Interposition Arthroplasty With Bone–Tendon Allograft: A Technique for Treatment of the Unstable Sternoclavicular Joint

Todd C. Battaglia, MD, Michael E. Pannunzio, MD, Abhinav B. Chhabra, MD, and Gregory G. Degnan, MD

Summary: Sternoclavicular joint instability is an uncommon but challenging clinical problem for the orthopaedic surgeon. Although most cases can be treated nonoperatively with minimal long-term pain or functional limitation, a small percentage may require surgical intervention. This includes chronic anterior instability associated with persistent pain or functional limitation as well as irreducible or recurrent posterior instability. Although numerous procedures have been described for treatment of the unstable sternoclavicular joint, the optimal method for stabilization has not been determined. Here we describe a technique using Achilles tendon allograft to create an interpositional arthroplasty and briefly present 3 illustrative cases in which we performed the procedure. We believe this method effectively stabilizes the joint, restores function, relieves pain, and has applications for traumatic sternoclavicular instability as well as instability related to other etiologies.

Key Words: sternoclavicular joint, dislocation, instability, interposition arthroplasty

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Sternoclavicular (SC) joint instability is an uncommon but challenging clinical dilemma. The majority of cases involve traumatic SC joint dislocations, which comprise only 3% of all shoulder injuries and 1% of all joint dislocations.[1–3] Large forces are typically required to produce these injuries, with motor vehicle accidents and contact athletics such as rugby and American football the most commonly implicated mechanisms.[1,4–6] Less common etiologies of SC joint instability include spontaneous dislocation, which classically occurs in young adults with generalized ligamentous laxity, and congenital deformity.[3,6–9] Nonunited fractures of the very medial clavicle—the so-called "pseudodislocation"—may also have a similar clinical presentation and require a treatment approach similar to that for true SC joint dislocation.[5,10] In fact, many SC joint injuries in patients younger than 25 years of age are actually fractures through the medial clavicular physis.[11] Regardless of etiology, however, anterior instability (i.e., where the clavicle translates anteriorly) is 3 to 20 times more common than posterior instability.[2,5,6,12,13]

Although nearly all cases of spontaneous dislocation respond to rehabilitation and skillful neglect, attempted closed reduction is recommended for acute traumatic anterior or posterior dislocation.[5,12,14,15] Many anterior dislocations remain unstable after closed reduction, but fortunately, recurrent and even irreducible anterior dislocations are usually tolerated without significant sequelae or complication.[3,5,6,12,14,15] Conversely, posterior dislocations are usually stable after closed reduction, especially if performed within 2 to 7 days after injury.[3,15,16] Successful closed reduction is occasionally not possible for these injuries, however, and due to potential compromise of the vital structures in close proximity to the medial clavicle, open reduction and fixation is then recommended.[2,5,6,15,17–19] Ultimately, despite occasional past recommendations for open reduction and fixation of all SC joint dislocations,[17] only a small population of patients with irreducible or recurrent posterior dislocation or chronic, symptomatic anterior instability typically requires operative intervention.[20]

Unfortunately, the optimal method of stabilization of the SC joint has yet to be determined. A variety of methods to stabilize the medial clavicle or reconstruct the SC joint have been described, many of which have been associated with significant complications.[2,5,13,15] Here, we describe a technique for stabilization of the SC joint using Achilles tendon (or other bone–tendon) allograft. Although previously described techniques have used assorted tendon grafts to stabilize the joint,[5] we are aware of none that use bony fixation to secure the graft, nor any that use the graft to resurface the medial clavicle, essentially producing an interpositional arthroplasty. In our experience, this procedure is useful for pure ligamentous insta-

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From the Department of Orthopaedic Surgery, University of Virginia, Charlottesville, VA.

Reprints: Todd C. Battaglia, MD, Department of Orthopaedic Surgery, University of Virginia Health Sciences Center, Box 800159, 400 Ray C. Hunt Drive, Charlottesville, VA 22908-0159 (e-mail: tcb9n@virginia.edu).

bility as well as medial clavicle fractures that make the SC joint unstable. Additionally, it effectively relieves pain, limits loss of motion, and minimizes potential complications often associated with other procedures.

SURGICAL TECHNIQUE

After induction of general anesthesia, the patient is placed supine in the semisitting (beach chair) position with all bony prominences well padded. A sandbag or a bump of towels placed between the scapulae assists with exposure. The chest, neck, and operative extremity are prepped and draped in a standard sterile fashion (Fig. 1). It is important to drape the extremity free to allow traction to be applied if necessary during the case. A 6 to 8 cm surgical incision is obliquely centered over the medial clavicle and SC joint and extends over the manubrium. The incision is created sharply through the skin and subcutaneous tissues directly onto the anterior clavicle. A thin layer of platysma may be present at this level and can be preserved for later repair. Careful dissection of the periosteum off the clavicle with the cautery is used to expose the medial clavicle, taking care to preserve the costoclavicular ligament insertion, if intact. The capsular ligament is also opened to expose the joint (Fig. 2). A broad, blunt retractor is placed posterior to the medial clavicle and SC joint and should be used judiciously from this point forward to protect the underlying thoracic contents.

Once the dissection is complete and the medial clavicle and SC joint are exposed, medial clavicle resection is performed. For purely ligamentous instability, a sagittal saw is used to resect approximately 10 mm of medial clavicle. The intra-articular disc and articular cartilage should be debrided as well. In cases involving a medial clavicle fracture, any comminuted fragments should be removed, along with the remnants of the articular cartilage and intra-articular disc. Additional bony resection with the saw may also be necessary to reach a total resection of 1 cm of medial clavicle. Thus, a fracture involving more than the medial 10 to 15 mm of clavicle may preclude use of this technique, as the resection level necessary to reach solid bone will leave a sternoclavicular gap too large to bridge stably with the allograft. Once the resection is complete and the joint window exposed, any fibrous or scar tissue posterior to the joint must be debrided to allow reduction, and subperiosteal dissection should be continued around the posterolateral corner of the sternum.

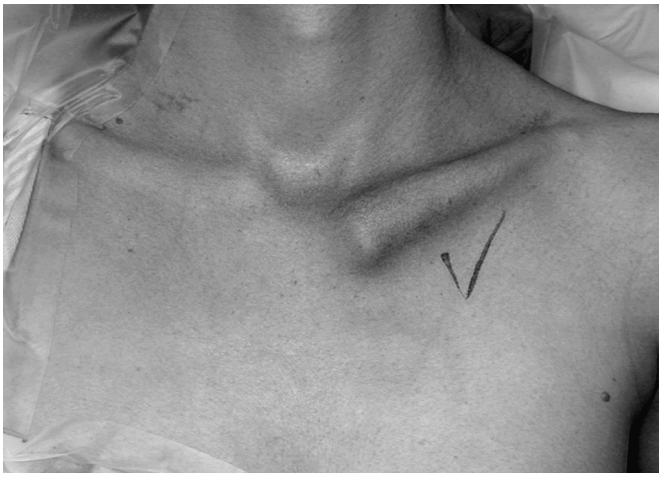

FIGURE 1. Intraoperative photograph demonstrating correct surgical positioning of a patient with a left anterior sternoclavicular dislocation.

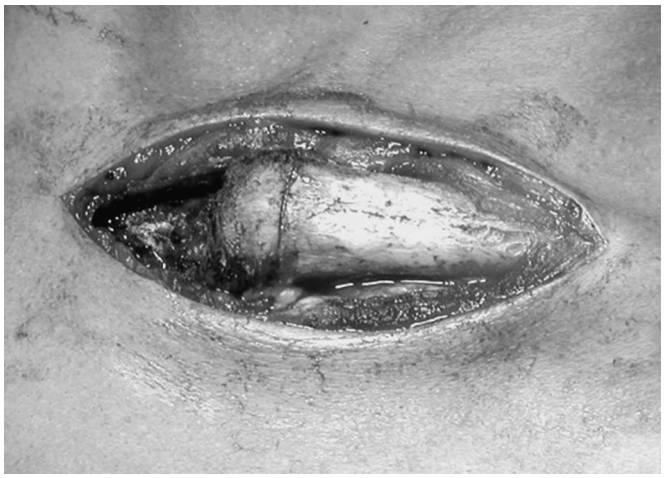

FIGURE 2. Intraoperative photograph demonstrating the surgical incision and exposure for sternoclavicular interposition arthroplasty.

Using a high-speed 4 mm rotary burr, an intraosseous tunnel is then created in the manubrium. The tunnel should be directed in an anterior to posterolateral direction, exiting out the posterior margin of the sternal joint surface (Fig. 3). Again, a retractor must be held deep to the manubrium at all times to prevent inadvertent injury to the vital posterior structures, as the great vessels and mediastinal contents lie directly retrosternal. It is strongly encouraged that a thoracic surgeon be readily available when performing this procedure. The burr or sagittal saw is also used to create a slot in the anterior surface of the medial clavicle, which will accept the bone plug of the allograft. This slot should measure approximately 15 mm in length, 8 to 10 mm in width, and 5 mm in depth. The posterior clavicular cortex is not violated (Fig. 3). Similarly, the allograft bone plug is reciprocally contoured to fit into the clavicular defect. Once a good fit is obtained, a towel clip used to provisionally hold the plug in position, confirming appropriate contouring of the plug to the clavicle. The distal end of the allograft tendon is then trimmed to fit through the sternal burr hole. The tendon is threaded through the sternal tunnel from posterior to anterior, and doubled back, looping it around itself to create an "anchovy"-type soft-tissue interposition. In cases

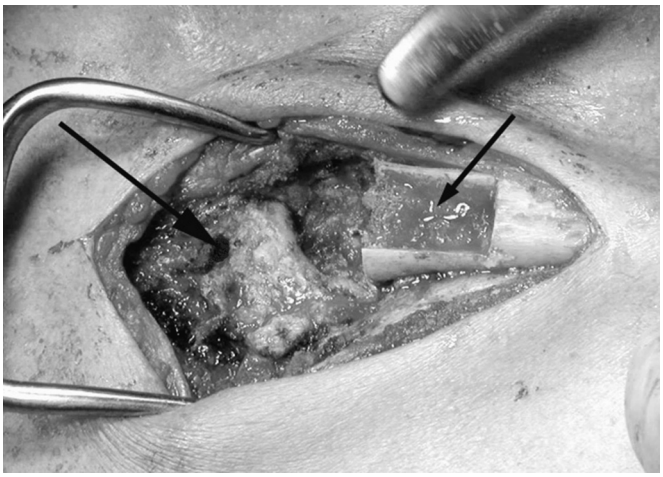

FIGURE 3. Intraoperative photograph demonstrating the clavicular trough (small arrow) and sternal burr hole (large arrow).

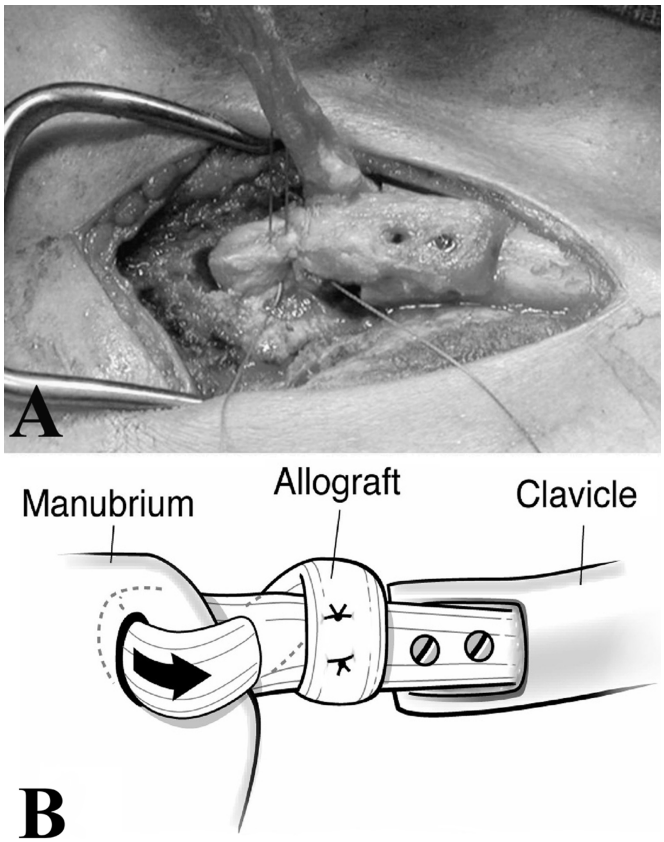

FIGURE 4. A, Intraoperative photograph demonstrating allograft placement and fixation. After completion (B), the bone plug will be secured with a second screw and the tendon will be wrapped around itself to increase the interposition (B).

of anterior clavicular dislocation, we thread the tendon through the sternum from back to front, to maximize the posterior vector pull on the medial clavicle. In cases of posterior dislocation, we pass the tendon from front to back for the opposite effect. Final fixation of the bone plug to the clavicle is completed using standard AO technique with two 2.7 or 3.5 mm lag screws. The clavicle is then reduced and the tendon allograft gently tensioned and sewn back upon itself with Ticron (US Surgical, Norwalk, CT) or other nonabsorbable suture (Fig. 4A). The graft should then be woven around itself in a figure-of-eight pattern to increase the surface area of the interposition and again secured with sutures (Fig. 4B).

After adequate hemostasis has been obtained, the wound is thoroughly irrigated with antibiotic solution and closed in layers. The platysma and subcutaneous layer may be closed with interrupted absorbable sutures. To minimize cosmetic deformity, staples are not recommended for skin closure. Immediate postoperative radiographs must be obtained to assess device placement and ensure there is no pneumothorax.

EXAMPLE CASE 1

The patient in this case was a 30-year-old right-handed female who was involved in a high-speed motor vehicle accident. Her only significant injury was a left anterior SC joint dislocation (Fig. 5). Closed reduction was performed without difficulty in the emergency room on the day of injury; however, she immediately redislocated when pressure was released. A second reduction was performed but was also unstable. The patient was then discharged to home in a sling. At her clinic visit the following week, the options of observant management versus surgical stabilization were discussed.

Approximately 6 weeks after the initial injury, the patient continued to have significant SC pain and expressed displeasure with the cosmetic deformity. She had also developed mild adhesive capsulitis of the ipsilateral shoulder during the period of sling immobilization. She elected to undergo SC joint reconstruction as described; a closed shoulder manipulation was performed at the same time. Her surgery was uneventful, and she was discharged to home the same day (Fig. 6). At her first postoperative visit (4 days after surgery), her wound was noted to be healing without sign of infection, and gentle physical therapy focused on passive glenohumeral motion, including internal rotation, external rotation, and pendulum exercises, was begun. No abduction or other significant SC joint motion was allowed for 6 weeks. At 6 weeks, her incision was well healed with only a slight prominence over the left SC joint when compared with the contralateral side. More aggressive range of motion exercises including overhead activities were instituted, with slow integration of strengthening maneuvers.

Range of motion at 2 months postoperatively demonstrated full forward elevation, full abduction, and internal and external rotation equivalent to the uninjured side. When assessed 15 months post-operatively using the sternoclavicular joint scoring system developed by Rockwood et al,[21] the pa-

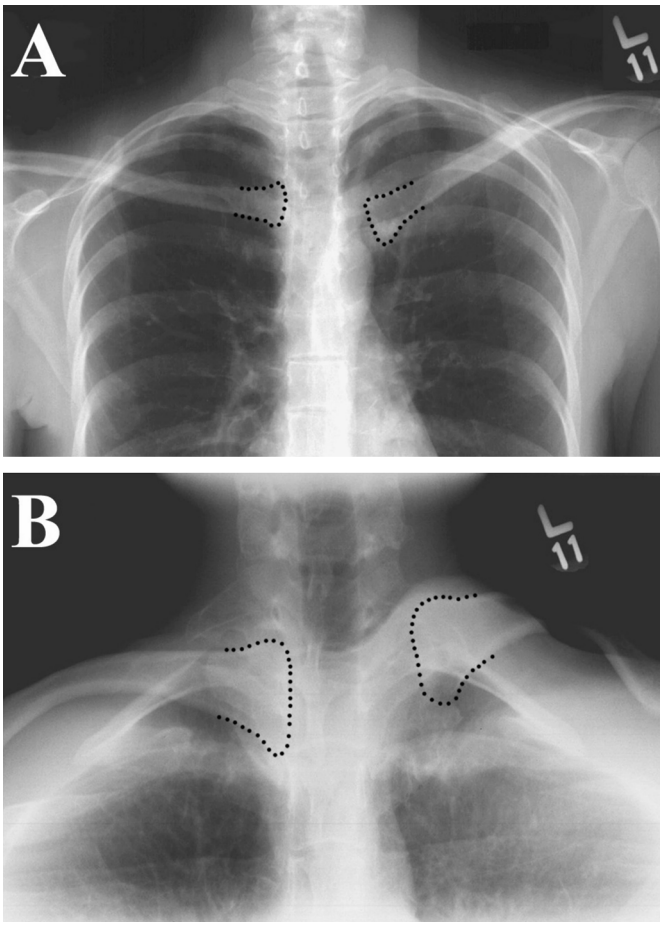

FIGURE 5. Preoperative (A) anteroposterior and (B) serendipity (Rockwood) radiographs demonstrating asymmetry and anterior dislocation of the left sternoclavicular joint.

tient's score of 14 (out of 15) was consistent with an overall excellent result. Importantly, her SC joint was asymptomatic; her minimal deficits were attributable to residual glenohumeral symptoms.

EXAMPLE CASE 2

The patient in case 2 was a 52-year-old right-hand-dominant female who fell down a flight of stairs onto her right shoulder, suffering a comminuted intra-articular fracture of her medial clavicle. This was treated nonoperatively by the referring physician, but the patient continued to complain of persistent pain with arm abduction and forward elevation more than 5 months after the injury. She also complained of a subjective sensation of posterior SC subluxation and periodic dysphagia. A computed tomography (CT) scan demonstrated no gross dislocation but did demonstrate nonunion of the medial clavicular fracture. Her symptoms failed to improve over the next 2 months despite further nonoperative treatment including a bone stimulator, abduction splinting, and activity restriction.

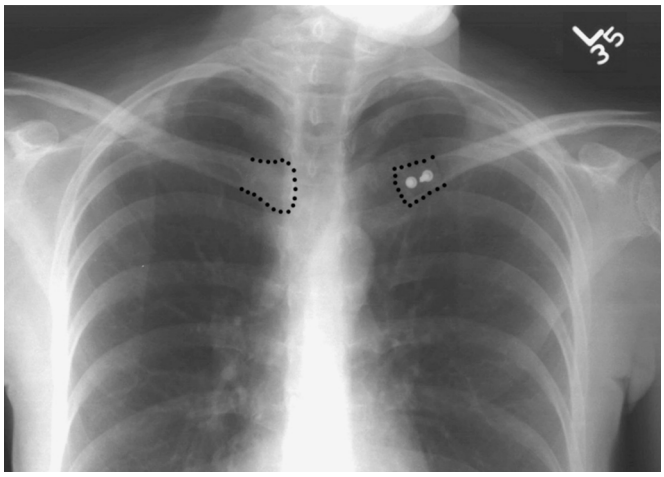

FIGURE 6. Postoperative radiograph demonstrating appropriate reduction of the left clavicle and device placement.

After discussion of medial clavicle resection versus reconstruction, the patient elected to proceed with the procedure described. This was performed 8.5 months after the original injury without intraoperative complication. She remained in the hospital for 2 days postoperatively and was discharged to home in a shoulder immobilizer. At her 10-day follow-up, her wound was healing well, and passive pendulum and shoulder rotation exercises were prescribed. One month later, abduction, overhead, and strengthening activities were added. The patient progressed well with the exception of a short period of discomfort and swelling 4 months postoperatively after mowing a 6-acre lawn with a push mower. This resolved after a single injection of local anesthetic and triamcinolone. Six months after surgery, the patient's range of motion was painless and symmetric in all directions when compared with the nonoperative side, with only minimal SC pain noted with cross-body hyperadduction maneuvers; this symptom also resolved by her 8-month follow-up. Twenty-five months after surgery, her Rockwood score was 14.

EXAMPLE CASE 3

This patient was a 22-year-old right-hand-dominant male Naval officer and competitive baseball player involved in a motor vehicle accident. His only significant injury was an anterior dislocation of his right SC joint. This was initially managed nonoperatively, with a short period of sling immobilization followed by physical therapy and gradual return to activities. He continued to suffer persistent pain, subjective "popping" of the joint, and inability to extend his shoulder to reach his back pockets. Multiple intra-articular injections had provided only temporary relief. When he presented at 2 years postinjury, he stated he was unable to perform his duties as a machinist or participate in athletics.

After discussion of the treatment options, he elected to undergo SC joint reconstruction as described. In this case, a

bone–patellar tendon allograft was used instead of Achilles tendon due to availability. Postoperatively, the patient was immobilized for 4 weeks, and then began gentle range of motion exercises, with no lifting or overhead activities allowed for 2 months. At 8 weeks after surgery, the patient was pain free except for mild incisional hypersensitivity, and at 6 months, he had joined a softball team and was throwing without pain. By his 1-year follow-up, the patient was playing baseball for a Division III collegiate team and reported full strength and range of motion in the operative extremity without pain or functional limitation, equivalent to a Rockwood score of 15. These results were unchanged at his last follow-up, more than 3 years after surgery.

DISCUSSION

Although most cases of SC joint dislocation or instability can be managed nonoperatively, surgical intervention may be necessary for chronic pain or limitation associated with anterior instability and for recurrent or irreducible posterior instability. The goals of surgery are pain relief and functional improvement through restoration of SC joint integrity and anatomy. The SC joint is the only articulation that joins the upper extremity to the torso and is capable of movement of more than 30° to 35° in all directions with normal shoulder motion.[5,16,22] Fortunately, the anatomy of the joint renders it an infrequently injured structure, with great intrinsic stability due to strong surrounding ligaments.

The joint capsule appears to be the most important anatomic structure in preventing displacement, especially the anterior and posterior capsular thickenings that form the anterior and posterior sternoclavicular ligaments.[23,24] The anterior ligaments were once believed to be stronger than the posterior ligaments, but a number of recent studies demonstrate that the posterior sternoclavicular ligament is the single most important factor in preventing both anterior and posterior translation.[5,6,12,22,25–28] The costoclavicular (rhomboid) ligament, which runs from the superior rim of the first rib to the clavicular undersurface, and the interclavicular ligament, which joins the 2 clavicular heads, add relatively little additional stability to an intact joint.[7,12,22,28]

A myriad of surgical procedures have been described to stabilize the SC joint, most attempting to directly repair the capsular ligaments or reconstruct them with soft tissue (using tissues including sternocleidomastoid, subclavius, fascia lata, Dacron tape, pectoralis, palmeris, plantaris, and gracilis tendons) or temporary bony fixation (with suture, metal wires, cannulated screws, and even external fixation).[3,5,10,29–31] Alternately, some authors have recommended stabilization of the clavicle to the first rib using sternocleidomastoid, subclavius tendon, or Dacron, with or without medial clavicle resection.[7,12,21] Many of these techniques have been developed in response to specific complications of other techniques, including catastrophic wire migration, recurrent instability, and bony erosion or nonunion.[2,5,13,15,31]

The procedure described in this paper, in addition to reducing the SC joint and restoring the ligamentous restraints to anteroposterior translation, effectively resurfaces the medial clavicle and provides a soft-tissue interposition through which motion can occur. In our experience, this effectively relieves pain but avoids the potential loss of motion associated with procedures that fix the medial clavicle to the first rib or fuse the SC joint and lessens the potential instability associated with medial clavicle excision. Furthermore, this technique does not require exposure of the first rib, diminishes the risks of bony erosion by Dacron or other cerclage material, and minimizes risks of device migration associated with smooth pins or wires. Finally, use of allograft eliminates the morbidity associated with autograft harvest sites.

Given the relative rarity of SC joint dislocations and the small percentage of those injuries that require operative treatment, it is not surprising that the literature on the subject consists largely of case reports and small patient series. Although this paper's senior author (G. D.) has used this technique for over a decade, he has performed the procedure fewer than 15 times.[32] Despite excellent anecdotal success, the majority of those cases were performed in the military, which does not maintain a central medical records system, preventing record retrieval and a larger, more formal outcome study. Certainly, this is a technically demanding procedure and is probably best used by the experienced shoulder girdle surgeon. We strongly recommend that appropriate assistance be available should complications arise, especially during the dissection and drilling portions of the case. The use of allograft is also not without risk, including the possibilities of infectious disease transmission or potential long-term deterioration given the large biomechanical stresses seen at the SC joint. In our experience, however, this procedure has been effective for pure ligamentous disruptions of the SC joint, including both anterior and posterior dislocations, as well as for very medial clavicle fractures that render the SC joint unstable. It may also be useful for primary degenerative disease of the SC joint, offering greater stability than the resection arthroplasty described by Rockwood et al.[21] Regardless, we do not recommend that this or any other reconstructive technique be the first option for SC instability. With nonoperative treatment, many, if not most, cases will go on to stable healing, with no lasting pain or functional limitations. However, for those patients plagued by persistent complications, or for those unwilling to accept the cosmetic deformity often associated with nonoperative treatment, we believe that this procedure is an effective method to reduce pain and restore function.

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