Sternoclavicular Reconstruction in the Young Active Patient: Risk Factor Analysis and Clinical Outcomes at Short-Term Follow-up

Nicholas Kusnezov, MD, CPT, MC, John C. Dunn, MD, CPT, MC,* Jeffrey M. DeLong, BS,† and Brian R. Waterman, MD, MAJ, MC**

Objective: To determine the functional outcomes in young, active individuals after sternoclavicular (SC) joint reconstruction.

Design: Level IV, case series.

Setting: United States military hospitals, 2008–2012.

Patients/Participants: Retrospective review of all consecutive patients from the Military Health System Management Analysis and Reporting Tool was performed. Patients who underwent other open-shoulder procedures (eg, acromioclavicular joint reconstruction), those of nonmilitary or retired status, and patients with under 12-month minimum follow-up without medical separation were excluded from further analysis.

Intervention: Open reconstruction of SC joint dislocation.

Main Outcome Measures: Primary outcomes of interest were clinical failure and medical separation due to persistent shoulder girdle dysfunction. Demographic data, surgical technique, outcomes, complications, and occupational military outcomes were recorded.

Results: Fourteen patients, with an average age of 26 years, experienced 8 anterior (57.1%) and 6 posterior (42.9%) SC joint dislocations. Four patients (28.6%) presented with dysphagia or dyspnea, and 10 patients (71.4%) had a missed diagnosis with an average of 13 months until diagnosis. Twelve of 14 (85.7%) patients underwent figure-of-eight tendon reconstruction, and 10 (71.4%) were able to return to full active military duty at an average 26.8 ± 12.9 months follow-up. There were 6 complications in 5 patients (35.7%), whereas 2 (14.3%) reported persistent instability and 2 (14.3%) required reoperation.

Conclusions: SC joint dislocations are rare injuries that are frequently missed on clinical presentation in this study. However, acute or delayed surgical reconstruction may afford predictable rates of return to function in young active military service members.

Key Words: sternoclavicular joint dislocation, reconstruction, military

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

(*J Orthop Trauma* 2016;30:e111–e117)

INTRODUCTION

Sternoclavicular (SC) joint injuries are rare, comprising only 3% of shoulder girdle injuries and 1% of all dislocations.[1,2] This may be attributable to the significant stability provided by the SC joint capsule and ligamentous complex.[3] The posterior ligamentous structures are more robust, possibly accounting for the relatively higher reported incidence rates of anterior SC joint dislocations.[1–5] Although anterior SC joint dislocations are often more symptomatic, posterior dislocations are associated with greater morbidity and mortality, specifically with mediastinal, esophageal, and/or tracheal encroachment in up to 30%.[6–8]

In the absence of cardiopulmonary compromise, the majority of SC joint dislocations can be successfully managed nonoperatively with physical therapy.[8] However, nonoperative management may occasionally lead to progressive symptomatic posttraumatic arthritis of the SC joint.[9] Persistent dynamic instability associated with pain can prevent full return to work or sporting activity, and this may necessitate operative management.[10] Surgical fixation may also be indicated for the treatment of chronic traumatic anterior or posterior SC dislocations that remain irreducible and symptomatic despite a prolonged course of rehabilitation.

There is no consensus on the optimal method for addressing acute or chronic episodes of SC joint instability or medial clavicle fractures.[7,11] Various techniques have been proposed, including Kirschner wire fixation,[12] screws,[13] plates,[14,15] transosseous sutures with[16] and without[17] suture anchors, and graft reconstruction.[4,11,18–28] Fixation may also be supplemented with open[29] or arthroscopic[30] medial

Accepted for publication October 26, 2015.

From the *Department of Orthopaedic Surgery and Rehabilitation, William Beaumont Army Medical Center, El Paso, TX; and †Medical University of South Carolina, Charleston, SC.

N. Kusnezov, J. C. Dunn, and B. R. Waterman are employees of the U.S. government. The remaining authors report no conflict of interest.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or the U.S. government.

This study was approved by the William Beaumont Army Medical Center Institutional Review Board, Package #399155-4: Clinical Outcomes after Shoulder and Elbow Surgery in the Military.

Reprints: Brian R. Waterman, MD, MAJ, MC, Department of Orthopaedic Surgery and Rehabilitation, William Beaumont Army Medical Center, 5005 North Piedras St, El Paso, TX 79920-5001 (e-mail: brian.r.waterman@gmail.com).

clavicle excision in an order to mitigate the risk of symptomatic posttraumatic SC joint arthrosis. However, existing clinical series are limited by their retrospective nature, limited analytic evaluation, and significant clinical heterogeneity, both in terms of patient demographics and injury characteristics. Consequently, there is a need for larger clinical series to guide surgical decision-making for this rare and potentially devastating injury. The primary goal of this study was to determine the functional outcomes in young active individuals after SC joint reconstruction, while performing a descriptive clinical analysis and quantifying perioperative risk with surgical management.

PATIENTS AND METHODS

Protocol approval was obtained from our Institutional Review Board. We performed a retrospective review of all United States military servicemembers undergoing open treatment of SC joint dislocation with or without the use of a graft [Current Process Terminology (CPT) code 23530 and 23532] from the Military Health System Management Analysis and Reporting Tool (M2) between August 1, 2008, and August 1, 2014. Patients who underwent other open procedures of the shoulder girdle (eg, acromioclavicular joint reconstruction), those of nonmilitary or retired status, and patients with under 12-month minimum follow-up without medical separation were excluded from further analysis.

Demographic and occupational data were extracted from the database, including age and branch of service. The investigators then performed line-by-line analysis of the Armed Forces Health Longitudinal Technology Application (AHLTA) electronic medical record to confirm the diagnosis, surgical procedure, and date of surgery and to collect additional patient-based (eg, sex, military rank, laterality, hand dominance, injury characteristics) and surgical factors (eg, indication for surgery, technique, graft or implant type), clinical and functional outcomes including perioperative complications, preoperative and postoperative self-reported pain score (scale, 0–10) and range of motion, secondary surgical interventions, timing of return to duty, and deployment history. All diagnoses were confirmed by an orthopaedic surgeon based on the combination of history, reproducibility on physical examination, and confirmatory basic or advanced radiographic imaging. Junior enlisted rank was defined as rank grade E1 through E5, with senior enlisted E6 and above. Officers and warrant officers were considered separately. The primary outcomes of interest were clinical failure, defined as either subjective reports of recurrent instability or secondary reoperation, and medical separation due to persistent shoulder girdle dysfunction. At the time of surgery, all patients were on some degree of activity restriction secondary to their respective shoulder girdle complaints.

Statistical means with 95% confidence intervals and/or SD were calculated for the continuous variables. Categorical data were expressed as frequencies or percentages. Univariate and χ^2 analysis was performed to evaluate the association between potential risk factors and the primary outcome measures. A P value of less than 0.05 was considered statistically significant.

Surgical Technique

In the supine position, the contralateral hemithorax and affected operative extremity are sterilely prepared and draped. A curvilinear incision of 8 to 10 cm is made over the SC joint down through subcutaneous tissue to the confluent fascial layer representative of the origin of the pectoralis major and insertion of the sternocleidomastoid. The fascia is incised and underlying SC joint capsule is incised and elevated subperiosteally, exposing the joint. At this point, the intra-articular disk is excised. The graft is harvested at this point, prepared in a typical fashion, and measured. A drill of appropriate caliber for the graft (often 4 mm) is used to create 2 anteroposterior tunnels in both the clavicle and manubrium, each roughly 1 cm from the joint, protecting the mediastinal structures posteriorly throughout. At this point, the pretensioned graft is passed in figure-of-eight fashion through the bone tunnels, with the cruciate limbs anterior. The joint is held reduced as the graft is tensioned and the tails are approximated and secured to each other with nonabsorbable, high-tensile suture. This is followed by a water-tight layered closure as preferred.

Postoperative Rehabilitation Protocol

Postoperatively, patients were generally immobilized in a sling for 6 weeks. At 2 weeks postoperatively, gentle pendulum exercises were commenced, followed by increasing range of motion exercises until 3 months. Strengthening began at 3 months, and by 6 months the patients were permitted to perform regular activity without restrictions.

Demographics

Our series included 14 active duty servicemembers undergoing surgery by 6 separate orthopaedic surgeons. The average age was 25.6 ± 6.4 years, and the majority were male (n = 13, 92.9%) and right-hand dominant (n = 12, 85.7%). Branch of military service included the Marine Corps (n = 5), Army (n = 4), Navy (n = 4), and Air Force (n = 1), and 11 (78.6%) servicemembers were junior enlisted. Twelve cases (85.7%) were chronic at the time of surgery, with an average of 18.8 months after initial injury. The average follow-up was 26.8 ± 12.9 (15.5–59.0) months. Traumatic etiologies included 2 motor vehicle collisions, 1 fell from a bicycle at high speed, 1 fell down a ship ladder well, 3 had combative-related injuries, 3 sports-related injuries, and 2 ground-level falls (Table 1). No definitive mechanism of injury was indicated in the medical record for the remaining 2 patients.

RESULTS

Eight (57.1%) patients presented with anterior and 6 (42.9%) with posterior SC joint dislocations. All patients experienced pain and mechanical clicking or popping in the affected shoulder with provocative overhead movements. Two (14.3%) complained of dysphagia and 2 (14.3%) of dyspnea at rest (posterior, n = 3). SC joint dislocation was

TABLE 1. Patient Demographics, Surgical Variables, Outcomes, and Complications

Patient ID	Age (y)	Sex	Laterality/Dominance	Direction	Mechanism	Missed	Time to Diagnosis (mo)	Time to Surgery (mo)	Chronicity (mo)
1	26	M	R, RHD	Posterior	Traumatic	Y	0.3	0.4	0.7
2	23	M	R, RHD	Posterior	Traumatic	Y	6.8	6.7	13.5
3	25	M	R, RHD	Posterior	Traumatic	Y	56.8	2.2	59
4	23	M	R, RHD	Anterior	Traumatic	Y	0.4	16.3	16.7
5	21	F	L, RHD	Anterior	Atraumatic	Y	15.1	1.7	16.8
6	22	M	R, LHD	Anterior	Traumatic	Y	35.2	5.1	40.3
7	29	M	R, RHD	Anterior	Atraumatic	N	0.9	5.2	6.1
8	22	M	R, LHD	Anterior	Traumatic	N	16.8	0.9	17.7
9	23	M	R, RHD	Anterior	Traumatic	Y	14.8	0.4	15.2
10	36	M	R, RHD	Anterior	Traumatic	N	1.3	28.3	29.6
11	25	M	R, RHD	Posterior	Traumatic	Y	3.2	1.6	4.8
12	43	M	R, RHD	Anterior	Traumatic	N	0.1	8.6	8.7
13	22	M	R, RHD	Posterior	Traumatic	Y	32.5	0.9	33.4
14	19	M	R, RHD	Posterior	Traumatic	Y	0.2	0.2	0.4

Patient ID	Follow-up (mo)	Procedure	Graft	Return to Full Duty (mo)	MEB (mo)	Complications/ Sequelae	Reoperation
1	15.5	Figure-of-eight, soft tissue	Autograft, gracilis, contralateral	4.2		Transient scapular winging	
2	59.0	CC ligament transfer, capsular repair, MCR	None	N/A	10.1	Adhesive capsulitis, PTOA, recurrent instability	Revision reconstruction
3	33.6	Figure-of-eight, soft tissue	Allograft, gracilis	6.6			
4	25.3	Figure-of-eight, soft tissue	Allograft, semitendinosus	10.1			
5	43.4	Figure-of-eight, soft tissue	Autograft, gracilis, ipsilateral	6.6		Recurrent instability	
6	36.4	Figure-of-eight, soft tissue, MCR	Allograft, achilles	6.6			
7	16.3	Figure-of-eight, soft tissue	Allograft, semitendinosus	N/A	16.7		
8	16.3	Figure-of-eight, soft tissue	Autograft, gracilis, ipsilateral	4.7			
9	27.3	Figure-of-eight, soft tissue	Allograft, tibialis anterior	8.5		Wound dehiscence	
10	17.1	Figure-of-eight, soft tissue	Autograft, semitendinosus, ipsilateral	5.3			
11	18.7	Figure-of-eight, soft tissue, MCR	Allograft, hamstring (unspecified)	6.3			
12	20.0	Figure-of-eight, soft tissue	Autograft, semitendinosus, ipsilateral	N/A	Out-process	Keloid formation, PTOA	Scar revision
13	17.3	Figure-of-eight, soft tissue	Autograft, gracilis, contralateral	5.7			
14	17.3	Figure-of-eight, #5 Ethibond	None	N/A	Out-process	PTOA	

MCR, medial clavicle resection; PTOA, posttraumatic osteoarthritis of the sternoclavicular joint; RHD/LHD, right/left-hand dominant.

missed in 10 patients (71.4%) on initial evaluation in the primary care or emergency setting. Dislocation was evident in 3 of 11 (27.3%) with designated SC joint radiographic series and 7 of 12 (58.3%) with CT scans. Significant mediastinal compression was appreciated in 2 patients. Soft tissue graft figure-of-eight reconstruction (autograft, n = 6; allograft, n = 6) was performed in 12 patients (85.2%), whereas 1 patient each underwent primary capsular repair and suture figure-of-eight reconstruction, respectively. Autografts included 4 gracilis and 2 semitendinosus autografts. Medial clavicle resection was performed in 3 patients (21.4%).

The self-reported pain score decreased on average from 4.2 (range, 2–7, n = 13) to 2 (range, 0–5, n = 13) at final follow-up, whereas all but 1 patient reported a minimal pain (0–3). Preoperative and early postoperative shoulder range of motion improved consistently at the 3- and 6-month follow-ups in all patients for whom range of motion was measured. Abduction improved an average of 35 degrees (26.9%, n = 4), from 91 ± 6 degrees to 159 ± 17 degrees, and forward flexion improved an average of 68 degrees (74.6%, n = 4) from 130 ± 47 degrees to 165 ± 9 degrees (74.6%) at final follow-up.

Ten servicemembers (71.4%) returned to full active duty at an average of 6.5 ± 1.7 months postoperatively; of the 4 (28.6%) who did not, 2 underwent medical separation at an average of 13.3 ± 4.6 months postoperatively and 2 others are at present on limited duty restrictions and in the process of medical separation. Two of those medically separated had figure-of-eight graft reconstruction (1 allograft and 1 autograft), whereas the other two had primary capsular repair and suture figure-of-eight reconstruction. Six servicemembers (42.9%) completed their military obligation at an average of 15.6 ± 5.7 months postoperatively, and 6 remain on active duty without limitation or activity modification. Three servicemembers (21.4%) also participated in postoperative combat deployments.

There were a total of 6 postoperative complications in 6 patients (35.7%), including 2 cases of recurrent instability (one at 2.7 and the other at 42 months postoperatively) (14.3%), 1 transient scapular winging secondary to compensatory scapular dyskinesis (7.1%), 1 adhesive capsulitis (7.1%), 1 wound dehiscence (7.1%), and 1 scar hypertrophy with hypersensitivity necessitating scar revision. The scapular winging markedly improved with targeted physical therapy with no further sequelae. One patient underwent revision reconstruction for recurrent instability (7.1%). Late sequelae of the injury included 3 cases of posttraumatic SC joint arthrosis, one of which had had a partial medial clavicle resection during the primary procedure. However, no patients required other further treatments aside from scar revision.

Statistical Analysis

Posttraumatic osteoarthrosis of the SC joint was found to be the only statistically significant predictor of medical separation on univariate analysis ($P = 0.048$). Although there were no significant predictors of clinical failure, the presence of complications ($P = 0.065$), posttraumatic osteoarthrosis ($P = 0.063$), recurrent instability ($P = 0.083$), and reoperation ($P = 0.083$) trended toward significance.

Posterior dislocations were missed more often than anterior dislocations on initial evaluation (100% vs. 50%, $P = 0.08$) and on average demonstrated a significantly greater improvement in (decrease of 5 vs. 0.6) self-reported pain scores and significantly lower absolute self-reported pain scores at 6 weeks (0.4 vs. 3.7, $P = 0.001$), 3 months (3.3 vs. 0.6, $P = 0.03$), and 6 months (3 vs. 0, $P = 0.02$) postoperatively. Return to duty (75% vs. 67%, $P = 0.28$), medical separation rate (25% vs. 33%, $P = 1.0$), time to surgery, and perioperative complication rates (38% vs. 33%, $P = 1.0$) were similar between anterior and posterior dislocation subgroups, respectively.

TABLE 2. Statistical Comparisons of Subgroup Outcomes

	Anterior	Posterior	*P*
Missed	4/8 (50%)	6/6 (100%)	0.08
Chronicity	18.9 mo	18.6 mo	0.977
Pain score			
Improvement	5	0.6	
6 wk	3.7	0.4	0.001
3 mo	3.3	0.6	0.029
6 mo	3	0	0.024
Return to full duty	6	4	1
Medical separation	2	2	1
Complications	3	2	1
	Autograft	**Allograft**	***P***
Time to return to full duty	5.3	7.6	0.02
Complications	3/6 (50%)	1/6 (16.7%)	0.55
Recurrent instability	1/6 (16.7%)	0/6 (0%)	1
Reoperation	1/6 (16.7%)	0/6 (0%)	1

Patients who underwent autograft reconstruction took significantly less time to return to full duty postoperatively (5.3 vs. 7.6 months, $P = 0.02$). However, there were a greater number of complications (50% vs. 16.7%), recurrent instability (16.7% vs. 0%), and reoperation (16.7% vs. 0%) in the autograft group, although this did not reach statistical significance (Table 2).

DISCUSSION

Since the first description of a traumatic SC joint dislocation over 150 years ago,[31] a variety of surgical techniques have been described for the management of both acute and chronic dislocations. Figure-of-eight soft tissue graft reconstruction has evolved as the most widely accepted technique because of its superior biomechanical performance over other previous techniques.[5] In a cadaveric model comparing 3 reconstruction techniques,[19,21,29] the figure-of-eight technique demonstrated the least laxity in both the anterior and posterior directions (36.9% and 3.8%, respectively) in addition to over 3- to 4-fold the average peak load in both the anterior and posterior directions.[5] However, all techniques were inferior to the native SC ligaments with regard to both anterior and posterior stability.

Despite this limited consensus, prevailing expert opinion in support of this technique is based solely on few selected biomechanical studies,[5,17] case reports,[20,21,23] and small noncomparative series[11,18,22,24,25] demonstrating favorable preliminary clinical outcomes (Table 3). Bae et al[18] reviewed the outcomes of 15 adolescents with anterior SC dislocations, eight of whom underwent figure-of-eight semitendinosus autograft reconstruction. Despite no reported complications, they found that only 60% of patients had stable pain-free joints at 4-year follow-up, and 13% experienced persistent instability. In a later series of 6 patients who underwent autologous hamstring reconstruction using the figure-of-eight construct, the authors found that all patients were able to return to full activity without limitations at 22 months postoperatively.[25] Similarly, Guan et al retrospectively reviewed 6

TABLE 3. Series Assessing Outcomes of SC Joint Reconstruction Utilizing Figure-of-Eight Soft Tissue Graft Technique

Series	No. Patients	Mean Age (y)	Mean Follow-up (mo)	Direction	Mechanism
Singer et al[25]	6, 3 M/3 F	22 (15–46)	22 (14–34)	3 anterior, 2 posterior, 1 combined	6 traumatic
Guan et al[22]	6, 1 M/5 F	22.2 (16–43)	40 (25–58)	6 anterior	4 traumatic, 2 atraumatic
Bae et al,[18] 2006*	15, 4 M/11 F	15.9 (12–23)	55 (7–164)	15 anterior	N/A
Sabatini et al[24]	10, 3 M/7 F	40.1 (18–59)	38 (24–67)	9 anterior, 1 posterior	7 traumatic, 3 atraumatic
This study	14, 13 M/1 F	25.6 (19–43)	26.8 (15.5–59.0)	8 anterior, 6 posterior	13 traumatic, 1 atraumatic

Series	Chronicity (DOI to DOS) (mo)	Procedure	Graft	Outcomes	Complications
Singer et al[25]	8	6 figure-of-eight	6 autograft: 4 semitendinosus, 2 gracilis	DASH improved significantly, all returned to full activity without limitation	1 infection, reoperation, no recurrence
Guan et al[22]	11	6 figure-of-eight	6 autograft: 2 semitendinosus, 4 gracilis	ROM: full, VAS: 0 in 5, 1–3 in 1, all returned to sports (4)/activities (2)	1 atraumatic failure at 4 y with secondary revision
Bae et al,[18] 2006*	All chronic, unspecified	11 repair/reconstruction, 4 medial clavicle resection	9 autograft: 8 semitendinosus, 1 SCM	60% stable, pain-free joint, 87% limitation in athletic/recreational activities, 13% persistent instability, 27% SRPS 1–2/10, 7% SRPS >5/10	No complications, no revisions
Sabatini et al[24]	18.2 (3–54.7)	10 figure-of-eight, augmented with tenodesis screws	10 allograft	27% good joint stability, 67% with activity restriction	1 hematoma, necessitating reoperation, 1 superficial wound infection, 1 recurrence, 1 PTOA
This study	18.8 (0.4–59.0)	13 figure-of-eight, 1 CC ligament transfer with medial clavicle resection	6 autograft: 2 semitendinosus, 4 gracilis, 6 allograft	SRPS decreased 4.2 to 2: >3 in 1, ROM improvement: Abd 35 degree, FF 68 degree, 71.4% returned to full active duty, 26.5% medical separation	2 recurrent instability, 1 necessitating surgery, 1 adhesive capsulitis, 1 scapular winging, 1 wound dehiscence, 1 keloid necessitating scar revision

*Demographics reported for all patients.
Abd, abduction; CC, coracoclavicular; FF, forward flexion; M/F, male/female; PTOA, posttraumatic arthritis; ROM, range of motion; SRPS, self-reported pain score.

patients who had undergone a modified figure-of-eight reconstruction using a hamstring autograft tunneled through unicortical drill holes. At a mean of 40-month follow-up, the authors found that all patients demonstrated improved pain, range of motion, and return to their preoperative activity level (4 athletes), with only 1 revision reconstruction with medial clavicle excision for atraumatic symptomatic recurrence at 4 years postoperatively.[22]

In the largest and most recent case series using figure-of-eight reconstruction, Sabitini et al reviewed allograft figure-of-eight reconstruction with disk excision augmented with biotenodesis screws in 10 patients with chronic anterior SC joint dislocations.[24] The authors found significant improvements in ASES and VAS scores, although 67% still reported limitations during sports and recreational activities at final follow-up. Additionally, 1 patient experienced a symptomatic recurrence and 1 developed posttraumatic osteoarthritis. Despite the low-profile construct, the authors reported a 20% rate of patient-reported knot discomfort.

To date, we present the largest series of SC reconstruction using primarily the figure-of-eight graft reconstruction technique in a young highly-active patient population. All of our patients for whom data were available experienced significant improvements in pain (n = 13) and range of motion (n = 4). Although most patients (n = 10, 71.4%) in this study returned to full active duty at an average of 6.5 ± 1.7 months postoperatively, 4 (28.6%) had undergone or were in the process of medical separation due to persistent shoulder disability, one of them also underwent revision reconstruction (7.1%). The inability to return to full active duty reflects the true limitations of the procedure in returning the high-demand individual to preinjury activity levels. This is consistent with existing series reporting 67%–87% of patients reporting postoperative limitation.[18,24]

The impact of chronicity has not been established in the literature. The average time from injury to surgery in our study was greater than that reported in other series.[22,24,25] This may be due to a larger predominance of posterior

dislocations, for which the average time to diagnosis was significantly longer (16.6 vs. 10.6 months for anterior dislocations). All 6 posterior dislocations were initially misdiagnosed, which is consistent with the literature, as posterior dislocations are more easily overlooked because of the lack of obvious deformity and potentially subtle symptomatology.[4,8] Surprisingly, the SC dislocations were evident in only 85.7% of CT scans, 27.3% of designated SC radiographs, and none of the nonspecific plain radiographs of the chest, shoulder, and clavicle. Although plain radiographs even with designated SC views may miss the dislocation, CT is thought to be the most reliable diagnostic modality.[1,8] However, if the dislocation is dynamic and reduced at the time of CT, it may be missed and should be accompanied by a careful physical examination.

Although anterior dislocations are far more common,[2] the high preponderance of posterior dislocations is likely reflective of their more symptomatic nature. Comparatively, the posterior dislocation subgroup demonstrated greater postoperative improvement in pain at final follow-up, which may be attributable to the more symptomatic nature and therefore greater capacity for clinical improvement among posterior dislocations.

In the first comparison of autograft to allograft figure-of-eight reconstruction, we found faster return to full duty in the autograft subgroup despite increased perioperative complications and clinical failures, although these also did not reach statistical significance. Autografts have been favored because of the benefits of improved biologic integration and increased strength.[18,22,25] Similar to reported rates of 10%–17%,[22,24] there were 2 patients with recurrent instability (14.3%) and one who elected for revision reconstruction (7.1%).

Finally, in lieu of reconstruction, medial clavicle resection with maintenance or reconstruction of stabilizing structures has been advocated in the setting of chronic dislocations.[8,29] In our series, the medial clavicle was resected in 3 patients (21.4%); however, one of these patients went on to develop recurrent instability and persistent pain. This underscores the importance of judicious resection, taking care not to overresect and thereby destabilize the joint.[32]

Similar to the few existing series, our study is limited largely by its retrospective nature and diversity of injury mechanism of injury, clinical presentation, and time to surgery. However, within this active subset, we have attempted to elucidate differences in clinical outcomes by the type of SC injury (eg, anterior vs. posterior), graft choice (eg, autograft vs. allograft), and time to treatment. Additionally, although this patient population too is heterogeneous to a degree, it is perhaps one of the more homogenous cohorts with respect to the existing studies in that we isolate predominant young males with very specific and strict physical demands. Because of the low incidence of this injury, a large multicenter study or meta-analysis would be necessary to more rigorously evaluate surgical variables and clinical outcomes after SC joint reconstruction. Furthermore, we were only able to assess short-term to intermediate-term outcomes. However, we followed the majority of patients to the point of separation, allowing an accurate appraisal of return to high-demand activity postoperatively. With a 12-month minimum follow-up, we identified four patients who were medically separated and would otherwise be excluded based on limited follow-up. Additionally, we identified a significant number of patients who were already separated by the time of final follow-up.

SC joint dislocations are a rare entity and the management remains controversial. In the largest series to date involving figure-of-eight soft tissue graft reconstruction in young active individuals, we found no significant difference in outcomes between the subgroups with anterior and posterior dislocations or the graft type. The autograft subgroup demonstrated faster return to full duty despite increased perioperative complications and clinical failures. However, although reconstruction provided adequate pain relief and restoration of range of motion in this young high-demand cohort, 35% experienced postoperative complications, 7% required revision reconstruction for recurrent instability, and roughly one-third (28.6%) were medically separated because of persistent shoulder disability at short-term follow-up.

REFERENCES

1. Cope R, Riddervold HO, Shore JL, et al. Dislocations of the sternoclavicular joint: anatomic basis, etiologies, and radiologic diagnosis. *J Orthop Trauma.* 1991;5:379–384.
2. Nettles JL, Linscheid RL. Sternoclavicular dislocations. *J Trauma.* 1968; 8:158–164.
3. Spencer EE, Kuhn JE, Huston LJ, et al. Ligamentous restraints to anterior and posterior translation of the stemoclavicular joint. *J Shoulder Elbow Surg.* 2002;1:43–47.
4. Aure A, Hetland KR, Rokkum M. Chronic posterior sternoclavicular dislocation. *J Orthop Trauma.* 2012;26:e33–e35.
5. Spencer EE, Kuhn JE. Biomechanical analysis of reconstructions for sternoclavicular joint instability. *J Bone Joint Surg Am.* 2004;86:98–105.
6. Ponce BA, Kundukulam JA, Pflugner R, et al. Sternoclavicular joint surgery: how far does danger lurk below? *J Shoulder Elbow Surg.* 2013;22:993–999.
7. Thut D, Hergan D, Dukas A, et al. Sternoclavicular joint reconstruction. A systematic review. *Bull NYU Hosp Jt Dis.* 2011;69:128–135.
8. Wirth MA, Rockwood CA. Acute and chronic traumatic injuries of the sternoclavicular joint. *J Am Acad Orthop Surg.* 1996;4:268–278.
9. de Jong KP, Sukul DM. Anterior sternoclavicular dislocation: a long term follow-up study. *J Orthop Trauma.* 1990;4:420–423.
10. Bicos J, Nicholson GP. Treatment and results of sternoclavicular joint injuries. *Clin Sports Med.* 2003;22:359–370.
11. Martenschlager F, Warth R, Millett PJ. Instability and degenerative arthritis of the sternoclavicular joint. A current concepts review. *Am J Sports Med.* 2013;42:999–1007.
12. Smolle-Juettner FM, Hofer PH, Pinter H, et al. Intracardiac malpositioning of a sternoclavicular fixation wire. *J Orthop Trauma.* 1992;6:102–105.
13. Brinker MR, Bartz RL, Reardon PR, et al. A method for open reduction and internal fixation of the unstable posterior sternoclavicular joint dislocation. *J Orthop Trauma.* 1997;11:378–381.
14. Hecox SE, Wood GW. Ledge plating technique for unstable posterior sternoclavicular dislocation. *J Orthop Trauma.* 2010;24:255–257.
15. Franck WM, Jannasch O, Siassi M, et al. Balser plate stabilization: an alternate therapy for traumatic sternoclavicular instability. *J Shoulder Elbow Surg.* 2003;12:276–281.
16. Abiddin Z, Sinopidis C, Grocock CJ, et al. Suture anchors for treatment of sternoclavicular joint instability. *J Shoulder Elbow Surg.* 2006;15: 315–318.
17. Thomas DP, Williams PR, Hoddinott HC. A "safe" surgical technique for stabilization of the sternoclavicular joint: a cadaveric and clinical study. *Ann R Coll Surg Engl.* 2000;82:432–435.
18. Bae DS, Kocher MS, Waters PM, et al. Chronic recurrent anterior sternoclavicular joint instability: results of surgical management. *J Pediatr Orthop.* 2006;26:71–74.
19. Burrows HJ. Tenodesis of subclavius in the treatment of recurrent dislocation of the sterno-clavicular joint. *J Bone Joint Surg Br.* 1951; 33:240–243.

20. Castropil W, Ramadan LB, Bitar AC, et al. Sternoclavicular dislocation—reconstruction with semitendinosus tendon autograft: a case report. *Knee Surg Sports Traumatol Arthrosc.* 2008;16:865–868.
21. Friedrich L, Afifi FK, Skarvan J, et al. Combined gracilis tendon autograft reconstruction and discus repair of a chronic anterior-superior sternoclavicular joint dislocation. *Knee Surg Sports Traumatol Arthrosc.* 2012;20:1978–1982.
22. Guan JJ, Wolf BR. Reconstruction for anterior sternoclavicular joint dislocation and instability. *J Shoulder Elbow Surg.* 2013;22:775–781.
23. Kawaguchi K, Tamaka S, Toshitomi N, et al. Double figure-of-eight reconstruction technique for chronic anterior sternoclavicular joint dislocation. *Knee Surg Sports Traumatol Arthrosc.* 2015;23:1559–1562.
24. Sabatini JB, Shung JR, Clay TB, et al. Outcomes of augmented allograft figue-of-eight sternoclavicular joint reconstruction. *J Shoulder Elbow Surg.* 2015;24:902–907.
25. Singer G, Ferlic P, Kraus T, et al. Reconstruction of the sternoclavicular joint in active patients with the figure-of-eight technique using hamstrings. *J Shoulder Elbow Surg.* 2013;22:64–69.
26. Uri O, Barmpagiannis K, Higgs D, et al. Clinical outcome after reconstruction for sternoclavicular joint instability using a sternocleidomastoid tendon. *J Bone Joint Surg Am.* 2014;96:417–422.
27. Gaines RJ, Liporace FA, Yoon RS, et al. A novel technique for ligamentous reconstruction of the sternoclavicular joint. *J Orthop Trauma.* 2014;28:e65–e69.
28. Battaglia TC, Pannunzio ME, Chhabra AB, et al. Interposition arthroplasty with bone-tendon allograft: a technique for treatment of the unstable sternoclavicular joint. *J Orthop Trauma.* 2005;19:124–129.
29. Rockwood CA Jr, Groh GI, Wirth MA, et al. Resection arthroplasty of the sternoclavicular joint. *J Bone Joint Surg Am.* 1997;79:387–393.
30. Tytherleigh-Strong GM, Getgood AJ, Griffiths DE. Arthroscopic intra-articular disk excision of the sternoclavicular joint. *Am J Sports Med.* 2012;40:1172–1175.
31. Rodrigues H. Case of dislocation, inwards, of the internal extremity of the clavicle. *Lancet.* 1843;7:309–310.
32. Eskola A, Vainionpää S, Vastamäki M, et al. Operation for old sternoclavicular dislocation: results in 12 cases. *J Bone Joint Surg Br.* 1989;71:63–65.