Treatment of Failed Coracoclavicular Ligament Reconstructions: Primary Acromioclavicular Ligament and Capsular Reconstruction and Revision Coracoclavicular Ligament Reconstruction

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Abstract: Acromioclavicular (AC) joint dislocations are a common injury affecting 2 of every 10,000 people in the general population and comprise 9% to 12% of all injuries to the shoulder. Most injuries occur through contact activity, which drives the acromion inferiorly with the clavicle remaining in its anatomic position, initiating a cascade of injury propagating from the AC ligament followed by failure of the coracoclavicular ligaments. Many techniques have been described for AC joint injuries, without a consensus gold standard. The revision setting offers even less consensus on treatment options and countless difficulties for surgeons. There have been more than 60 described procedures regarding AC and coracoclavicular ligament reconstructions, with significant controversy regarding the optimal intervention for each injury. When these techniques fail, it is important to pinpoint the mechanism of failure to construct a successful plan for revision. The purpose of this Technical Note is to describe our preferred method of primary AC and revision coracoclavicular reconstruction using a combination of autograft and allograft semitendinosus as well as TightRope fixation.

The acromioclavicular (AC) joint is a diarthrodial joint serving as the articulation between the scapula and clavicle and is responsible for both scapulothoracic and clavicular motion, allowing the shoulder to perform dynamic movements.1,2 AC-joint dislocations are a common injury, affecting 2 of every 10,000 people in the general population and comprise 9% to 12% of all injuries to the shoulder.1,3,4 Most injuries occur through contact activity, which drives the acromion inferiorly with the clavicle remaining in its anatomic position, initiating a cascade of injury propagating from the AC ligament followed by failure of the coracoclavicular (CC) ligaments.5,6 Many techniques have been described for AC joint injuries, without a consensus gold standard.7 The revision setting offers even less consensus on treatment options and countless difficulties for surgeons.

There have been more than 60 described procedures regarding AC and CC ligament reconstructions, with significant controversy regarding the optimal intervention for each injury.7,8 When these techniques fail, it is important to pinpoint the mechanism of failure to construct a successful plan for revision.9,10 Fracture and loss of reduction are the 2 most common complications and occur the most in patients with chronic instability.9,11 Previous bone tunnels, which occur in up to 20% of cases, make the coracoid both susceptible to fracture and a difficult complication to handle intraoperatively.12,13 Loss of reduction occurs up to 23% of

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cases and has been found to be correlated with bone quality, button placement, and adjunct operations conducted to reinforce the repair. Surgeons must be mindful of these challenges in the revision scenario and must select their constructs accordingly.

The purpose of this Technical Note is to describe our preferred method of primary AC and revision CC reconstruction using a combination of autograft and allograft semitendinosus as well as TightRope fixation. This technique offers several advantages over other methods, such as using previous tunnels in the clavicle and placing grafts around the coracoid to minimize chance of fracture and restoration of normal joint kinematics through reconstruction of both the AC and CC ligaments (Table 1). TightRope fixation was installed to assist the autograft and allograft constructs to give the revision the best chance to maintain reduction.

### Operative Technique (With Video Illustration)

#### Patient Positioning and Anesthesia

The narrated video provides an overview of the described surgical technique (Video 1). The patient is initially placed supine on the operating table and general endotracheal anesthesia is used for induction, which it may be combined with regional nerve blocks to maximize postoperative pain control. The patient is then brought to the beach-chair position, and care is taken to pad all bony prominences. The knees are placed in slight flexion, with a pad under the popliteal fossa. The head and neck are positioned carefully and assessed, ensuring neutral position. The operative extremity is draped free, and a well-padded Mayo is placed underneath the elbow. An examination under anesthesia should be performed. Pearls and pitfalls associated with this procedure are listed in Table 1.

### Operative Technique: Surgical Approach

At case initiation, a routine diagnostic shoulder arthroscopy may be performed to assess and/or address concomitant shoulder pathology. Attention is then turned to the AC joint. A 6-cm anteroposterior saber-type incision extending from the coracoid to the posterior aspect of the AC joint is made, centered 2-3 cm medial to the AC joint. Meticulous hemostasis is maintained, and full-thickness flaps are elevated medially and laterally. Dissection is carried to the level of the deltotrapezial fascia, and the fascia is carefully split along the longitudinal axis of the clavicle, and preserved to facilitate later layered closure. Next, a full-thickness periosteal dissection of the distal clavicle and medial aspect of the acromion is performed, skeletonizing the clavicle and medial acromion. The superior and inferior aspects of the coracoid are also exposed. Time is taken to debride CC ligament scar, down to the

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**Table 1. Pearls and Pitfalls of Primary AC Ligament Reconstruction and Revision CC Ligament Reconstruction**

| Pearls                                                                 | Pitfalls                                                                 |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------|
| Previous bone tunnels must be scrutinized for positioning, size, or damage. Improperly positioned tunnels must be repositioned, overly large tunnels may be addressed using screw fixation | Careful retraction or dissection adjacent to the coracoid; the musculocutaneous nerve must be protected |
| To restore native stability, the surgeon must position bone tunnels at the site of native conoid (medial-most, 30-45 mm medial from the AC joint) and trapezoid (lateral-most, 15 mm lateral from the conoid, and more anterior) | Careful drilling near coracoid or acromion to prevent injuries to neurovascular structures or rotator cuff |
| Fluoroscopy should be used to confirm adequate reduction of both AC and CC joints | Adequate spacing of tunnels to prevent convergence or fracture |
| The AC joint should be over-reduced during initial fixation due to an inevitable amount of creep in the tendon graft | Risk of coracoid fracture if old and new drill holes are too close. The surgeon must ensure appropriate spacing of drill holes |

AC, acromioclavicular; CC, coracoclavicular.
anterior acromion (Fig 1A). All previous sutures and grafts are removed (Fig 1B).

Graft Preparation
Graft preparation is performed according to surgeon preference. Semitendinosus or tibialis anterior allograft or autograft may be used. The grafts must be prepared to accommodate a 4.5-mm sizing block, with each free end whip-stitched using FiberTape (Arthrex, Naples, FL). Our technique uses a semitendinosus allograft and semitendinosus autograft (Fig 2).

Primary CC Ligament Reconstruction
A tunnel is made at the midline of the acromion, a tunnel is made for suture passage. This tunnel should be approximately 4 to 5 mm in diameter to match graft thickness (Fig 3). A stay suture is placed in this tunnel. The 2 existing clavicular tunnels from the previous CC ligament reconstruction are identified and will be used for later graft passage. These tunnels should be oriented accordingly: (1) approximately 35 to 40 mm to the AC joint and slightly posterior on the clavicle to recreate the conoid ligament and (2) approximately 20 to 25 mm medial to the AC joint (corresponding to 15 mm lateral to the first clavicular tunnel), which is used to match the anatomic footprint of the trapezoid ligament.

A passing suture is placed through the most lateral clavicular hole, used for later graft passage. The medial clavicular hole is reserved for the TightRope, which consists of a Dog Bone (Arthrex) button and a continuous loop of braided No. 5 FiberTape suture (Arthrex). Next, attention is paid to the coracoid, where a pre-existing tunnel was used for a passing suture that passed through the coracoid and medial clavicular hole for later passage of the AC TightRope (Arthrex).

The FiberTape limbs used for the AC TightRope (Arthrex) are placed into the slots of the Dog Bone precontoured button, ensuring that the implant will sit flush on the coracoid base. All FiberTape limbs are loaded through the passing suture and pulled superiorly through the coracoid and clavicle bone tunnels. The clavicle Dog Bone Button is then loaded to the suture and tensioned securely against the superior clavicle until the clavicle is fully reduced into anatomic position (Fig 4). Slight overreduction is recommended to overcome inevitable creep in the system.

Primary CC Ligament Reconstruction: Graft Integration
Both ends of the prepared semitendinosus autograft and allograft are passed graft passed around the inferior aspect of the coracoid using a previously placed passing suture. The semitendinosus allograft (graft #1) is passed inferior to superior around the posterior aspect of the clavicle, using a passing suture (Fig 5). The 2 limbs of the graft are crossed on top of the clavicle, medial to the Dog Bone button, and sutured to one another. The remaining limb is crossed deep to the anterior limb and passed inferior-to-superior through the prior lateral clavicle tunnel and secured with a 4.75-mm (polyether ether ketone) interference screw is used to secure the graft to the superior clavicle (Fig 6). The tendon is then passed over the clavicle, underneath the acromion, and through the acromial tunnel from inferior-to-superior. A second interference screw is used to secure the graft to the acromion.

AC Capsular Ligament Reconstruction
After the completion of this step, the semitendinosus autograft (graft #2) is passed from the coracoid, anterior and posteriorly around the acromion to complete a full reconstruction of the AC joint capsule (Fig 7). A combination of 2.9-mm short PushLocks with SutureTape and 3.5-mm SwiveLocks (Arthrex) was used this to affix the graft and hold the capsule in place. At conclusion, reduction is confirmed using intraoperative fluoroscopy. The shoulder is taken through a full arc of motion to check for impingement and stability.

Closure and Postoperative Rehabilitation
The wound is irrigated and closed in a layered manner. Sterile dressing is applied and the patient is placed in a padded abduction sling with elbow support. The patient will remain in the padded abduction sling
with elbow support for a total of 6 weeks. The patient will be instructed to perform gentle passive range of motion exercises of the shoulder, elbow, and wrist daily. Prior to 4 weeks, shoulder passive range of motion is limited to 90° forward flexion, 60° external rotation, and 30° abduction. From 4 to 6 weeks postoperatively, range of motion exercises are used to increase external rotation. Resistance exercises may begin 6 weeks postoperatively. Patients are expected to return to full activity at 4 months postoperatively. Anteroposterior radiographs of the right shoulder are obtained 6 weeks after AC-CC reconstruction, confirming excellent reduction of the AC joint (Fig 8).

**Discussion**

This Technical Note describes our technique for treatment of multiple failed CC ligament reconstructions using a semitendinosus allograft and TightRope fixation to reconstruct and reinforce the CC ligament, and a semitendinosus autograft to reconstruct the AC capsular ligaments. Advantages of this procedure include use of previous drill holes for graft passage and TightRope fixation of the CC ligament to prevent refracture and restoration of normal joint kinematics through reconstruction of both the AC and CC ligaments. This Technical Note highlights the importance of the CC ligament as a static stabilizer and our revision technique to provide a robust fixation that addresses both the CC ligaments and AC capsular ligament through a complete reconstruction.

Significant attention has been placed on anatomical reconstruction of the CC ligaments. Several current anatomic techniques have involved cortical fixation devices, free tendon grafts, or a combination of the two.\(^{15-17}\) The current anatomic reconstruction technique recreates the 2-bundle course of the CC ligament complex. Such anatomic restoration has been reported to closely replicate the properties of the native CC ligaments more than traditional techniques, such as the Weaver–Dunn procedure, which involves distal clavicle excision and transfer of the coracoacromial ligament.\(^{18-20}\) It should be noted that anatomic reconstruction of the CC ligament is not without limitations. Drill holes through the clavicle and/or coracoid serve as stress risers, which may cause the construct to fail as a result of conjoined tendon tears, fracture, or cutout.\(^{21,22}\) A biomechanical study by Martetschläger et al.\(^{23}\) that examined the effect of coracoid drilling in 18 fresh-frozen cadaveric scapulae following anatomic CC ligament reconstruction found that single drill holes of 2.4 mm resulted in greater load to failure than one or two 4-mm drill holes (506 ± 73.3 N for one 2.4-mm tunnel vs 392 ± 98.2 N for two 4-mm tunnels, and 459 ± 143.8 N for one 4-mm tunnel, \(P = .015\)). The mechanism of failure in all specimen was fracture of the coracoacromial process. The clinical implications of the findings of Martetschläger et al.\(^{23}\) are redemonstrated in a review by Millett et al.\(^{24}\) that examines 12 studies that reported complications after CC ligament reconstruction at a rate of 39.8%, among the most serious being distal clavicle and/or coracoid fractures as a result of bone tunnels. The findings of Martetschläger et al.\(^{23}\) and Millett et al.\(^{24}\) illustrate the importance of using the necessary minimum number of drill holes during AC joint reconstruction. A notable
The pearl of our technique is the conservative approach to bone tunnels and the use of grafts around the coracoid base instead of drilling an additional transcoracoid tunnel. In the revision scenario, if previous drill holes are present and appropriately positioned, the present technique offers a powerful option to maximize stabilization and minimize transosseous fixation points along the clavicle and coracoid.

While the CC ligament may portend vertical stability, isolated reconstruction of the CC ligament is subjected to greater horizontal forces without the stress shielding presence of AC ligaments. In their biomechanical study, Gonzalez-Lomas et al. highlights the importance of the AC ligaments as horizontal stabilizers, reporting a 50% decrease in horizontal translation when both AC and CC ligaments are repaired compared with free tissue isolated CC ligament reconstruction. Walters et al. further investigated the clinical importance of AC ligament reconstruction in their matched cohort study. Their findings showed that patients who underwent AC/CC reconstruction had a significantly smaller difference in CC distance when compared with the contralateral shoulder than those who underwent isolated CC reconstruction (0.9 ± 4.0 mm vs 4.0 ± 4.7 mm, \( P = .014 \)). In addition, the AC/CC reconstruction group had fewer complications (7.0% vs 30.7%, \( P = .035 \)) and fewer reoperations (1 vs. 8 \( P = .01 \)) than those in the CC ligament control group. Our technique uses 2 tendon-free grafts to reconstruct both the conoid and trapezoid CC ligaments as well as the superior and posterior AC ligaments. The free tendon grafts create a complete triple-bundled reconstruction of the AC joint to optimize restoration of anatomy and biomechanics in the shoulder. Accordingly, combined AC/CC ligament reconstruction should be attempted, when possible, to resist both anteroposterior and superior migration and, ultimately, mitigate risk of construct failure and/or reoperation.

Finally, the use of 2 free tendon grafts in this surgical technique forms a robust triple-bundle construct of the AC joint. This triple-bundle construct maximizes resistance to anteroposterior and superior migration through reconstruction of the AC, conoid, and trapezoid ligaments. Le Hanneur et al. demonstrated the biomechanical advantages of a triple-bundle technique in their cadaveric study, which they found a triple-bundle construct to have significantly less anteroposterior translation (4.6 ± 0.7 mm), as compared with a single-bundle construct (7.8 ± 1.1 mm) at 10 N (\( P = .003 \)). Similarly, in a cadaveric study of 12 paired shoulders by Le Hanneur et al., the triple-bundle construct group displayed significantly less anterior (2.80 ± 0.87 mm vs 5.39 ± 0.94, \( P = .011 \)) and posterior (3.84 ± 2.50 mm vs 14.01 ± 7.49 mm, \( P = .014 \)) translation compared with the Weaver–Dunn repair group. The clinical implications of triple-bundle fixations have been demonstrated by Tauber et al., who found that patients who underwent AC joint stabilization using a triple-bundle approach had significantly greater AC joint stability and lower rates of recurrence than patients with a single-bundle fixation. These findings emphasize the biomechanical and clinical advantages our current approach to AC and revision CC reconstruction, that biomechanically optimizes reconstruction of the AC joint and minimizes deformity.

Limitations
This technique is not without limitations. Although we endorse the current technique in the setting of revision AC and CC reconstruction, studies with long-term follow-up are necessary to evaluate the long-term outcomes.

**Fig 7.** Acromioclavicular ligament reconstruction. Right shoulder, beach-chair position. The semitendinosus autograft (graft #2) is passed from the coracoid, anterior and posteriorly around acromion to complete a full reconstruction of the acromioclavicular joint capsule. 2.9-mm PushLocks and 3.5-mm SwiveLocks affix the graft.

**Fig 8.** Postoperative imaging. Anteroposterior radiograph of right shoulder postacromioclavicular–coracoclavicular reconstruction, confirming excellent reduction of the acromioclavicular joint.
term follow up are necessary to best assess outcomes. The use of biologic grafts plays an important role in the success of the technique with autografts being found to have superior clinical and radiographic outcomes over allografts.\(^{30}\) This technique is also performed under the belief that a Dog Bone Button in combination with SwiveLock and SutureTape achieve the best reduction with minimal risk of recurrent instability.

**Conclusions**

The described surgical technique provides a powerful option for revision of multiple failed CC ligament reconstructions through the complete reconstruction of an AC joint in which the conoid, trapezoid, and AC ligaments are reconstructed using 2 tendon grafts and reinforced with a TightRope fixation to serve as an internal brace construct. This technique minimizes transosseous fixation points for graft passage using previous drill holes, incorporates biological tendon grafts to optimize biocompatibility, and restores normal joint kinematics through reconstruction of both the AC and CC ligaments.

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