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Anatomic reconstruction of acromioclavicular joint dislocations using allograft and synthetic ligament

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Background: Acromioclavicular (AC) separations are commonly seen shoulder injuries. Numerous surgical reconstruction techniques have been described. In this study, we present a series of patients who underwent an anatomic reconstruction using a synthetic ligament and allograft construct.
Methods: We performed a retrospective review of patients with type IV or V AC separations who underwent primary or revision AC reconstruction with a luggage-tag synthetic ligament and a semitendinosus allograft placed through the anatomic insertion sites of the coracoclavicular ligaments. Patient-reported outcomes, as well as complication rates, were recorded at a minimum 2-year follow-up.
Results: Ten patients with a mean age of 44.2 ± 14.9 years were included in the study. The mean Disabilities of the Arm, Shoulder and Hand score was 15.5 ± 15.4; mean Single Assessment Numeric Evaluation score, 81.8 ± 12.1; mean Simple Shoulder Test score, 11.4 ± 1.1; mean American Shoulder and Elbow Surgeons score, 84.6 ± 15.7; mean Constant score, 82.5 ± 11.6; and mean visual analog scale score, 2 ± 2.6.
Conclusion: The technique using a luggage-tag synthetic ligament along with an anatomic allograft coracoclavicular ligament reconstruction is a safe, effective alternative to other techniques described in the literature.

Acromioclavicular (AC) joint dislocations are common injuries in active individuals. The mechanism of injury is typically a direct blow to the top of the shoulder and is classified as types I-VI depending on the degree of soft-tissue injury and displacement.[29] Type I is a sprain of the AC ligament with no displacement. Type II is a rupture of the AC ligament and sprain of the coracoclavicular (CC) ligaments, with a slight increase in the CC distance compared with the contralateral side. In type III-VI injuries, both the AC and CC ligaments are ruptured. In type III injuries, there is 25%-100% vertical displacement of the clavicle but the joint is reducible, as the deltotrapezial fascia has not been violated. Type IV injuries have posterior displacement of the clavicle through the trapezial fascia, whereas type V injuries show 100%-300% vertical displacement. Type VI injuries are exceedingly rare and are characterized by inferior displacement and entrapment of the distal clavicle under the conjoint tendon. The treatment of type I and II injuries is conservative, whereas types IV-VI are generally treated operatively.[4,7,8,16] The treatment of type III injuries is controversial, with patient-specific factors playing a larger role in decision making.[4]

Many AC joint reconstruction techniques have been developed over the years. Weaver and Dunn[35] were the first authors to publish a case series of coracoacromial (CA) ligament transfers to the distal clavicle. In the Weaver-Dunn technique, the distal clavicle is excised, the CA ligament is passed into the intramedullary canal of the clavicle, and the sutures are tied over a bone bridge.

Since the original technique was described, numerous variants of the Weaver-Dunn procedure have been developed.[1,2,9,11,13-15,18-23,25-27,33,34] Many of these variants incorporated either AC or CC transfixation methods to protect the reconstruction during healing. Indeed, biomechanical studies have shown that isolated CA ligament transfers are significantly weaker than the native CC ligaments, and augmentation techniques can help restore time-zero strength to the native state.[12,36] This has not proved clinically significant, however, as the recurrent instability rates between CA ligament transfer techniques with and without supplemental fixation are similar (15%-29%).[31]

The high rate of recurrent instability and poor restoration of biomechanics in the axial plane with CA ligament transfer procedures prompted the development of anatomic reconstruction

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techniques using tendon grafts. Mazzocca et al[24] described a technique in which a doubled-over semitendinosus allograft was docked into a 7-mm bone socket at the base of the coracoid and secured with an interference screw. The free ends of the graft were then passed through 6-mm tunnels in the clavicle corresponding to the anatomic insertion sites of the conoid and trapezoid ligaments. Biomechanically, this construct was more stable to cyclic loading than the modified Weaver-Dunn technique in the anterior-posterior direction. However, drilling a 7-mm socket at the coracoid base theoretically raised the risk of fracture.

To mitigate the fracture risk of the original anatomic reconstruction technique, a new method was described by Baldwin et al.[3] Instead of the use of a coracoid bone tunnel, a loop of graft was passed under the coracoid tip. The free ends were then passed through the loop in a luggage-tag configuration, after which they were passed through the clavicle and secured as previously described. At 4.5 years' follow-up, the authors reported redisplacement in 5% and pain resolution in 94% of the patients in their series.

Luggage-tag CC fixation using a synthetic ligament was also recently described, and favorable results with its use have been reported.[19,37] A braided polyester graft is strong and has the potential for tissue ingrowth.[17] In addition, it provides secure but nonrigid fixation of the AC joint, allowing normal clavicular rotation with shoulder motion. It is a nonanatomic, single-bundle technique, however, and requires appropriate placement between the native insertion sites to allow accurate joint reduction.[32]

In this study, we introduce a technical variation that combines luggage-tag synthetic ligament reconstruction and anatomic allograft reconstruction of the CC ligaments. During healing, the potential stress shielding of the allograft by the synthetic graft would theoretically minimize progressive tendon creep and elongation with cyclic loading. This study details the surgical technique and presents the clinical and radiographic results of a series of patients who underwent the procedure.

Methods

Study design

We performed a retrospective review of consecutive patients who underwent primary or revision anatomic AC joint reconstruction using both semitendinosus tendon allograft and the LockDown Shoulder Stabilization System (LSSS) (LockDown Surgical, Chanhassen, MN, USA) between May 2014 and May 2018. The exclusion criteria included clinical follow-up < 2 years and the presence of concomitant fractures about the shoulder girdle. All surgical procedures were performed by a single surgeon (J.I.).

Data collected included initial diagnosis and indication for surgery; duration of clinical and radiographic follow-up; Disabilities of the Arm, Shoulder and Hand score; Single Assessment Numeric Evaluation score; visual analog scale score for pain; Simple Shoulder Test score; American Shoulder and Elbow Surgeons score; Constant score; and complications. Preoperative, initial postoperative, and most recent follow-up radiographs were reviewed and assessed for loss of reduction over time.

Surgical technique

All patients were positioned in the supine position with a small bump under the ipsilateral scapula. Prior to skin incision, the semitendinosus allograft was prepared with either FiberLink sutures (Arthrex, Naples, FL, USA) or the Speedtrap graft preparation device (DePuy Mitek, Raynham, MA, USA) and pre-tensioned at 9 kg (20 lb) for ≥20 minutes. A horizontal skin incision was made, and full-thickness skin flaps were elevated. The deltotrapezial fascia was incised, and portions of the pectoralis major and anterior deltoid muscles were elevated in a subperiosteal fashion to expose the AC joint, distal clavicle, and coracoid process.

By use of a radiopaque ruler, the length of the entire clavicle was measured under intraoperative fluoroscopy. Anatomic drill hole positions were then calculated using the ratios described by Rios et al[28] and marked on the clavicle with electrocautery. Five millimeters of distal clavicle was resected to assist with reduction and decrease the risk of postoperative AC joint arthrosis.

To allow room for graft and LSSS passage around the coracoid, the coracohumeral ligament was released from the coracoid, and a large Satinsky vascular clamp was passed from medial to lateral to avoid injury to the underlying neurovascular structures. With the AC joint held reduced, a NiceLoop (Wright Medical, Memphis, TN, USA) was then passed through these holes and tied for provisional fixation and prevention of anteroposterior translation of the distal clavicle. This step is very important as it achieves and maintains AC joint alignment in the axial plane. A FiberTape (Arthrex) was then passed around the base of the coracoid in a luggage-tag fashion. While the joint was being held reduced as confirmed by fluoroscopic imaging, the LSSS measuring tape was used to determine the correct final device size.

Two 2.5-mm drill holes were made, one in the acromion and one in the distal clavicle. With the AC joint held reduced, a NiceLoop was then passed through these holes and tied for provisional fixation and prevention of anteroposterior translation of the distal clavicle.

Two 3.5-mm drill holes were made at the predetermined positions on the clavicle: The lateral hole was drilled superior to inferior and the medial hole was drilled obliquely posterior to anterior to re-create the anatomic trajectories of the trapezoid and conoid ligaments, respectively. A small curette was used to ensure the holes were patent for graft passage.

The 2 limbs of the graft were passed under the coracoid with a Satinsky clamp, and the graft was then secured using the luggage-tag technique.[3] The 2 limbs of the graft were brought up through the holes, and while tension was held on each limb with the AC joint reduced, 3.5-mm polyetheretherketone screws (Arthrex) were placed in each hole. The graft limbs were then tied together over the top of the clavicle.

The LSSS device was shuttled under the coracoid using the previously placed measuring tape, and the loop end was brought over the clavicle and tied to the previously passed FiberTape luggage-tag suture. To avoid placement of an additional stress riser in the clavicle and to minimize the risk of fracture, the optional LSSS anteroposterior clavicular screw was not used in any case. Final fluoroscopic imaging was then used to confirm reduction.

The deltotrapezial fascia was repaired in interrupted fashion with heavy nonabsorbable braided suture, with care taken to bring the underside of the pectoralis major and anterior deltoid up to provide additional soft tissue over the reconstruction. The subcutaneous tissues and skin were closed over a drain. Patients were placed in a shoulder immobilizer for 6 weeks, at which time they began formal physical therapy.

Results

A total of 10 eligible patients were identified and successfully contacted by phone for follow-up (Table I). All patients had either type IV or V AC injuries. The mean age at the time of surgery was 44.2 years (range, 21-61 years). There were 7 men and 3 women. Of the cases, 8 were primary reconstructions whereas 2 were revisions. Two patients underwent surgery <4 weeks after injury, whereas the other 8 had chronic injuries.

Table I
Averages of outcome measures (N = 10)

	Average
Age, yr	44.2 ± 14.9
F/U, mo	40.4 ± 11.1
Radiographic F/U, mo	10.3 ± 11.1
DASH score	15.5 ± 15.4
SANE score	81.8 ± 12.1
VAS pain score	2 ± 2.6
SST score	11.4 ± 1.1
ASES score	84.6 ± 17.3
Constant score	82.5 ± 11.6

F/U, follow-up; *DASH*, Disabilities of the Arm, Shoulder and Hand; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons.

The average follow-up period was 40.4 months (range, 24-54 months), at which point the mean outcome scores were as follows: Disabilities of the Arm, Shoulder and Hand score, 15.5 ± 15.4; Single Assessment Numeric Evaluation score, 81.8 ± 12.1; Simple Shoulder Test score, 11.4 ± 1.1; American Shoulder and Elbow Surgeons score, 84.6 ± 15.7; Constant score, 82.5 ± 11.6; and visual analog scale score for pain, 2 ± 2.6. Table II provides a summary of the data and stratifies outcomes by primary vs. revision cases.

The average length of radiographic follow-up was 10.3 months (range, 0-36 months). Of the 10 patients, 2 (20%) did not undergo the radiographic evaluation. In 9 of 10 patients (90%), postoperative reduction was maintained. There were no cases of infection, hardware complications, or recurrent instability requiring reoperation.

Discussion

The technique combining synthetic ligament reconstruction and anatomic allograft reconstruction of the CC ligaments attempts to address the potential drawbacks of previously described methods.[31] The results of this study suggest that combining the LockDown device with anatomic CC ligament reconstruction using allograft is a viable surgical treatment option for AC dislocations. There was an 8% rate of recurrent dislocation, which is lower than the 15%-29% reported in the literature. In addition, there were no hardware complications or reoperations.

Initial efforts at AC reconstructions were nonanatomic procedures. In the modified Weaver-Dunn technique, the distal clavicle is excised, after which the acromial end of the CA ligament is passed through the intramedullary canal and tied over a bone bridge. Isolated CA ligament transfers have historically shown a 90% rate of good to excellent results, with a recurrent instability rate of 16%.[27,30,34,35] Furthermore, the addition of trans-articular stabilization has not decreased the incidence of recurrent dislocation but rather introduced a significant rate of fixation-related complications.[28]

Table II
Averages of primary vs. revision outcome measures

	Primary (n = 8)	Revision (n = 2)
Age, yr	41.9 ± 15.5	53.5 ± 10.6
F/U, mo	41.5 ± 11.3	36 ± 12.7
Radiographic F/U, mo	11.6 ± 12.1	5 ± 4.2
DASH score	12.3 ± 15.6	28.3 ± 1.2
SANE score	82.9 ± 13.4	77.5 ± 3.5
VAS pain score	2.1 ± 2.9	1.5 ± 0.7
SST score	11.5 ± 1.1	11 ± 1.4
ASES score	83.7 ± 19.5	87.8 ± 3.1
Constant score	85.2 ± 10.5	71.5 ± 12

F/U, follow-up; *DASH*, Disabilities of the Arm, Shoulder and Hand; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons.

Attempts to improve on these results led to the development of an anatomic CC ligament reconstruction procedure by Mazzocca et al.[24] This involved securing a doubled-over soft-tissue graft into a 7-mm tunnel at the coracoid base, with the free ends passing through clavicular tunnels at the native trapezoid and conoid ligament insertion sites. This technique was shown to be superior to the modified Weaver-Dunn procedure in restoring anteroposterior stability of the AC joint.[24] Its use of a large bone tunnel at the base of the coracoid, however, theoretically increases the risk of fracture. Fractures after AC reconstructions involving transcoracoid drilling have been reported in the literature.[6,10]

An alternative anatomic CC ligament reconstruction technique was presented by Baldwin et al.[3] In their method, the soft-tissue graft was secured to the coracoid with a luggage-tag loop, obviating the use of a coracoid tunnel. The authors reported a 5% rate of re-displacement and 94% rate of pain resolution in their series. The current technique reinforces the soft-tissue reconstruction described by Baldwin et al with a synthetic graft. This theoretically reduces the potential for loss of reduction via soft-tissue creep. However, the small number of patients in this retrospective study makes it difficult to directly compare rates of re-displacement with other studies.

A potential problem with relying solely on soft-tissue grafts to maintain AC joint reduction is creep. Even with preconditioning, tendons can elongate under chronic loads. The technique presented in this study supplements allograft fixation with the LockDown synthetic ligament. The LockDown device is a robust, braided polyester graft that is stronger than No. 2 FiberWire (Arthrex) and less rigid than a screw, making it less likely to break or cut out with cyclic loading.[5]

Clinical results with synthetic ligament reconstructions have been encouraging. Although the LockDown device was originally designed for revision AC reconstructions after failed Weaver-Dunn procedures, it soon came to be used in primary settings. Wood et al[37] reported good outcomes with no radiographic failure in a group of military recruits who underwent a CA ligament transfer augmented with a synthetic CC ligament reconstruction. In addition, Kumar et al[19] found that patients treated with the LockDown device had significantly better postoperative outcomes and a quicker return to work than those treated with a modified Weaver-Dunn procedure. Our article describes an alternative technique that can be used by surgeons who perform AC reconstructions. Although it does not suggest that the described technique is superior, it does add technical points that surgeons can decide to use in their practice.

This study has a number of limitations. First, our sample size was fairly small, making it difficult to compare our complication rate with the complication rates in the overall literature. We also did not have any preoperative data to assess the degree of improvement postoperatively. In addition, we did not have long-term follow-up for most patients. Finally, the surgical procedures were performed by a single high-volume surgeon, which improves the internal validity of the study but makes it difficult to generalize the results to the rest of the community.

Conclusion

According to the results of this study, the presented technique is an effective surgical treatment for AC dislocations. It provides strong, nonrigid fixation and anatomic ligament reconstruction while minimizing the risk of iatrogenic fracture and graft elongation.

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