears to be biomechanically superior and may result in favorable long-term outcomes.[45] They also contend that the semitendinosus figure-of-8 tendon reconstruction restores native joint stiffness better than the intramedullary tendon and subclavius reconstructions do.[45] These findings suggest that the semitendinosus figure-of-8 tendon reconstruction may have a role in the treatment of patients with SC joint instability. Clearly, additional data needs to be collected on the short-term and long-term clinical outcomes of patients with this reconstruction method.

An understanding of changes in clavicular motion, if any, following an SC joint reconstruction would be helpful for a rehabilitation specialist to incorporate into treatment. Previous biomechanical studies have found that a normal clavicle undergoes 50° of rotation, 35° of elevation, and 35° of anterior-posterior glide.[14] No studies have investigated the clavicular biomechanics following SC joint reconstructions. A difference in the motion of the clavicle post-surgery may create alterations in force generation, adaptations for joint mobility, and changes in force coupling throughout the shoulder girdle. At the time of discharge, this patient demonstrated a greater degree of SC joint stiffness in all planes with passive manual glides on his reconstructed side compared to his uninvolved side. Despite this stiffness, he was able to attain full functional shoulder girdle motion. Given the atraumatic nature of his instability, it is reasonable to suspect that his uninvolved side may have generalized increased joint hypermobility. It is difficult to predict how side-to-side variability of his SC joint mobility will influence his function in years to come. The intensity and type of activities he decides participate in will play a role in the emergence of symptoms in the future. It is the author's opinion that compensatory patterns at his acromioclavicular joint, glenohumeral joint, and thoracic spine may develop as a result of his body being familiar with the previous amount of SC joint mobility he had during functional movements.

The most difficult variable to control in patients with SC joint trauma is the number and severity of other body areas injured—most notably the acromioclavicular joint, glenohumeral joint, ribs, cervical spine, and thoracic spine. It is the author's opinion that the degree and severity of the injuries of these adjacent body areas may influence the progression and outcome of each SC joint reconstruction surgery. Since the biomechanics of the clavicle have not been studied following an SC joint reconstruction, it is the author's assumption that there are likely to be variances in the amount of clavicular mobility at the reconstructed SC joint compared to the uninvolved side. The clavicular ROM changes will likely create compensatory joint motion along the kinetic chain—specifically the acromioclavicular joint, glenohumeral joint, scapulothoracic articulation, upper thoracic spine, and the elbow joint. Future SC joint reconstruction outcome studies should stratify the procedures into traumatic and atraumatic. Injuries classified as traumatic would give a high index of suspicion to consider other joints needing treatment and ultimately influencing the post-surgical functional outcomes. In addition, non-traumatic SC pathology may indicate the need for a regional biomechanical assessment to insure that the SC joint pathology is not itself a secondary lesion.

Patients considering an SC joint reconstruction should be thoroughly screened by a physical therapist and an orthopedic surgeon to determine how well their shoulder girdle may be able adapt to the potential biomechanical changes. It is the author's opinion that patients who have had significant shoulder girdle injuries in the past, as well as those with injuries from the trauma that destabilized the SC joint, be counseled on a guarded prognosis. These patients appear more likely to develop symptoms in adjacent shoulder girdle areas if they intend to return to high-level overhead or contact sports. In the author's clinical experience, patients with 1) traumatic SC joint instability, 2) adjacent shoulder girdle compensation and injury as a result of the original trauma, and 3) waited more than two years prior to having SC reconstruction surgery have residual functional limitations and may have a poorer prognosis. Trauma was not a factor in the etiology of this patient's SC joint instability and no other compensatory movement patterns were observed prior to his surgery. The lack of trauma and short timeframe from onset of symptoms to surgery may have contributed to his excellent prognosis and successful outcome.

The length of time from a traumatic SC joint instability to the time of surgery may play a critical role in the long-term functional outcome. If a patient delays a surgical stabilization procedure and continues to use the shoulder girdle in a limited capacity, they are likely to develop scapular dyskinesia, muscle atrophy, and maladaptive shoulder girdle positioning. Each of these impairments may lead to compensation and eventual overuse in the cervical spine, thoracic spine, rotator cuff, acromioclavicular joint, long head biceps, and labrum. In addition, continuing to function with an unstable SC joint may increase the likelihood of SC arthrosis and this may complicate the reconstruction at a later time. These factors were instrumental in assisting the patient and his family to decide to proceed with the SC reconstruction rather than opting for conservative treatment, such as physical therapy.

Conclusion

Although studies are needed to investigate the long-term outcomes following SC joint reconstruction, the figure-of-8 procedure has been shown to be the strongest.[45] Just over a decade ago, there was limited data supporting successful SC joint reconstruction outcomes. As a result, many doctors probably still recommend conservative treatment and long-term activity modification for SC joint instability. Stabilization procedures were primarily recommended for posterior dislocations because of the risks to vascular and airway structures. Over the last decade, the figure-of-8 procedure has gained acceptance and studies have validated the strength of the reconstruction.[46] This has encouraged more doctors to recommend this surgery to treat moderate to severe SC joint instability. Patients with traumatic SC dislocations may not benefit from undergoing extended conservative treatment, based on the author's aforementioned assumptions in acquiring compensatory patterns, especially with a validated figure-of-8 stabilization procedure available.

The patient in this case report achieved an excellent outcome at one year following surgery. The author was able to perform specific manual therapy techniques to assist the patient in attaining key criteria to allow timely progression through the rehabilitation guideline. The identification and application of manual therapy interventions served an integral role to optimize the shoulder girdle biomechanics as the patient returned to functional and sport-specific movement patterns.

The rarity of SC joint instability, not to mention the small number of patients that have elected to have a figure-of-8 reconstruction technique, make quality long-term outcome studies difficult. In the future, a well-designed outcome study will need to take into account the direction of dislocation, if trauma was involved, and whether the instability is acute or chronic. For proper stratification, patients included in the study should be separated into groups consisting of posterior acute, posterior chronic, anterior traumatic acute, anterior traumatic chronic, and anterior atraumatic chronic SC instability. Based on the current body of literature, the author believes that it may be necessary to separate patients into these groups to account for distinct variables that may have an influence on long-term rehabilitative outcomes. This information will be critical for the rehabilitation team to assist in determining the functional prognosis of each specific SC instability case.

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