Sternoclavicular Joint Reconstruction
A Systematic Review

David Thut, M.D., David Hergan, M.D., Alex Dukas, M.A., Michael Day, M.Phil., and Orrin H. Sherman, M.D.

Abstract
Background: Dislocation of the sternoclavicular joint is a rare injury that has a low incidence of significant long-term symptoms. Surgical reconstruction of the joint is indicated in patients with symptomatic, chronic anterior instability or with irreducible or recurrent posterior instability. There have been many reported techniques for stabilization of the joint, but few investigators have reported more than several cases. The ideal reconstruction has not been identified.

Purpose: The purpose of this investigation was to perform a systematic review of the available literature with the objective of identifying one technique of sternoclavicular reconstruction that could be recommended.

Methods: A systematic review of literature pertaining to treatment of sternoclavicular joint injuries was performed, focusing on clinical reports with at least six patients and 1 year of follow-up. We also reviewed biomechanical reports pertaining to sternoclavicular reconstruction.

Results: Six clinical reports and two biomechanical studies were identified that met our inclusion criteria. Treatments described in the clinical reports included conservative treatment with a sling, repair of the joint capsule with provisional stabilization, and joint reconstruction with local tissue or graft tissue. One biomechanical study compared the strength of three reconstruction techniques.

Conclusion: Reconstruction with tendon tissue woven in a figure-of-eight pattern through drill holes in the manubrium and clavicle is stronger than reconstructions with local tissue. The review of clinical reports suggests excellent outcomes with this technique, and it is recommended in cases of chronic instability. In cases of acute instability requiring open reduction or inability to maintain a reduction in a posterior dislocation, there is evidence that repair of the joint capsule is sufficient surgical treatment.

Injuries to the sternoclavicular joint are rare.1-3 While the bony architecture lends little inherent stability to the joint, the anterior and, particularly, the posterior ligaments make it one of the most stable joints in the body.4-7 Allman8 described sprain injuries to the sternoclavicular joint and assigned them a grade from I (no joint laxity) to III (complete rupture of sternoclavicular and costoclavicular ligaments with dislocation). Dislocation of the sternoclavicular joint occurs most commonly in the anterior direction. The mechanism of traumatic anterior dislocation typically involves an indirect force on the shoulder with the arm abducted.9 Spontaneous anterior and, rarely, posterior dislocations have been reported as well.10-15 Biomechanical studies have shown that the force required to dislocate the clavicle posteriorly is 50% greater than the force needed for an anterior dislocation, due to the strength of the posterior joint capsule.5,16 Accordingly, clinicians see posterior dislocations less frequently. The mechanism can involve either a medially directed force on the shoulder, with the arm adducted and flexed, or a posterior force on the medial clavicle.17-19 Posterior dislocations can be associated with injuries to the underlying mediastinal structures and require formal reduction.20-24 Investigators have encouraged the presence of thoracic surgery personnel in the operating theater during reduction, due to the risk of significant vascular or visceral injury.25
While both spontaneous and traumatic anterior dislocations frequently remain chronically unstable, the incidence of debilitating symptoms is low.26-28 Conversely, the sternoclavicular joint is commonly stable following reduction of a posterior dislocation.23,29 Chronic instability, however, can lead to vascular and visceral injuries over time.30 Indications for surgical stabilization of the sternoclavicular joint include 1. chronic symptomatic anterior instability and 2. recurrent or irreducible posterior dislocation.31 Given the benign course of chronic anterior instability and the rarity of recurrent posterior instability, reconstruction of the sternoclavicular joint is a rare procedure.32 The proximity of the mediastinal structures and the lack of familiarity of most orthopaedic surgeons with the local anatomy make stabilization a relatively risky procedure. Multiple techniques have been reported in the literature, though the published series are typically quite small.33-37 The goal of this article is to review the literature systematically with the objective

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>No. Shoulders</th>
<th>Follow-Up</th>
<th>Procedure</th>
<th>Results</th>
<th>Complications</th>
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<tbody>
<tr>
<td>Ferrandez et al., 1988</td>
<td>Six acute subluxations</td>
<td>2.5 yrs</td>
<td>Valpeau sling, 3 wks</td>
<td>Excellent results for pain, mobility, resumption of work</td>
<td>None</td>
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<tr>
<td></td>
<td>Six acute dislocations</td>
<td>2.5 yrs</td>
<td>Capsule repair with K-wire fixation</td>
<td>Four shoulders with residual deformity, one with small prominence Five with normal motion, one with moderate limitation All resumed work</td>
<td>Two cheloid scars One mediastinal K-wire migration</td>
</tr>
<tr>
<td>Franck et al., 2003</td>
<td>10 acute dislocations: seven ant, three post</td>
<td>&gt; 1 yrs</td>
<td>Balser plate, removed at 3 mos</td>
<td>Avg Constant score 90.2+ -6.6 One sternoclavicular arthritis</td>
<td>One seroma</td>
</tr>
<tr>
<td>Rockwood et al., 1997</td>
<td>Six chronic without prior surgery</td>
<td>5.7 yrs</td>
<td>Resect 1.5 cm medial clavicle, tie capsule and disc into medullary canal, repair capsule</td>
<td>Six excellent results on their scale</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Six chronic with prior surgery</td>
<td>10.1 yrs</td>
<td>Resect 1.5 cm medial clavicle, tie capsule and disc into medullary canal, repair capsule</td>
<td>Two excellent, three fair, one poor</td>
<td>None</td>
</tr>
<tr>
<td>Bae et al., 2006</td>
<td>Nine chronic anterior</td>
<td>55 mos</td>
<td>Graft (8 semitendinosus, 1 sternocleidomastoid fascia) woven in figure-of-eight through two drill holes in manubrium and two in clavicle</td>
<td>Avg SST score, 11.4 (maximum, 12)</td>
<td>None</td>
</tr>
<tr>
<td>Abiddin et al., 2006</td>
<td>Eight shoulders, two acute, six chronic, seven anterior, one posterior</td>
<td>4.5 yrs</td>
<td>Two suture anchors in manubrium, sutures in clavicle, repair capsule</td>
<td>Mean Oxford score15.75 (12 best, 60 worst) Mean Constant Score 74.88 (100 best)</td>
<td>Two reoperations, one after fall from horse, one after failure at 1 year, revision failed at 3 yrs.</td>
</tr>
<tr>
<td>Armstrong and Dias, 2007</td>
<td>Seven shoulders, chronic</td>
<td>39.7 mos</td>
<td>Use medial sternocleidomastoid as graft, leave attached to manubrium, through drill hole in clavicle Repair capsule</td>
<td>Two stable shoulders, four transient subluxation, one instability limiting sports</td>
<td>Two transient scar sensitivity</td>
</tr>
</tbody>
</table>

SST, Simple Shoulder Test
of finding a preponderance of support for one specific technique.

Materials and Methods
We searched the Medline® and PubMed® databases for English language articles relevant to sternoclavicular joint instability. The search terms “sternoclavicular” and “clavicle” were used independently as well as paired with “dislocation” and “reconstruction.” Relevant articles, including review articles, were pulled for study. The bibliographies of each report were reviewed for relevant articles missed in our computerized literature search.

Two different groups of articles were included in our review according to criteria chosen prior to beginning the literature search. Any article directly addressing the biomechanics of sternoclavicular reconstructions in cadavers was included. Clinical articles were required to be primary case series of at least six patients, each receiving the same reconstruction and with at least 1 year of follow-up. Case control studies or randomized studies with six patients per group and 1 year follow-up would have been included as well. Articles were restricted to reconstructions after ongoing traumatic or spontaneous instability. Reconstructions required after clavicle or manubrial resection for infection or tumor were excluded, as those reconstructions included soft tissue reconstruction for chest wall defects. Treatment of sternoclavicular arthritis without instability was also excluded. Two of the authors reviewed articles and abstracts and agreed upon the final list of included articles. The same authors also assessed the level of evidence of each clinical report.

Results

Literature Search
The literature search identified six reports that met inclusion criteria for the clinical reports. While several of the included papers reported results of reconstructions in a heterogeneous group of patients, each had tables that allowed extraction of a group of at least six patients treated in a uniform fashion for instability. All reports represented level IV clinical evidence. The quality of the outcome measures was inconsistent among the reports, but any report with a follow-up of at least 1 year was included per our methodology. Two relevant biomechanical studies were identified that report upon the strength of specific sternoclavicular reconstruction techniques. The clinical reports are summarized in Table 1, and the biomechanical reports are summarized in Table 2.

Clinical Reports
In 1988, Ferrandez and colleagues reported their experience with 17 acute sternoclavicular injuries. Patients were divided into two groups. One group represented a series of six patients with subluxations of the joint, which were treated conservatively with a Valpeau sling for 3 weeks. At follow-up, ranging from 1 to 4 years (average, 2.5 years), all conservatively treated patients had “excellent results in terms of pain, mobility, and resumption of work.” The only exception was one patient unable to return to work due to an unrelated femur fracture. The remaining 10 patients had sternoclavicular dislocations and were treated surgically. All patients were treated with sternoclavicular Kirschner (K-) wires to temporarily stabilize the joint while a capsular repair healed. Four patients had the addition of surgical wire fixation from the medial clavicle to the manubrium. Those patients did not represent a large enough group to be independently included in this study, though it is relevant to note that one of these patients experienced mediastinal migration of a K-wire. The six patients who did not have sternoclavicular wiring, however, are included here. On an average of a 2.5 year follow-up, four patients were reported as having deformity at the sternoclavicular joint, one had no deformity and one had a “small prominence.” Five of the six had what was described as normal motion, while one had moderate limitation. All were able to resume work though one had retired. Two patients had cheloid scarring, and one had mediastinal migration of K-wires.

Table 2 Overview of Biomechanical Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Technique</th>
<th>Results</th>
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<tbody>
<tr>
<td>Thomas et al., 2000</td>
<td>“Safe” repair with two sutures passed through drill holes in manubrium and clavicle</td>
<td>50 kg anterior force caused 50% subluxation of joint repaired both with No. 5 Ethibond and PDS</td>
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<tr>
<td></td>
<td>Suture around clavicle and first rib</td>
<td>50 kg anterior force caused 75% subluxation of joint repaired both with No. 5 Ethibond and PDS</td>
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<tr>
<td>Spencer and Kuhn, 2004</td>
<td>Subclavian tendon through drill holes in medial clavicle</td>
<td>Peak load 75.6 ± 19.0 N anterior 51.5 ± 28.9 N posterior</td>
</tr>
<tr>
<td></td>
<td>Capsule and disc into medullary canal</td>
<td>Peak load 84.6 ± 45.7 N anterior 85.0 ± 22.8 N posterior</td>
</tr>
<tr>
<td></td>
<td>Figure-of-eight semitendinosus graft through two drill holes in clavicle and two in manubrium</td>
<td>Peak load 230.3 ± 146.1 N anterior 241.4 ± 49.7 N posterior</td>
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<tr>
<td></td>
<td></td>
<td>(p = 0.004 relative to intramedullary anterior)</td>
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<tr>
<td></td>
<td></td>
<td>(p = 0.004 relative to both intramedullary and subclavian posterior)</td>
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PDS, polydioxone suture.
In 1997, Rockwood and associates\textsuperscript{\textcopyright 14} reported on their re-
was the only complication. \textsuperscript{\textcopyright 6.6. The seroma 
Constant score for the group was 90.2 
he had the lowest Constant score in the group. The average 
patient had arthrosis noted on radiographic evaluation, and 
reported. The investigators noted no redislocations. One 
of follow-up was not reported). DASH (disabilities of the 
follow-up at greater than 1 year after surgery (average length 
of follow-up was not reported). DASH (disabilities of the 
arm, shoulder, and hand) score and Constant scores were 
reported. The investigators noted no redislocations. One patient had arthrosis noted on radiographic evaluation, and he had the lowest Constant score in the group. The average Constant score for the group was 90.2 ± 6.6. The seroma was the only complication.

In 1997, Rockwood and associates\textsuperscript{\textcopyright 14} reported on their re-
results of reconstructing the stabilizing ligaments of the medial 
clavicle using the joint capsule and disc, while preserving the periosteal attachments of the proximal clavicle. All patients had chronic symptoms following sternoclavicular injuries. Their two groups were divided based upon presence of previous surgery. While they included patients with post traumatic arthritis and instability, we were able to extract data for those with instability. The procedure involved dissecting the periosteal sleeve off of the medial clavicle from the cranial to caudal surface, keeping a tube intact for later repair. The medial aspect (1.5 cm) of clavicle was resected. The capsule and disc were maintained and brought with a suture into the medial medullary canal of the clavicle and tied through drill holes. The periosteal sleeve was then repaired. If the costoclavicular ligaments were injured, several sutures were placed to hold reduction of the medial clavicle to the first rib. The investigators devised a rating scale based on pain, range of motion, strength, limitation, and subjective result in order to evaluate outcomes. Excellent, good, fair, and poor results were defined based on numerical scores. Of the six instability patients in group I, those without prior surgery, all achieved excellent results. Time of follow-up ranged from 2.0 to 14.5 years (average, 5.7 years). Of the 6 patients with instability in group II, the prior surgery group, two achieved excellent results, three fair and one poor results. Time of follow-up ranged from 3.3 to 18.3 years (average, 10.1 years). The study concluded that patients with atraumatic spontaneous anterior dislocation should be treated nonsurgically. Traumatic anterior dislocations are treated conservatively, unless there is ongoing painful 

In 2003, Franck and coworkers\textsuperscript{\textcopyright 42} reported their experience 
with sternoclavicular stabilization with a Balser plate. They operated on 10 patients diagnosed with acute instability of the sternoclavicular joint but in whom a stable reduction could not be achieved. Seven patients had anterior dislocations, and three had posterior dislocations. One of the posterior dislocations was associated with a medial clavicular physeal injury. The surgical technique consisted of placing a hooked plate on the medial clavicle to reduce the dislocation. In patients with anterior dislocations, the hooks were placed posterior to the manubrium. In the patients with posterior dislocations, the hooks were placed in an intraosseous position in the manubrium to prevent redisplacement posteriorly. Plates were removed at 3 months after injury, with the exception of one patient who had the plate removed at 2 months due to seroma formation. Nine patients were available for follow-up at greater than 1 year after surgery (average length of follow-up was not reported). DASH (disabilities of the arm, shoulder, and hand) score and Constant scores were reported. The investigators noted no redislocations. One patient had arthrosis noted on radiographic evaluation, and he had the lowest Constant score in the group. The average Constant score for the group was 90.2 ± 6.6. The seroma was the only complication.

In 2006, Bae and colleagues\textsuperscript{\textcopyright 43} reported the results of 
surgical stabilization of the sternoclavicular joint for chronic instability after anterior dislocations. All patients had been through and failed a course of conservative treatment. Twenty-four patients had undergone surgery and 15 were available for longer-term follow-up. Average age of patients was 15.9 years, with a range of 12 to 23 years. Average follow-up was 55 months, with a range of 7 to 164 months. The investigators utilized several surgical techniques. Five had medial clavicular resections, with removal of 2 to 2.5 cm of bone and closure of the medial periosteum “when possible.” Nine patients had reconstruction of the medial sternoclavicular joint. In eight patients, semitendinosus tendon was used, and, in one case, sternocleidomastoid fascia graft was used. In each reconstruction case, the graft was woven in a figure-of-eight through drill holes in the medial clavicle and the manubrium. Postoperatively, the patients were immobilized in a sling and swathe for 2 to 4 weeks, followed by progressive mobilization in PT. Unfortunately, the only outcome measure that is divided out based upon surgical technique is the Simple Shoulder Test (SST). The maximum possible score is 12, and higher numbers reflect better shoulder function. In the reconstructed patients, the average score was 11.4, with a range from 8 to 12. No major complications were reported.

Abiddin and coworkers\textsuperscript{\textcopyright 44} published their experience 
with sternoclavicular stabilization using suture anchors in 2006. Their cases were somewhat heterogeneous. Of their eight shoulders, five had traumatic instability and three had spontaneous instability. All but one of the patients had anterior instability. The indications for surgery were described as “pain associated with instability of the sternoclavicular joint.” Patient age ranged from 16 to 48 years, average 23.5 years. Follow-up ranged from 1 to 7.6 years with a mean of 4.5 years. The procedure was performed at a mean of 14 months after initial dislocation, but the range was from immediate to 4 years. Though not explicitly stated in the text, it appears that the one joint that was immediately stabilized was in a 16-year-old patient, who had undergone stabilization on the right side and then in falling from a horse sustained a redislocation of the operative side and a new dislocation of the left sternoclavicular joint. The right side was revised and the left side was repaired acutely. The reported technique involved placing two suture anchors in the manubrium and passing the sutures through drill holes on the anterior surface of the clavicle. The joint capsule was then repaired. Patients were immobilized in a sling for 2 weeks, followed by progressive mobilization. No strenuous activities were allowed for 4 months. At follow-up, there were no instances of infection or hardware migration. Two patients required reoperation. One was the patient who had fallen from a horse, and the other was a patient with initial
Injuries that included sternum and rib fractures. He required revision stabilization 1 year after initial surgery. He had satisfactory results after initial revision for 3 years, but then had a medial clavicle excision. Reported results included the subjective Oxford Shoulder Questionnaire and the objective Constant Score. On a range from 12 (best) to 60 (worst), the mean Oxford score was 15.75 (range, 12 to 38). The average Constant score was 74.88 (range, 33 to 87), with the maximum Constant score of 100 representing a best outcome. The only unsatisfactory result was for the patient with multiple surgeries (Constant score, 33). The investigators concluded that their technique was anatomic and easy to perform, with a low complication rate. They recommended the procedure for patients with persistent, painful recurrent instability of the sternoclavicular joint.

Armstrong and Dias\textsuperscript{45} published their results of sternoclavicular reconstruction using sternocleidomastoid tendon in 2007. Their series included seven shoulders in six patients with chronic sternoclavicular instability. Their patients ranged in age from 18 to 24 years, with an average of 20.7 years. Four patients had a history of trauma, and the others had spontaneous instability. In six, shoulder symptoms were present from 2 to 8 years. One patient had 3 months of symptoms, and in one patient duration was not documented. Their surgical technique was as follows: the medial border of the sternocleidomastoid tendon was released proximally to obtain a 3 mm piece of tendon, with a strong manubrial attachment of at least 8 cm in length. The suture was passed from cranial to caudal through a 3.2 mm drill hole made in the medial clavicle. The tendon was then repaired to itself at the manubrial insertion. The capsule and disc were repaired. Patients were reviewed at a mean follow-up of 39.7 months (range, 15 to 63 months). Two patients reported scar sensitivity, one transient, but on resolving only after 1 year. They reported only on the stability of the joint. Two patients had a joint that was stable for all activities; four patients were stable except for transient subluxation but were not limited in activity; and one patient was stable most of the time but unable to participate in sports. The only patient with residual pain was the one with scar sensitivity, which resolved. They note that one of their patients was able to return to rugby.

**Biomechanical Reports**

Thomas and associates\textsuperscript{46} reported on a “safe” technique to suture the medial clavicle to the manubrium. They described their “safe” repair as using two sutures passed through drill holes in the medial clavicle and manubrium anteriorly. Rather than passing the sutures out the posterior cortices, however, the sutures were brought through the cortex in the joint, so as not to enter the intrathoracic space. This approach was compared to a repair where the sutures were passed around the medial clavicle and first rib. Four joints were used. The “safe” repair was performed using No. 5 Ethibond and PDS (polydioxone) suture. The first rib repair was performed using the same two sutures. Each construct, therefore, was tested in only one joint. The two “safe” repairs were intact with 50 kg of anteriorly directed force applied to the medial clavicle; however, both had 50% anterior subluxation of the joint. The first rib repairs also held 50 kg of force but with 75% anterior subluxation. The investigators then reported on three cases where their “safe” technique was used for joint reconstruction, making no mention of capsular closure.

Spencer and Kuhn\textsuperscript{47} compared the strength of three different reconstructions in cadavers. The first reconstruction used the subclavian tendon, left on its first rib attachment, and bringing it through a drill hole in the medial clavicle, as described by Burrows.\textsuperscript{46} The second reconstruction, the intramedullary ligament reconstruction, was as described by Rockwood and colleagues.\textsuperscript{14} The details are outlined above. The third reconstruction was using a semitendinosus tendon in a figure-of-eight through two drill holes in the medial clavicle and two drill holes in the manubrium. Each repair was tested in anterior and posterior directions. The reconstructions were compared to the stiffness of native ligaments. In the anterior direction, the intramedullary reconstruction showed a 70.1% decrease in stiffness, the subclavian reconstruction showed a 56.9% decrease in stiffness, and the figure-of-eight reconstruction showed a 36.9% reduction in stiffness. There was no significant difference between the figure-of-eight and the subclavian reconstructions (p = 0.078), but there was between the figure-of-eight and the intramedullary ligament reconstruction (p = 0.004). The peak load, defined as the load causing 100% displacement of the medial clavicle, was 230.3 ± 146.1 N for the figure-of-eight, 84.6 ± 45.7 N for the intramedullary, and 75.6 ± 19.0 N for the subclavian. In the posterior direction, the intramedullary reconstruction showed a 74.4% decrease in stiffness, the subclavian reconstruction showed an 82.3% decrease in stiffness, and the figure-of-eight reconstruction showed a 3.8% reduction in stiffness. The differences were significant between the figure-of-eight and the other two methods (p = 0.004). Peak load was 241.4 ± 49.7 N for the figure-of-eight reconstruction, 85.0 ± 22.8 N for the intramedullary reconstruction, and 51.5 ± 28.9 N for the subclavian reconstruction. Four of the six subclavian reconstructions failed before reaching 100% anterior displacement, and all of them failed prior to reaching 100% posterior displacement.

**Discussion**

The goal of our systematic review was to determine the best method of reconstructing the unstable sternoclavicular joint. We were able to identify six clinical papers reporting on seven case series that met our inclusion criteria. No report had a level of evidence greater than level IV. Unfortunately, the reports’ heterogenous outcome measures do not lend themselves easily to comparison. Additionally, the paucity of complications reported hinders stratification of the techniques based on that measure.

Two reports addressed the stabilization of acutely injured
joints. Ferrandez and coworkers\(^41\) treated six patients with acute capsular repair and stabilization with K-wires. One patient had a K-wire migrate into the mediastinum, only one of the six had no deformity, one had limitation of motion, but all returned to work. The second report by Franck and associates\(^42\) reported the use of a hooked Balser plate to provisionally fix the joint, while awaiting healing of the repaired capsule. They had no redislocations and an average constant score of 90.2 ± 6.6. One patient developed arthritis in the joint. The positive results in these studies suggest that if surgery is required in the acute setting, capsular repair with provisional fixation may be satisfactory treatment. The risk of wire migration is significant and is reported in multiple other studies in the literature.\(^49\)-\(^52\)

The reports included in our review described five different reconstruction techniques for chronic instability. Rockwood and colleagues\(^14\) developed their own scoring system to evaluate sternoclavicular symptoms. They found that in patients with instability, excellent results were consistently obtained by simple resection of the medial clavicle and closure of the periosteal sleeve over the bone. Abbidin and coworkers\(^43\) stabilized the medial clavicle with suture anchors in the manubrium. Two of eight shoulders required revision surgery, one due to recurrent trauma and one because of failure at 1 year.

Three of the reconstruction techniques utilized tissue grafts to reconstruct the joint. Rockwood and associates\(^14\) used the joint capsule and intra-articular disc, pulled into the osseous canal, to stabilize joints that had previous resections. Two patients achieved excellent results, three had fair results, and one had a poor result; there were no good results. Armstrong and Dias\(^45\) used sternocleidomastoid tendon through a single drill hole in the medial clavicle to reconstruct the joint in seven shoulders. Two patients had a joint that was stable for all activities, four were stable except for transient subluxation, and one was unable to participate in sports.

Bae and colleagues\(^43\) reported their results reconstructing the sternoclavicular ligaments, using tendon graft passed in a figure-of-eight through drill holes. They reported no complications and an average score on the SST of 11.4 (maximum, 12). The excellent results in their report are corroborated in two case reports in the literature as well. In addition, the strong clinical outcomes for this technique are supported by biomechanical studies. Spencer and Kuhn\(^47\) showed that the initial strength of such a reconstruction was significantly stronger than either an intramedullary reconstruction, as recommended by Rockwood and coworkers\(^14\) or a subclavian reconstruction as advocated by Burrows.\(^48\)

In preparing our study, we performed a thorough review of the English literature on reconstruction for sternoclavicular instability. Strict, predetermined criteria were used to evaluate reports for inclusion in our review. We were able to include six clinical reports and examine the results of different treatments. Our clinical findings were strengthened by the results of a very good biomechanical report evaluating reconstruction strength.

A review of this literature is limited by the fact that most papers report single cases or small series of patients. There are several published techniques without sufficient numbers of patients or sufficient follow-up to be included in our review.\(^53\) We identified no prospective studies, and the outcome measures in most reports were weak. The incidence of sternoclavicular instability requiring surgery is low enough that a randomized prospective study is unlikely to have sufficient numbers of patients unless a multicenter trial was developed. Our hope is that future reviews of clinical results will include prospectively collected data on joint stability, shoulder range of motion, return to activity, and validated shoulder-specific outcome measures. Because of the low numbers of patients, studies have not adequately separated shoulders with different types of instability. Anterior and posterior instability are typically reported together, with little effort to separate acute from chronic instability. A large multicenter study may demonstrate that different techniques are successful in different clinical scenarios.

The medial physis of the clavicle remains open into a person’s mid-twenties, so dislocations of the sternoclavicular joint in children typically represent a fracture dislocation. We excluded articles that explicitly described treatment of fracture dislocations.\(^53\)-\(^56\) We note that in the Bae and associates\(^43\) report, the average age of the patients was 15.9 years, though injuries were described as joint dislocations. Future studies should be clear about the difference between shoulder dislocation and fracture dislocation.

**Conclusion**

The literature supports conservative treatment for most patients with chronic anterior sternoclavicular instability, as these patients will tolerate their condition. Those patients with ongoing disability may be candidates for joint reconstruction. Patients with posterior dislocations are typically stable after reduction, but require surgery if they redislocate or if there is ongoing symptomatic instability. The clinical literature is replete with proposed procedures to stabilize the sternoclavicular joint. A systematic review of both clinical and biomechanical data led us to recommend a reconstruction technique for patients who have continued symptomatic instability. The approach is to use tendon graft in a figure-of-eight fashion through drill holes in the sternum and manubrium. Patients who are treated surgically in the acute setting may do well with provisional stabilization of the joint and repair of local joint capsule. Surgeons should be aware of the significant risk of pin migration at the sternoclavicular joint.

**Disclosure Statement**

None of the authors have further financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock
ownership, honoraria, and paid expert testimony.

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