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Sternoclavicular joint allograft reconstruction using the sternal docking technique

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Background: The sternoclavicular joint may become unstable as a result of trauma or medial clavicle resection for arthritis. Allograft reconstruction with the figure-of-8 configuration is commonly used. This study was conducted to determine the outcome of sternoclavicular joint reconstruction using an alternative graft configuration.

Methods: Between 2005 and 2013, 19 sternoclavicular joint reconstructions were performed using a semitendinous allograft in a sternal docking configuration. The median age at surgery was 44 years (range, 15-79 years). Indications included instability in 16 (anterior, 13; posterior, 3) or medial clavicle resection for osteoarthritis in 3. The median follow-up time was 3 years (range, 1-9 years).

Results: Two reconstructions (10.5%) underwent revision surgery, 1 additional patient had occasional subjective instability, and the remaining 16 (84%) were considered stable. Sternoclavicular joint reconstruction led to improved pain (visual analog scale for pain subsided from 5 to 1 point, $P < .01$), with pain being rated as mild or none for 15 shoulders. At the most recent follow-up, the median 11-item version of the Disabilities of the Arm, Shoulder and Hand and American Shoulder and Elbow Surgeons scores were 11 (interquartile range [IQR], 0-41) and 88 (IQR, 62-100) respectively. The cosmetic aspect of the shoulder was satisfactory in 16 reconstructions (84%), with a median of 10 points (IQR, 9-10 points) on the visual analog scale for overall satisfaction.

Conclusion: Reconstruction of the sternoclavicular joint with a semitendinous allograft in a sternal docking fashion restores stability in most patients requiring surgery for instability of the sternoclavicular joint or medial clavicle resection for osteoarthritis.

The sternoclavicular joint may become a source of symptoms secondary to traumatic dislocation,[6,12,16] spontaneous instability in patients with generalized joint laxity,[2,4] or arthritic conditions such as rheumatoid arthritis and osteoarthritis.[4,17] Nonoperative management is commonly considered as a first line of treatment for most patients, except for acute posterior dislocation.[8] However, some individuals with chronic instability or arthritis will continue to complain of debilitating symptoms despite conservative management and may be considered for surgery.

Surgical management of chronic instability and painful arthritis of the sternoclavicular joint typically involves resection of the medial end of the clavicle, with or without ligament reconstruction, or, rarely, temporary plate fixation.[7,10-12,16,17] Reconstruction of the sternoclavicular ligaments has been performed with various soft tissue structures (subclavius muscle, sternocleidomastoid muscle, hamstring autograft, or allograft, among others) and with some

variation in the configuration of the reconstruction.[1,5,7,12,13,16] Biomechanical and clinical studies have favored use of a hamstring tendon in a figure-of-8 fashion.[14,15]

We adopted early in our practice a semitendinous allograft reconstruction in a figure-of-8 fashion.[14] Our observations when performing such reconstruction were that (1) as we tied the figure-of-8 in the front, the clavicle tended to be displaced anteriorly, and (2) the anterior knot of the graft resulted in a bulky reconstruction not cosmetically appealing. For these reasons, we modified the graft configuration to keep the graft centralized in the coronal plane between clavicle and sternum and facilitate graft passage into the sternum. This study describes our sternal docking technique for reconstruction of the sternoclavicular joint and reports the outcomes obtained using this technique in patients with instability or arthritis.

Materials and methods

Patients

Between 2005 and 2013, the lead author (J.S.S.) performed 19 consecutive reconstructions of the sternoclavicular joint ligaments using

a tendon allograft in a sternal docking fashion in 18 patients (1 patient underwent bilateral reconstructions). There were 11 men and 7 women, with a mean age at the time of reconstruction of 42 years (range, 17-79 years).

The indications for surgery were sternoclavicular joint instability in 16 shoulders (15 patients) and osteoarthritis in 3 shoulders. Of the 15 patients with instability, the patient with bilateral instability reported no history of trauma and had generalized ligamentous hyperlaxity. The remaining 14 patients related their instability to a motor vehicle accident (7 shoulders) or a fall (7 shoulders). The instability pattern was anterior in 13 shoulders and posterior in 3 shoulders. For patients with a clear history of trauma, the average time between injury and surgery was 3.9 years (range, 1 month-26 years). All patients were evaluated preoperatively with a physical examination, plain radiographs, and computed tomography of both sternoclavicular joints with 3-dimensional reconstruction. All patients had undergone a trial of conservative treatment before surgery.

Surgical technique

All operations were performed with the patient under general anesthesia and supine. The head of the table was raised approximately 30° from the horizontal. The affected upper extremity was draped free, and both sternoclavicular joints were included in the surgical field. Exposure was performed through an anterior skin incision centered across the inferior third of the affected sternoclavicular joint.

Once the joint was exposed, the medial 5 to 10 mm of the clavicle was resected with a micro sagittal saw. Care was taken to remove the medial bone fragment subperiosteally without undue traction to prevent injury to the structures posterior to the joint. Any nonunited fragments in patients with fracture dislocations were removed.

Two holes were created on the anteroinferior and anterosuperior aspects of the medial clavicle exiting into the medullary canal using a high-speed 4.0-mm burr. A curette may be used to remove cancellous bone between the canal and the clavicle perforations. The same burr was used to create an oblong hole on the sternal facet of the sternoclavicular joint. Two additional holes were created on the anterior cortex of the sternum superiorly and inferiorly, and a curette was used to communicate these 2 holes with the 1 oblong hole created on the sternal articular facet.

All reconstructions were performed using a semitendinous allograft. The allograft was split in half for smaller patients, whereas the whole diameter of the graft was used in larger patients. The length of the graft may be measured with a suture passed along the planned graft trajectory or can be determined in situ after the graft has been placed, which is our preferred method Once the graft is placed through its course with #2 FiberWire suture (Arthrex, Naples, FL, USA) in only one end, the graft is cycled, and the second suture is placed at the length that would provide ideal tension. A nonabsorbable suture (#2 FiberWire) was placed in a running locking configuration on each end of the graft.

The graft was then passed in a sternal docking fashion (Fig. 1). One end of the graft enters the medullary canal of the clavicle, exits through the inferior hole, and re-enters through the superior hole. This leaves 2 ends of the graft exiting the clavicle medullary canal. Both ends are then fed into the oblong hole at the sternal facet of the joint and separately retrieved though the anterosuperior and anteroinferior holes in the anterior cortex of the clavicle. Traction applied to both ends of the graft keeps the clavicle stable and centralized on the sternum (Fig. 2). The FiberWire sutures placed on the ends of the graft are tied together, and the reconstruction is reinforced further, if needed, with multiple interrupted sutures connecting the 2 limbs of the graft. The remainder of the closure is routine.

Postoperative management

After surgery, patients are placed in a shoulder immobilizer for 6 weeks. Active range of motion exercises of the elbow, wrist, and hand are encouraged, but shoulder motion is discouraged. At 6 weeks, the shoulder immobilizer is discontinued, and patients are started on a program of active assisted range of motion exercises with stretching. Strengthening of the deltoid, rotator cuff, and periscapular muscles is started at week 8 to 10, and strengthening with elastic bands is started at week 10 to 12. Patients are allowed unrestricted use of the affected shoulder 6 months after surgery.
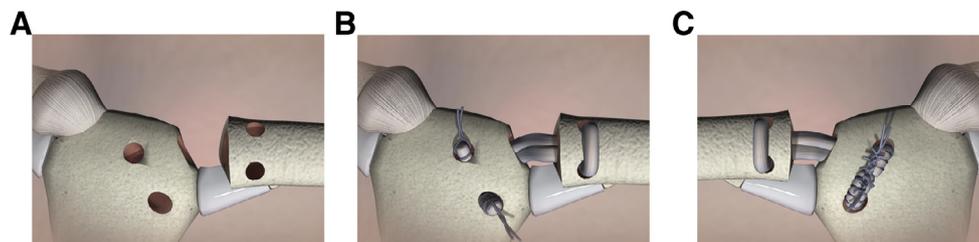

Figure 1   Schematic of the sternal docking technique. (**A**) Tunnel placement. (**B**) Graft passage. (**C**) Final reconstruction.

Figure 2   The sternal docking technique. (**A**) Graft inserted through clavicle tunnels. (**B**) Passage through the sternum. (**C**) Final reconstruction.

Table I
Details of the reconstructions included in this study

Patient	Age (yr)	Sex	Diagnosis	Preoperative pain grade	FU (yr)	Most recent VAS (points)	Most recent ASES (points)	Complications
1	50	M	Instability	Severe	5.2	2	83	
2	61	M	Instability	Moderate	3.6	0	91	
3	40	F	Osteoarthritis	Severe	3.1	0	98	
4	64	F	Osteoarthritis	Severe	2.6	5	62	
5	21	F	Instability	Moderate	7.8	10	25	Instability with revision surgery
6	45	M	Instability	Severe	10.5	0	100	
7	44	M	Instability	Severe	3.1	2	85	
8	32	M	Instability	Mild	8.5	0	100	
9	48	F	Instability	Moderate	8.4	0	98	
10	38	M	Instability	Moderate	3.8	2	88	
11	79	M	Instability	No pain	7.3	0	68	
12	48	M	Instability	Mild	5.7	5	57	Instability with revision surgery
13	15	F	Instability	Mild	1.0	0	100	
14	79	M	Osteoarthritis	Moderate	2.5	2	90	
15	17	M	Instability	Moderate	1.0	0	100	
16	17	F	Instability	Moderate	2.8	0	100	
17	19	F	Instability	Severe	1.6	1	85	
18	19	F	Instability	Moderate	1.3	4	85	
19	56	M	Instability	Moderate	2.6	8	50	Instability

FU, follow-up; *VAS*, visual analog scale; *ASES*, American Shoulder and Elbow Surgeons; *M*, male; *F*, female.

Evaluation

Patients were evaluated for pain and satisfaction using visual analog scales. Motion, deformity, cosmesis, and stability were assessed on physical examination. Overall, patient-reported outcomes were evaluated using the American Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment Form and the 11-item version of the Disabilities of the Arm, Shoulder and Hand (*Quick*DASH). Complications and reoperations were also recorded. The median follow-up time was 3 years (range, 1-9 years).

Statistical analysis

Categorical variables are presented as numbers with proportions and continuous variables as means with ranges, medians with interquartile ranges (IQR), or medians with ranges. The Wilcoxon signed rank test was used to compare medians of paired continuous data. Statistical tests were 2-sided with statistical significance considered at $P < .05$.

Results

Complications and revision surgery

At the most recent follow-up, stability of the sternoclavicular joint had been restored objectively and subjectively in 16 shoulders (84%). The remaining 3 shoulders had persistent instability. In all 3 cases, the direction of instability was anterior. Two patients underwent revision surgery, and subjective and objective stability was achieved in both after the revision procedure. There were no other complications or reoperations (Table I).

Clinical outcomes

Sternoclavicular joint reconstruction was associated with improved pain. The visual analog scale (VAS) for pain subsided from a median of 5 points preoperatively to 1 point at the most recent follow-up ($P < .01$), with pain being rated as mild or no pain in 15 shoulders. At the most recent follow-up, the median active forward flexion was 165° (IQR, 145°-175°), the median active external rotation was 80° (IQR, 70°-80°), the median *Quick*DASH score was 11 points (IQR, 0-41 points), and the median ASES score was 88 points (IQR, 62-100 points).

The cosmetic appearance of the shoulder as it relates to the position of the medial end of the clavicle compared with the opposite side was satisfactory in 16 reconstructions (84%), with a median of 10 points (IQR, 9-10 points) on the VAS for overall satisfaction. Before surgery, 7 patients complained of dysphagia, breathing difficulties, or hoarseness, and these symptoms were completely resolved in all 7 patients after surgery.

Discussion

The sternoclavicular joint can become a substantial source of symptoms and disability in patients with traumatic injuries, osteoarthritis, or rheumatoid arthritis.[2,4,6,12,16,17] When debilitating symptoms persist despite an adequate physical therapy program, surgery may be considered. Chronic instability and painful arthritis of the sternoclavicular joint are typically managed surgically with resection of a small portion of the medial end of the clavicle, with or without ligament reconstruction, or, rarely, temporary plate fixation.[1,7,10-12,16,17]

Various techniques have been described in the literature for reconstruction of the sternoclavicular joint ligaments.[1,5,7,12,13,16] In a biomechanical cadaveric study, Spencer and Kuhn[14] reported superior properties for a figure-of-8 reconstruction using a semitendinous allograft compared with reconstruction using an intramedullary ligament or the subclavius tendon. Since the publication of that study, several authors have reported the clinical outcome of reconstructing the sternoclavicular ligaments with autograft, allograft, or synthetic ligaments.

Bak et al[1] reported 32 reconstructions using autograft tendon. Mean Western Ontario Shoulder Instability Index scores statistically improved from 44% to 75%, and there were only 2 failures (7.4%), although 40% of the patients reported persistent discomfort and almost 70% complained of donor site morbidity. Sabatini et al[12] reported 10 reconstructions using allograft in a figure-of-8 fashion. Pain improved from a VAS of 7 preoperatively to 1.15 postoperatively, with improvement in ASES scores as well. Uri et al[16] reported 32 reconstructions using the sternal tendon of the sternocleidomastoid muscle. Pain, Oxford score, and Subjective Shoulder Value significantly improved, and only 2 patients experienced persistent postoperative instability. Petri et al[9] reported 21 reconstructions using a hamstring tendon autograft in a figure-of-8 configuration. No recurrent instability was reported, and there were significant improvements in ASES, *Quick*DASH, and Single Assessment Numeric

Evaluation scores. Good results have also been published using artificial ligament devices.[3,10]

Early in our practice, the lead author (JSS) adopted the figure-of-8 allograft technique described by Spencer and Kuhn.[14] Although stability was restored, we noted that as we tied the figure-of-8 in the front, the clavicle tended to be displaced anteriorly and that the anterior knot of the graft resulted in a bulky reconstruction not cosmetically appealing. In addition, substantial retrosternal dissection was required to prepare the sternum and pass the graft, a concern also raised by others.[7]

In an attempt to achieve a more centralized reconstruction and avoid retrosternal dissection, the sternal docking technique reported here was developed. Allograft tendon is used for the reconstruction, but the graft is placed in the clavicle through bone tunnels exiting into the medullary canal, and both graft ends are docked into the articular facet of the sternum and retrieved anteriorly. The results of our study seem to indicate that using this graft configuration provides clinical outcomes similar to those reported by others but with less difficulty in passing the graft. In patients with a completely intact clavicle, the benefit of this technique must be balanced with the potential for increased instability as a consequence of medial clavicle resection and disk resection. However, in most patients with instability in the setting of fracture dislocations, sequelae, or physeal injuries, or arthritis, resection of a small portion of the distal end of the clavicle oftentimes becomes necessary.

Our study has a number of weaknesses, including the mix of diagnoses (instability and arthritis), its retrospective nature, and the lack of postoperative computed tomography to assess in detail the relative positions of the clavicle and the sternum after reconstruction. The study also has a number of strengths: all patients were operated on by a single surgeon using the exact same technique, the same allograft tendon was used in all cases, and no patients were lost to follow-up.

Conclusion

Reconstruction of the sternoclavicular joint with a semitendinous allograft in a sternal docking fashion restores stability in most patients requiring surgery for instability of the sternoclavicular joint or medial clavicle resection for arthritis. Although less retrosternal dissection is required compared with other reported techniques, meticulous attention to detail when performing this technique is required to reduce the risk of catastrophic complications.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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