Technical Note

Sternoclavicular Joint Reconstruction With Gracilis Tendon Autograft

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Abstract: Clinical instability of the sternoclavicular (SC) joint is a challenging problem. Recurrent subluxation and pain can lead to significant functional limitations. Although many patients respond positively to conservative treatment, chronic dislocations often require operative intervention. The complex anatomy of the diarthrodial SC joint and the existence of concomitant SC joint degenerative changes compounded with close-by neurovascular structures present a surgical challenge. The purpose of this Technical Note is to describe a technique for the open management of symptomatic sternoclavicular joint instability using a figure-of-8 reconstruction with a gracilis autograft. The present authors believe this technique provides a technically safe and reproducible method for reconstructing the SC joint without compromising biomechanical strength.

The sternoclavicular joint (SCJ) is a diarthrodial structure that connects the upper extremity to the axial skeleton.[1] The inherent stability of the joint is secondary to the joint capsule and the costoclavicular and interclavicular ligaments.[1-6] Dislocations of the SCJ are rare injuries, accounting for just 3% of all pathologies of the shoulder girdle and 1% of all dislocations.[1,7-9] For these reasons, injuries to the SCJ are typically traumatic in nature.[1,10,11]

Most SCJ dislocations occur in the anterior direction, as the posterior capsular structures of the SCJ are powerful in preventing posterior translation.[4,12,13] Biomechanical data in the literature state that a 50% stronger force is required for posterior dislocation of the SCJ compared with anterior.[1,5] Despite the rare occurrence of posterior SCJ dislocations, these injuries are potentially life-threatening due to the close proximity of the vascular structures that lie directly posterior to the joint.[1,8,12,14]

Although many anterior SCJ dislocation injuries can be treated nonoperatively, chronic dislocations that remain symptomatic may require operative reconstruction.[1,15] In addition, posterior dislocations require immediate closed reduction in the operating room, with SCJ reconstruction indicated for cases of recurrent instability and pain after closed reduction.[1,16,17] Several surgical techniques for both acute and chronic SCJ instability are described in the literature, including direct repair of the SC and costoclavicular ligaments, reconstruction of the costoclavicular ligament, and medial clavicle resection.[1,18-23] A 2011 systematic review found "figure-of-8" reconstruction to be the most effective of all reconstruction techniques, and clinical outcomes studies have reported improvements in patient satisfaction and clinical outcomes scores after SCJ reconstruction using this technique.[1,11,12,15,20,24] Based

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on these findings, over the last decade a figure of 8—shaped reconstruction of the SCJ with autologous hamstring tendons has gained popularity.[1,18-22] The purpose of this Technical Note is to present a figure-of-8 reconstruction technique for SC joint stabilization using a hamstring autograft as biological augmentation.

Surgical Technique (With Video Illustration)

There are numerous operative techniques described for SCJ reconstruction in the orthopaedic literature. These techniques include variations in the use of allograft or autograft, figure-of-8 configurations, intramedullary graft reconstructions, synthetic reconstructions, and tenodesis techniques using either the sternal head of the sternocleidomastoid or the subclavius.[25,26] We will describe the senior author's preferred surgical technique, using a figure-of-8 reconstruction with gracilis autograft.[27] The basis for the use of a figure-of-8 technique is from increasingly reported techniques within the literature on SCJ reconstructions.[11,12,19,20,24,28,29] The initial surge in this technique began with the work of Spencer and Kuhn[30] in 2004, which reported on the biomechanical analysis of different SCJ reconstructions and found the figure-of-8 construct to have a load to failure roughly 3 times greater than other techniques.

Procedure

The complete procedure is outlined in Video 1. Before entering the operating room, the patient is medically optimized and a thoracic surgeon is notified.[1,20] A preoperative computed tomography angiogram is obtained to evaluate the relationship of the SCJ to the major mediastinal vessels. After the induction of general anesthesia, the patient is placed supine on the operating table. The head of the bed is placed in 30° of Trendelenburg and the patient's head is slightly tilted to the nonoperative side, as seen in Figure 1.

Before prepping and draping, the patient should undergo an examination under anesthesia to evaluate the mobility and reducibility of the SCJ before surgical intervention. The patient is then prepped and draped in a normal, standard orthopaedic fashion. A surgical timeout is completed confirming the correct patient, site, and surgery, and that all required implants are in the room before incision.

Following clinical examination to confirm the hypermobility of the medial clavicle under anesthesia, the hamstring tendon autograft (gracilis tendon) is harvested in a standard fashion. Both ends of the tendon are then whip-stitched with non-absorbable, high-strength sutures (FiberWire #2; Arthrex, Naples, FL) and measured to determine the proper tunnel diameter.

To begin, a 6- to 8-cm incision is made above the center of the medial clavicle, which ensures proper exposure (Fig 2).[1,8,20] The sternocleidomastoid (SCM) is then sharply elevated from the clavicle and preserved in order to adequately repair during closure.[1,20,31] The tendon of the SCM typically runs directly anterior to the SCJ. A horizontal incision is made through the SC capsule, which is then elevated off the medial clavicle and sternum subperiosteally, therefore allowing access extending from 2 cm medially onto the sternum and 4 cm laterally over the clavicle. A thorough and complete capsular release should be performed circumferentially to ensure the medial clavicle is fully mobilized.[8] A subperiosteal dissection needs to be carried out laterally for about 6 to 8 cm so that the clavicle can be mobilized superiorly to allow access to the retrosternal space (Fig 3). At this time, the articular disc is thoroughly evaluated and removed carefully with a scalpel.

Fig 1. Patient setup with the head of the bed in 30° of Trendelenburg. The patient's head is slightly tilted to the nonoperative side. Patient is in the supine position for a right-sided surgery.

In cases of SCJ arthritis and SCJ instability, a medial clavicle excision of 8 to 10 mm can be considered, although in the senior author's experience this is rare and the preference is to preserve the bone so as to maintain stability.[1,8,20,31] Excess synovium and, if present, osteophytes are debrided out of the joint. Next, the clavicle is carefully retracted superiorly and a subperiosteal dissection is carried out retrosternally using a curved periosteal elevator (Fig 4).[1,8,20] The curved periosteal elevator is also a useful tool both to clear off the undersurface of the medial clavicle and to perform the retrosternal subperiosteal dissection.

Following proper exposure, attention is then turned to the placement of drill tunnels. A curved periosteal elevator, used previously to carefully dissect, is placed

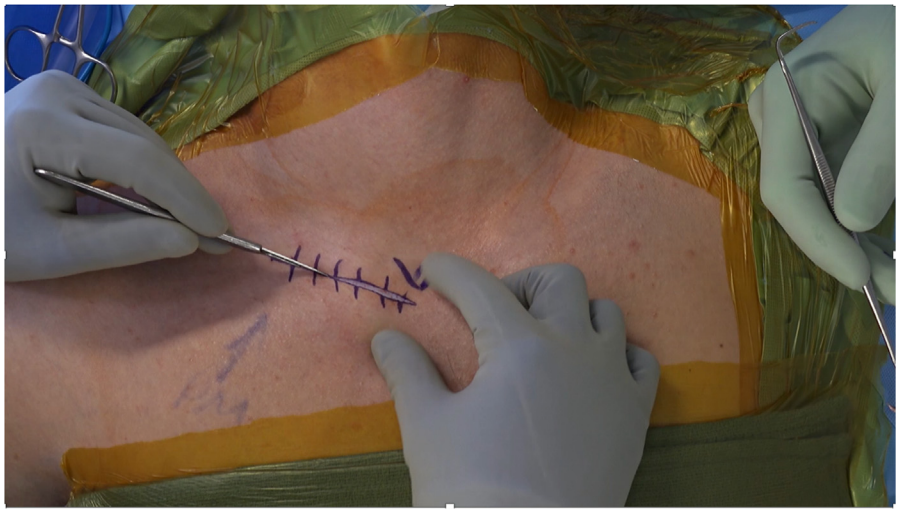

Fig 2. Patient is in the supine position for a right-sided surgery. A 6- to 8-cm incision is made over the center of the medial clavicle, which ensures proper exposure as seen in this approach to the right SCJ in a supine patient. (SCJ, sternoclavicular joint.)

posterior to the sternum to protect the retrosternal space during placement of bone tunnels into the sternum. Two guide pins are placed in the superior and inferior aspects of the sternum spaced approximately 15 mm apart (Fig 5). Care is taken to avoid excessive convergence or tunnel break out. Next, two 4-mm drill tunnels are made with a cannulated reamer. These tunnels are drilled from anterior to posterior, with care taken to keep the curved elevator beneath the sternum to protect the retrosternal structures and avoid vascular injuries in the retrosternal space.

Next, attention is turned to the placement of bones tunnels into the medial aspect of the clavicle. A malleable retractor is placed posteriorly behind the medial aspect of the clavicle for protection of the subclavian vessels and retrosternal vascular structures. Again, 2 guide pins are placed from anterior to posterior in the metaphysis, and two 4-mm tunnels are drilled with cannulated reamers in the superior and inferior aspect of the medial clavicle. These are placed roughly 15 mm apart in an anterior to posterior direction (Fig 6). In younger patients, care is taken to avoid the medial physis.

During placement of these tunnels, the goal is to establish holes in the superior and inferior aspects of the medial clavicle and in the articulating portion of the manubrium. These drill holes should be placed 1 to 2 cm away from the joint line and 1 to 1.5 cm apart to allow for an adequate bone bridge. Sizing of these tunnels is determined based on the size of the reconstruction graft, with 4.0-mm tunnels recommended in most cases with the use of a gracilis autograft. The senior author strongly prefers to use autograft tissues for the graft to improve the chance for successful healing and to decrease the risk of recurrent instability. The

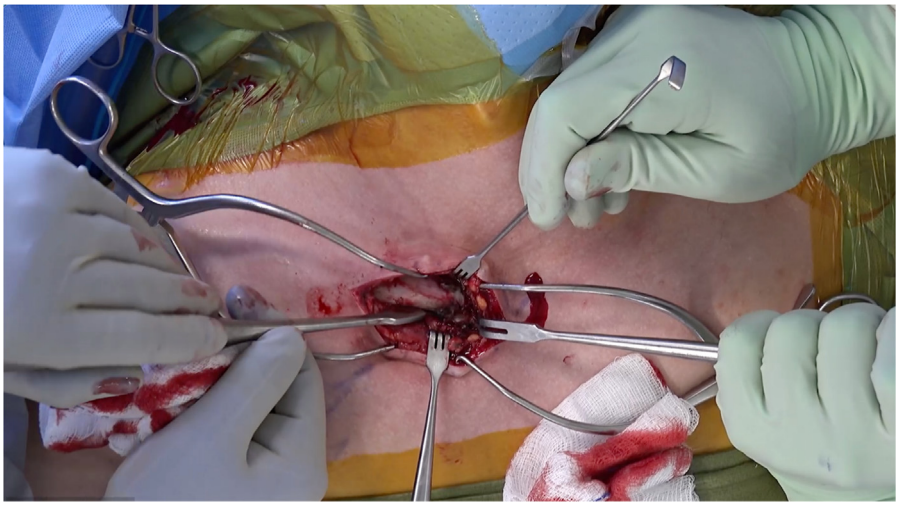

Fig 3. Patient is in the supine position for a right-sided surgery. An elevator is used to carefully perform a subperiosteal dissection. This is carried out laterally roughly 6 to 8 cm so that the clavicle can be mobilized superiorly to allow access to the retro-sternal space.

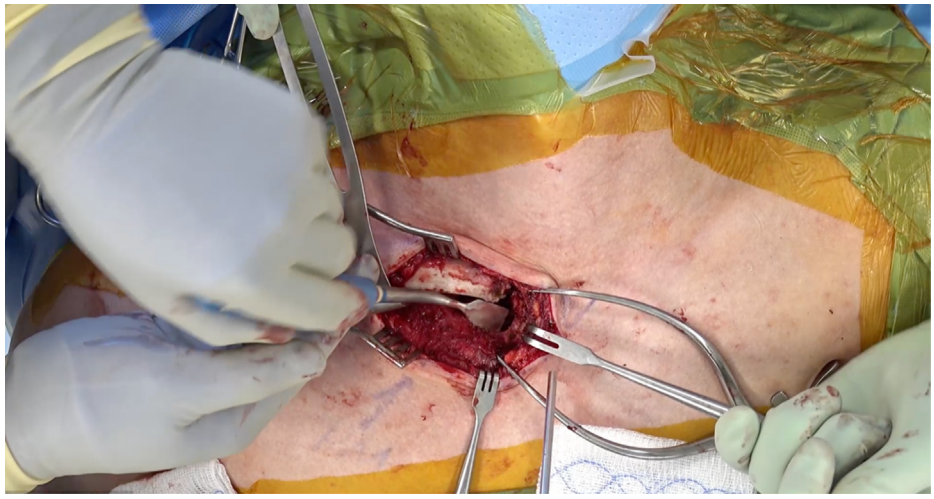

Fig 4. Patient is in the supine position for a right-sided surgery. The clavicle can be carefully retracted superiorly allowing for subperiosteal dissection retrosternally. This is typically performed using a curved periosteal elevator.

tunnels are drilled in an anterior to posterior direction, with great care taken to avoid overpenetration. Initially, guide pins are inserted, then overdrilled with the appropriately sized cannulated drill according to the graft diameter and the bone size. Another potential consideration for this portion of the procedure is the use of unicortical drill holes aimed toward the joint in an anterior-to-posterior direction followed by connecting these tunnels through additional drill holes into the medial surface of the clavicle or the lateral surface of the sternum, respectively.

Regardless of technique used, after completion of these drill holes, passing sutures are placed into the bone tunnels and the graft is shuttled through in a figure-of-8 configuration such that the parallel limbs are posterior and the cruciate limbs are anterior (Fig 7).[8,20] The 2 whip-stitched free ends of the graft are then knotted together and the construct is secured with No. 2 permanent sutures placed through the tendon knot.[20,25] The sutures and excess free ends of the graft are then cut (Fig 8).

After fixation, demineralized bone matrix is injected around the bone tunnels with the goal of enhancing tendon incorporation and minimizing tunnel widening.[20] The construct is then tested for dynamic stability under direct visualization by pulling and pushing on the medial aspect of the clavicle with a Kocher clamp and by placing the upper extremity through passive range of motion.[8,20] Next, the periosteum and capsule are tightened in a pants over vest configuration to add additional stability. Finally, the SCM is meticulously repaired and the skin is closed in standard fashion.

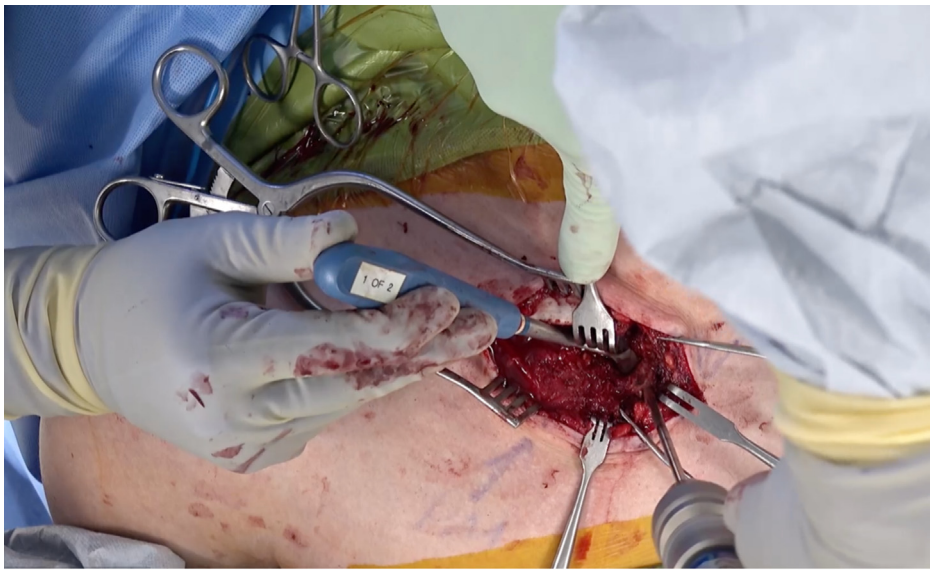

Fig 5. Patient is in the supine position for a right-sided surgery. A curved periosteal elevator, used previously to carefully dissect, is placed posterior to the sternum to protect the retrosternal space during placement of bone tunnels into the sternum. Two guide pins are placed in the superior and inferior aspects of the sternum spaced approximately 15 mm apart. Care must be taken to avoid excessive convergence or tunnel break out. Next, two 4-mm drill tunnels are made with a cannulated reamer drilled from anterior to posterior. Again, care must be taken to keep the curved elevator beneath the sternum to protect the retrosternal structures and avoid vascular injuries in the retrosternal space.

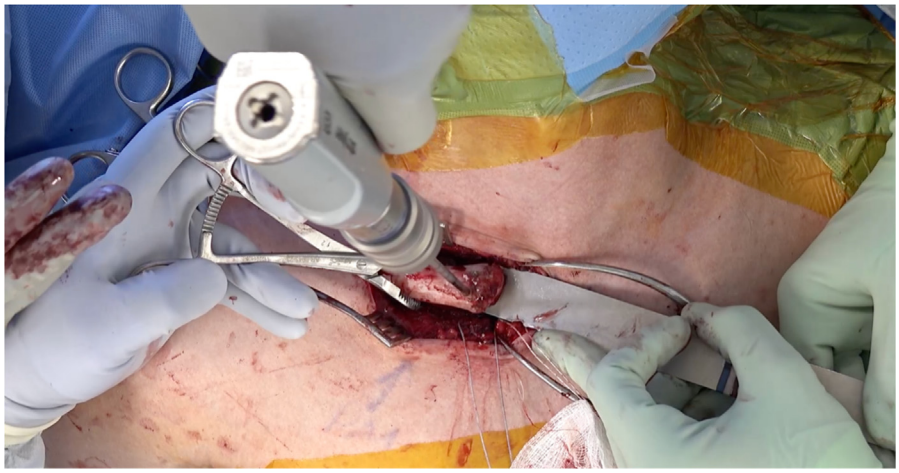

Fig 6. Patient is in the supine position for a right-sided surgery. A malleable retractor is placed posteriorly behind the medial aspect of the clavicle for protection of the subclavian vessels and retrosternal vascular structures. Similar to the sternal side, 2 guide pins are placed from anterior to posterior in the metaphysis, and two 4-mm tunnels are drilled with cannulated reamers in the superior and inferior aspect of the medial clavicle placed roughly 15 mm apart.

Postoperative Rehabilitation

Patients are instructed to remain non–weight-bearing in a sling postoperatively for 6 weeks. During this time period, the sling may be removed to perform gentle pendulums without scapular protraction or retraction. At 6 weeks, the patients are promoted to active assist range of motion followed by progression to active range of motion and strengthening of the shoulder and scapular stabilizers beginning at 8 weeks. Criteria for return to sport includes: no pain with sport-specific exercise, full and painless range of motion, and strength within 10% of the contralateral extremity.[1,7,20,25,32] Return to full activity typically occurs around 6 months postoperatively.[20] Pearls and pitfalls of the technique are described in Table 1.

Discussion

The proposed surgical technique of an SC joint reconstruction using hamstring autograft provides the surgeon with technical pearls to perform a safe stabilization procedure using a figure-of-8 construct, which has been shown to have promising biomechanical and clinical outcomes.[1] The complexity of the diarthrodial joint connecting the upper extremity to the axial skeleton in combination with the resident anatomical structures represents a surgical challenge, and numerous techniques have been described for stabilization of the SCJ with mixed results. Spencer and Kuhn[30] performed a biomechanical, cadaveric analysis of various SCJ reconstruction techniques, including intramedullary ligament reconstruction, subclavius tendon reconstruction, and figure-of-8 SCJ reconstruction with hamstring graft. The study group found the figure-of-8 reconstruction to have the strongest biomechanical stability at time zero.

Clinically, a 2020 investigation by Lacheta et al.[1] reported on clinical outcomes, survivorship, and return to sports after hamstring tendon autograft reconstruction

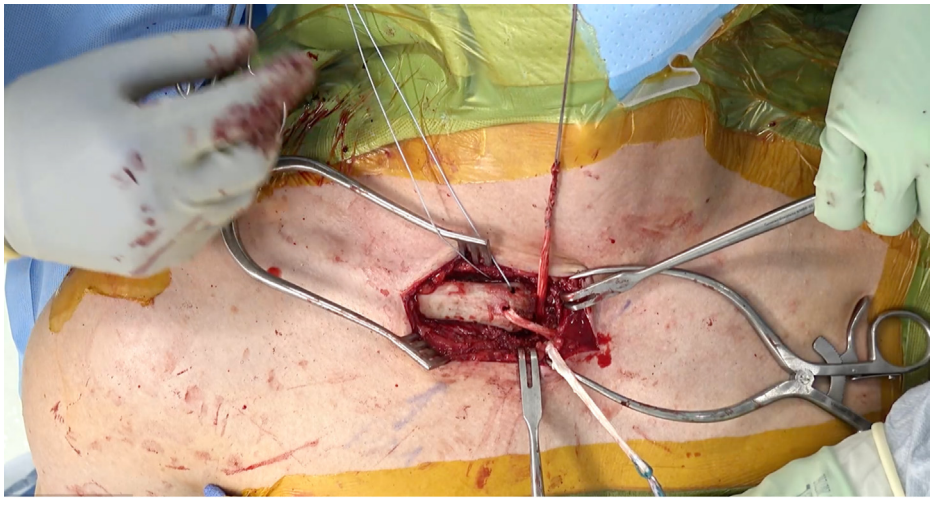

Fig 7. Patient is in the supine position for a right-sided surgery. After placement of drill holes, passing sutures are placed into the bone tunnels and the graft is shuttled through in a figure-of-8 configuration such that the parallel limbs are posterior and the cruciate limbs are anterior.

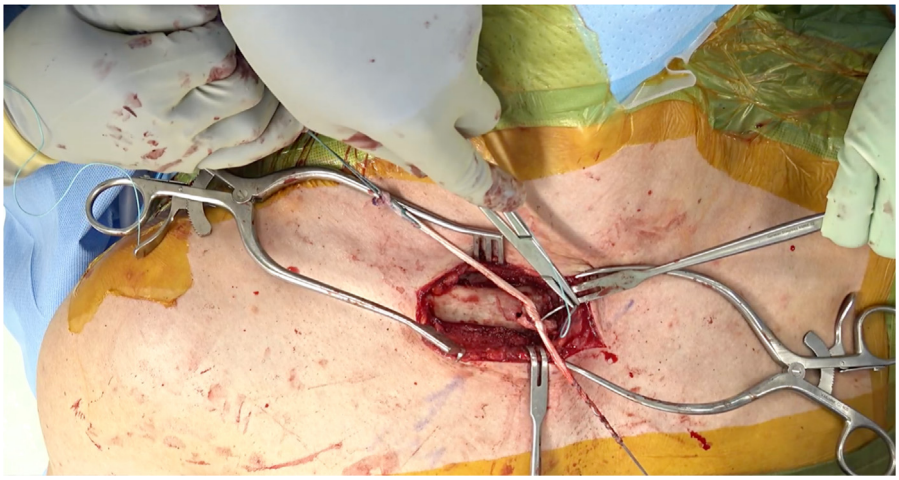

Fig 8. Patient is in the supine position for a right-sided surgery. The 2 whip-stitched free ends of the graft are then knotted together and the construct is secured with No. 2 permanent sutures.

for SCJ instability at a minimum of 5-year follow-up in the senior surgeon's practice. The authors reported on a total of 22 shoulders that underwent SCJ reconstruction at a mean patient age at time of surgery of 31.3 years (range 15.8-57.0 years). At the time of final evaluation, there were a total of 18 shoulders with a mean follow-up of 6.0 years (range 5.0-7.3 years). The authors found that all clinical outcome scores improved significantly from preoperatively to postoperatively: American Shoulder and Elbow Surgeons (50.0-91.0; $P = .005$), Single Assessment Numeric Evaluation (45.9-86.0; $P = .007$), Disabilities of the Arm, Shoulder and Hand, short version (44.2-12.1; $P = .003$), and 12-item Short Form Survey, Physical Component Summary (39.4-50.9; $P = .001$). In addition, they reported a construct survivorship of 90% at 5-year follow up. In total, there were 2 patients with failed treatment, which occurred at 82 and 336 days postoperatively. The reported reasons for failure were persistent pain and instability. These patients eventually underwent revision SCJ reconstruction and capsulorrhaphy. The investigation allowed patients the option of answering questions related to sport activity and found that 15 patients participated in recreational or professional sports prior to their injury, and at final follow up 14 patients (94%) returned to their preinjury level of sports participation. These results led to the authors concluding that SCJ reconstruction using a hamstring tendon autograft for SC joint instability results in statistically significant improvement in clinical outcomes with high patient satisfaction and 90% survivorship at a minimum of 5-year follow-up. This is in line with previous 2-year results of the same study group.[20]

In addition, Bak and Fogh[24] reported on 27 patients who underwent SC joint reconstruction using a hamstring tendon autograft with suture anchor fixation to the sternum. They reported their results at a mean follow-up of 54 months, with functional outcomes

Table 1. Pearls and Pitfalls

Pearls
A thoracic surgeon should be notified/available for the surgical procedure. A thoracotomy tray should be in the room. Two large-bore intravenous lines should be in place before starting the procedure.
A thorough and complete capsular release and extensive subperiosteal dissection should be performed circumferentially to ensure the medial clavicle is fully mobilized.
The retrosternal space is carefully dissected using a curved periosteal elevator. Care must be taken to avoid excessive penetration when drilling the sternal tunnels.
A malleable retractor protects the structures deep to the medial clavicle prior to drilling of the bone tunnels.
During all drilling, protective retractors should be used beneath the sternum and clavicle to avoid injury to retrosternal structures and the subclavian vessels.
Drill holes should be placed 1-2 cm away from the joint line and 1-1.5 cm apart to allow for an adequate bone bridge.
After fixation, demineralized bone matrix is injected around the bone tunnels with the goal of enhancing tendon incorporation and minimizing tunnel widening.
Pitfalls
Failure to notify thoracic surgeon to have on "stand-by" during the case.
Incomplete capsular release leading to inability to fully mobilize the medial clavicle and safely place a malleable retractor.
Drill holes places with inadequate bone bridge risking iatrogenic fracture.
Overpenetration of tunnels are drilled in an anterior to posterior direction with great care taken to avoid overpenetration

significantly improved from baseline. They did report 2 patients (7%) who underwent revision surgery as well as 10 patients (37%) who reported persistent discomfort at follow-up. Guan and Wolf[28] reported a smaller case series of 6 patients who underwent SCJ reconstruction using a semitendinosus hamstring autograft in a figure-of-8 fashion. At a mean follow-up of 3 years, all patients reported improved functional outcome scores with no reports of residual instability. These patients reported their level of disability according to Disabilities of the Arm, Shoulder and Hand, short version decreased from 59 to 4 (range 0-10).

Although nonoperative management often is recommended in the setting of anterior instability as well as in cases of successful closed reduction for posterior instability events, nonsurgical management mostly fails in young, athletic patients with high functional demands.[20] Although surgical stabilization has demonstrated successful clinical results, there are concerns that the removal of the intra-articular disk during the described procedure may lead to early arthritis. However, this complication was not seen in the study by Lacheta et al.[1] with minimum 5-year outcomes. The investigators, which include the same principal investigator as in this Technical Note (P.J.M.), used a clinical indicator for SCJ arthritis as reported by Katthagen et al.[27] and assessed pain in different categories during different activities. In all categories, a significant decrease in pain was observed indicating clinically no advanced arthritis present at the 5-year follow-up time point. Despite the aforementioned excellent clinical outcomes in addition to the low incidence of perioperative complications, the authors of this text believe that surgery should be performed by experienced and skilled surgeons using the appropriate techniques in select patients and that a thoracic surgeon should be on stand-by during the procedure, given the proximity the key neurovascular structures posterior to the joint. Other risks of the procedure include persistent instability leading to persistent pain and/or functional limitations. With these precautions in mind, we believe that the presented technique provides a safe and reproducible option for surgeons while providing promising results for our patients.

In conclusion, we present a technique for the open management of the SCJ instability using a figure-of-8 reconstruction with a gracilis autograft. The authors believe this procedure to be technically reproducible and safe when using the pearls and meticulous surgical technique described in the aforementioned text.

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