Technical Note

Arthroscopic Anatomic Knotless Coracoclavicular Ligament Repair Without Coracoid Drilling

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Abstract: Acromioclavicular joint injuries are common in young active patients. A wide variety of surgical techniques exist to address specific complications associated with surgery. Complications after surgery include loss of reduction, fracture of the clavicle or coracoid, failure of fixation, and prominent and symptomatic hardware. This technique aims to reduce these complications with an arthroscopic anatomic coracoclavicular ligament repair using knotless adjustable loop buttons with fifth-generation suture tape and no drilling of the coracoid.

Introduction

Acromioclavicular (AC) joint injury is commonly seen in the young athletic population.[1] Patients are frequently treated nonoperatively because up to 89% of AC joint injuries are low grade and do not require surgery.[1] In the smaller percentage of patients who do require surgery, surgical technique has some of the widest variability in all of orthopaedics, with more than 60 different techniques described.[2] The various techniques aim to avoid complications, such as infection, hardware irritation, coracoid fracture, clavicle fracture, and loss of reduction. Infection after AC joint reconstruction is rare and is seen in 3.8% of cases; however, nonabsorbable suture, use of allograft, and nonarthroscopic approaches have been associated with an increased infection risk.[2-4] Hardware irritation is common and may be seen in 25-39% of patients postoperatively.[5,6] Risk of postoperative fracture ranges from 5% to 20% and is at the coracoid in up to 87% of fractures.[2,7] Loss of reduction has been observed in 6.5% to 80% of patients postoperatively and occurs when the construct is not sufficiently strong enough to resist the forces from the weight of the arm.[8] We present a surgical technique aimed to reduce the risk of hardware irritation with a knotless low-profile implant, reduce fracture risk with no drilling through the coracoid, and reduce loss of reduction with small-diameter anatomic clavicle tunnels and fifth-generation adjustable loop fixation with high-strength suture tape.

Patient Evaluation

Patients with AC joint instability often describe an initial injury from a direct blow to the lateral acromion.[9] Indirect forces from a fall on an outstretched arm can also result in AC joint instability.[9] Patients who present less than 3 weeks from the initial injury can be treated as an “acute” injury, and patients presenting 3 or more weeks after injury are classified as “chronic”.[10] This is important to identify because it has implications on use of allograft for reconstruction in chronic injuries.[10] On physical examination, patients may be tender at the AC joint, with a notable prominence of the distal clavicle when sitting upright. The cross-body adduction test is the most sensitive physical examination test, and the O’Brien active compression test is the most specific test for AC joint injury.[10,11] The shrug test will demonstrate whether or not the distal clavicle is reducible or if there is interposed deltotrapezial fascia that prevents reduction with shoulder shrug.[11]

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Imaging

Standard radiographs are obtained at initial evaluation and include AP, axillary, and scapular Y views. The AP view will demonstrate superior subluxation of the distal clavicle at the AC joint if the coracoclavicular (CC) ligaments are disrupted.[9] It is important to scrutinize the axillary view to detect posterior dislocation of the distal clavicle, as seen in a type IV injury. Additional radiographic views help to better define the injury and include Zanca and bilateral AC joint views to compare the side-to-side CC interval difference and differentiate between a type III and V injury.[11] If additional intra-articular pathology is suspected on the basis of history, examination and initial radiographic imaging, then advanced magnetic resonance imaging (MRI) may be considered for further evaluation.[11]

Indications

After obtaining the appropriate imaging studies, the injury is classified according to the Rockwood classification from grades I to VI (Table 1).[9,11,12] Operative management is typically recommended for type IV, V, and VI injuries.[10,11,13] Nonoperative management is recommended for type I and II injuries.[9–11] Surgical management of type III injuries is controversial, and early surgical intervention for higher-demand patients may be indicated.[9] For patients with injuries less than 3 weeks old, repair without allograft may be considered; however, for injuries greater than 3 weeks old, allograft reconstruction is indicated.[10]

Surgical Technique

Preoperative Planning

Preoperatively, full-length bilateral clavicle films are obtained, and the desired conoid and trapezoid tunnels are templated at 30% and 17% of the total clavicle length, respectively, as described by Rios et al. (Fig 1).[14]

Positioning

The patient is positioned in the beach chair with a pneumatic arm holder. The c-arm is brought in prior to prepping and draping to confirm adequate visualization of the coracoclavicular (CC) interval. Examination under anesthesia is performed to assess reducibility of the clavicle.

Table 1. The Rockwood Classification[12]

	Rockwood Classification	
Type	Radiographs	Treatment
I	Normal	Nonoperative
II	CC interval <25% displaced	Nonoperative
III	CC interval 25-100% displaced	Controversial
IV	Distal clavicle posterior dislocation	Operative
V	CC interval >100% displaced	Operative
VI	Distal clavicle inferior dislocation	Operative

CC, coracoclavicular.

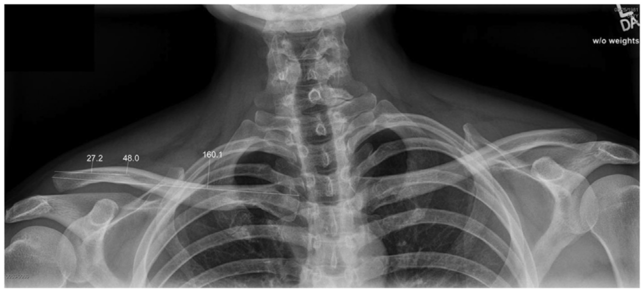

Fig 1. Bilateral clavicle radiograph with measurements demonstrating the preoperative templated anatomic tunnel location of the conoid and trapezoid tunnels. The conoid tunnel is templated at 30% of the total clavicle length from the distal clavicle. The trapezoid tunnel is templated at 17% of the total clavicle length from the distal clavicle.

Diagnostic Arthroscopy

Diagnostic arthroscopy is performed with a 30° arthroscope, and a standard posterolateral viewing portal is made followed by an accessory anterior superior viewing portal (Video 1). This portal is placed slightly more lateral to the standard anterior superior portal to improve access to the coracoid. Any intra-articular pathology is addressed at this time.

Establish Accessory Anterolateral Portal

The camera is switched to a 70° arthroscope to improve visualization of the base of the coracoid. The rotator interval is debrided to expose the base of the coracoid. An accessory anterolateral portal is made with needle localization, and a cannula is placed for later suture passage.

Arthroscopic Preparation of the Coracoid

The arthroscope is moved to the anterior superior portal. A radio frequency wand is brought in through the accessory anterolateral portal, and the coracoid is skeletonized until its base and genu are well visualized, as it turns toward the scapular body (Fig 2). If the surgeon plans on using tendon graft for reconstruction, the undersurface of the coracoid is decorticated with a motorized shaver. The superior surface of the coracoid is also cleared of soft tissue to allow suture passage from the undersurface of the clavicle. An accessory superomedial portal is established anterior to the clavicle and just medial to the coracoid. This allows for a better angle to release the pectoralis minor from the medial aspect of the coracoid and to clear off the tissue superior to the coracoid (Fig 3).

Establish Anatomic Tunnels in the Clavicle

An incision is planned at a distance from the distal clavicle that will be between the planned conoid and

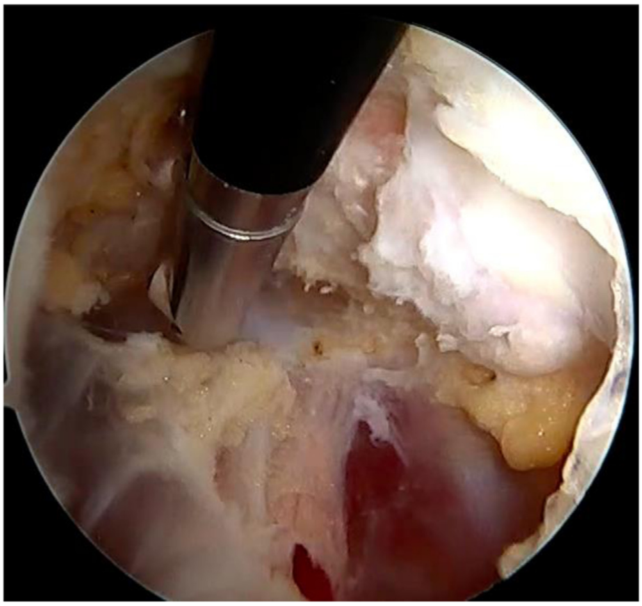

Fig 2. The arthroscope is in the anterior superior portal on the right shoulder. The radio frequency wand is in the accessory anterolateral portal. This image demonstrates clearance of the rotator interval to expose and skeletonize the undersurface of the coracoid.

trapezoid tunnels. The incision is made, and care is taken to sharply incise the deltotrapezial fascia for later repair. A ruler is used to mark the desired distance from the end of the distal clavicle for the conoid and trapezoid tunnels, based on preoperative templated measurements. A 3-mm drill bit is used to drill a hole in the clavicle at the planned conoid tunnel location, aiming toward the base of the coracoid under fluoroscopic guidance (Fig 4).

Place Shuttle Sutures Around the Coracoid

The drill is removed, and a passing suture is placed down the drilled tunnel (Fig 5). The arthroscope is used to locate the passing suture in the space between the clavicle and the coracoid, and the passing suture is placed beneath the coracoid on its medial aspect with the grasper in the accessory portal superior and medial to the coracoid (Fig 6). The passing suture is retrieved from beneath the coracoid and taken out of the accessory anterolateral portal (Fig 7). A shuttling loop is tied in this suture on the clavicle side for later shuttling (Fig 8). A second passing suture is placed through the same drill hole (Fig 9). The second passing suture is placed lateral to the coracoid with the grasper in the accessory portal superior and medial to the coracoid (Fig 10). The second passing suture is retrieved from the lateral aspect of the coracoid and the shuttling loop taken out the accessory inferior anterolateral portal (Fig 11).

Shuttle and Assemble the Adjustable Loop Button

The unassembled open adjustable loop cortical button (BTB TightRope II, Arthrex, Naples, FL) is taken out of the prepackaged card to access the free open loop of the unassembled implant. The needle is cut off from the free loop (Fig 12). The free loop is maximally

Fig 3. The radio frequency wand has been moved to the accessory portal just superior and medial to the coracoid. This allows for release of the pectoralis minor and clearance of tissue superior to the coracoid.

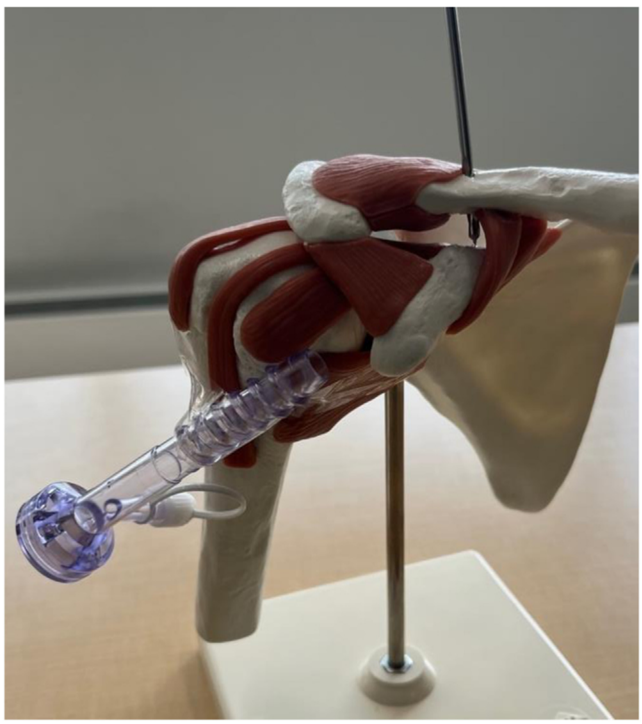

Fig 4. Three-millimeter drill is aimed toward the coracoid.

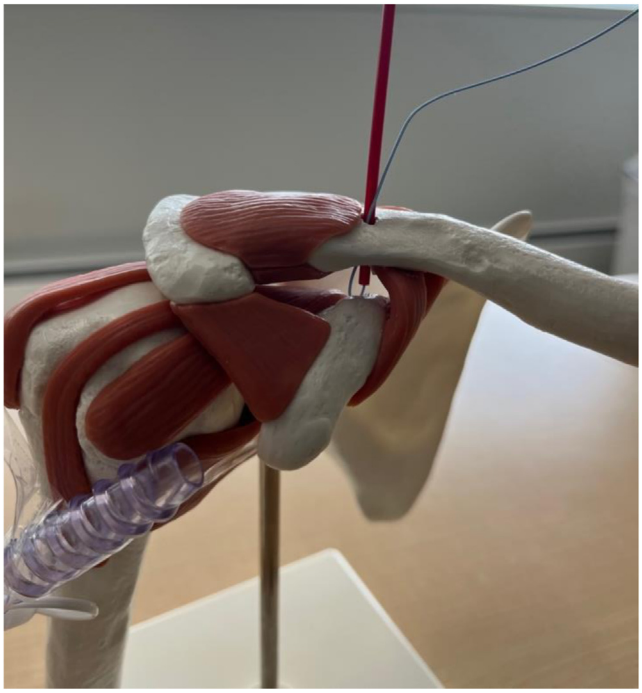

Fig 5. The first shuttle suture is placed through the tunnel in the clavicle.

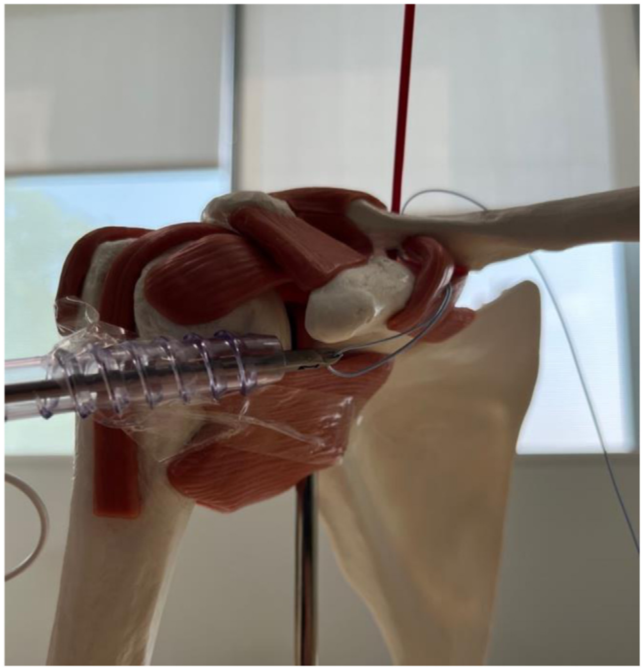

Fig 7. The first shuttle suture is taken from inferior to the coracoid and out of the accessory anterolateral portal for later shuttling.

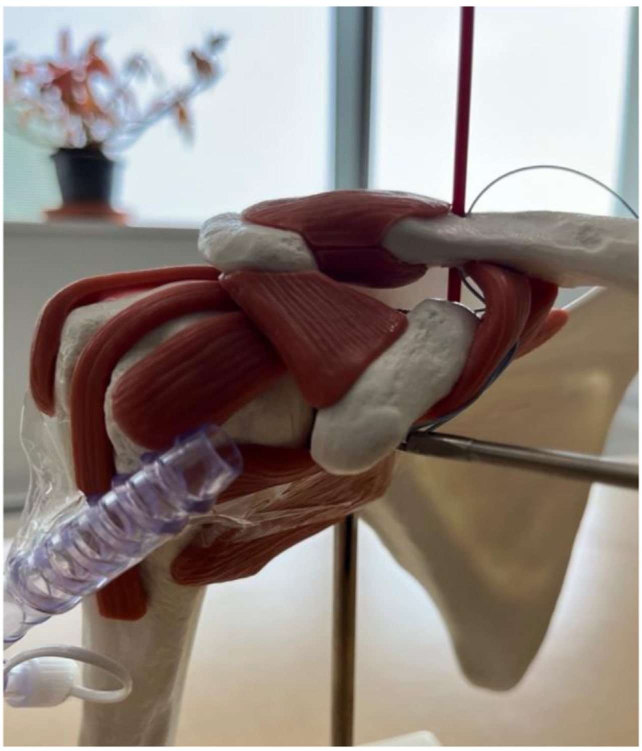

Fig 6. The first shuttle suture is passed medially and inferiorly to the coracoid with the grasper in the accessory portal superior and medially to the coracoid.

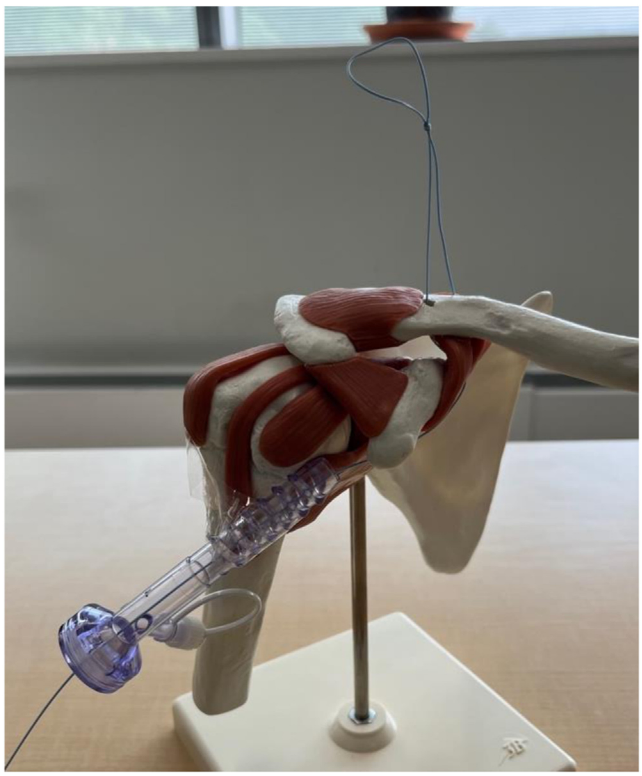

Fig 8. One strand of the shuttle suture is pulled all the way out the accessory anterolateral portal while keeping the other free strand on the clavicular side. A loop is tied on the clavicular strand for later shuttling.

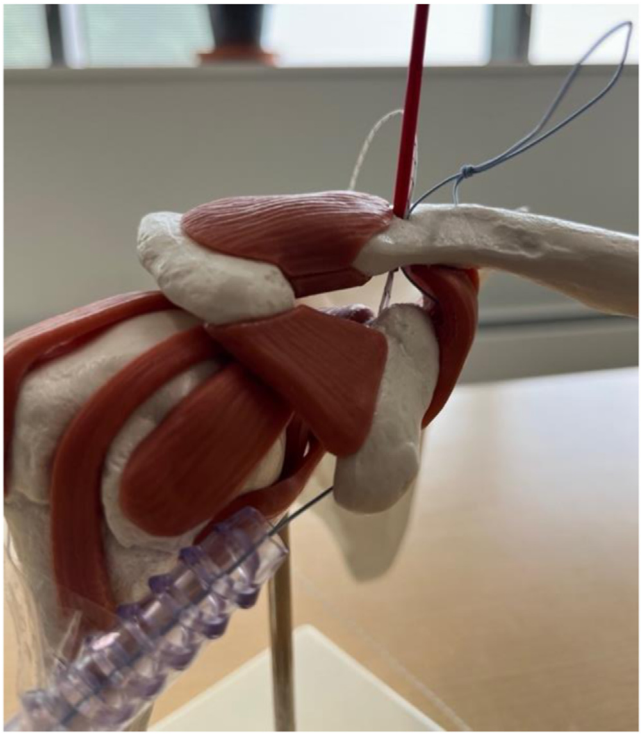

Fig 9. A second shuttle suture is placed through the same 3-mm drill hole in the clavicle that the first shuttle suture was placed in.

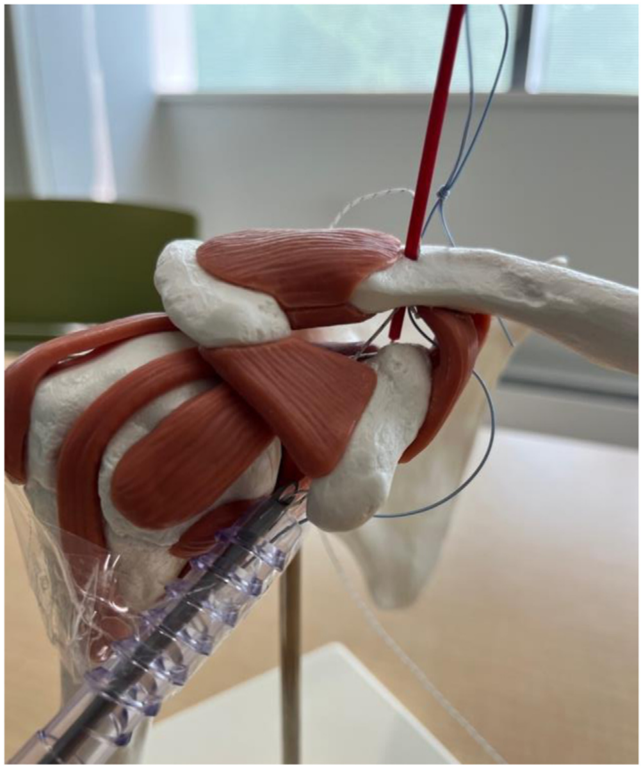

Fig 11. The grasper is moved to the accessory anterolateral portal, and the second shuttle suture is taken out. Ensure the loop side stays on the accessory anterolateral portal side for later shuttling.

lengthened prior to shuttling (Fig 13). The free loop is placed in the shuttling suture on the clavicle side and pulled down medial to the coracoid, under the base of the coracoid and out the accessory anterolateral portal.

The free loop of the adjustable loop is then placed in the shuttle suture in the accessory anterolateral portal and shuttled back up the lateral aspect of the coracoid and out the conoid drill hole (Fig 14). The adjustable loop button is assembled by placing the free limb through

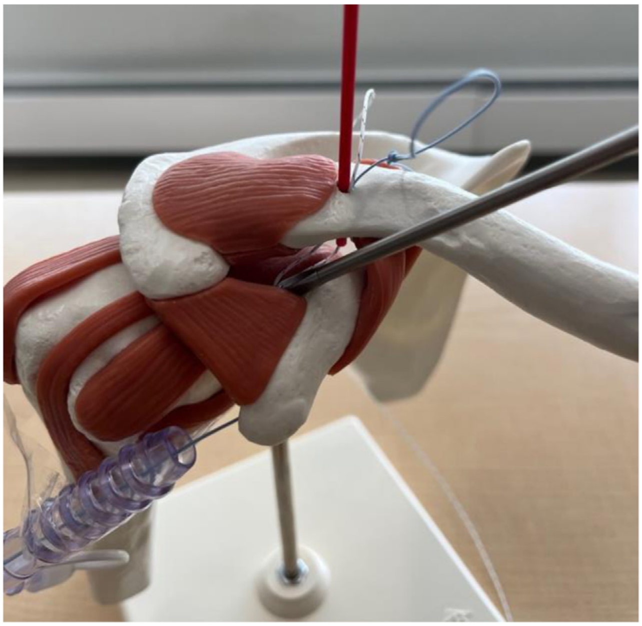

Fig 10. The second shuttle suture is placed lateral to the coracoid with the grasper in the accessory portal superior and medial to the coracoid.

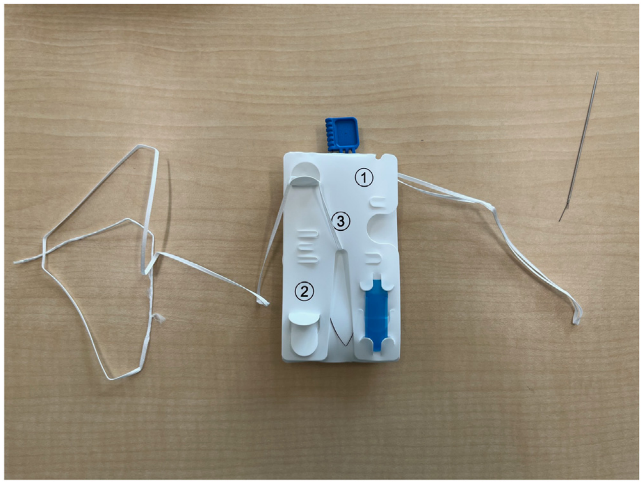

Fig 12. The open adjustable loop is disassembled from the prepackaged card, and the needle is cut from the free loop end.

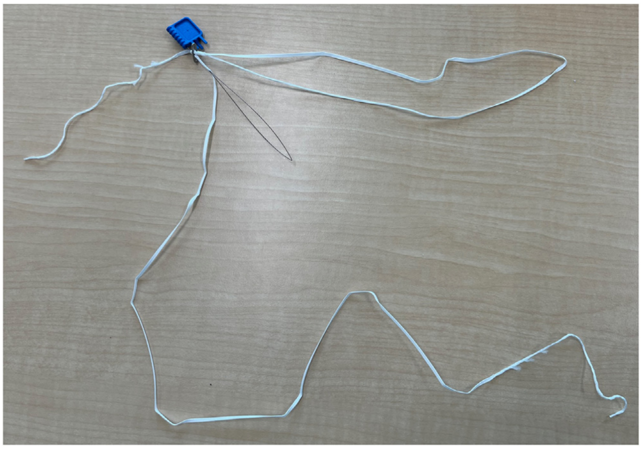

Fig 13. The free loop end of the adjustable loop button is maximally lengthened prior to shuttling around the coracoid base.

the loop (Fig 15), then the free limb through the wire loop (Fig 16), and finally pulling the wire to load and close the adjustable loop (Fig 17).

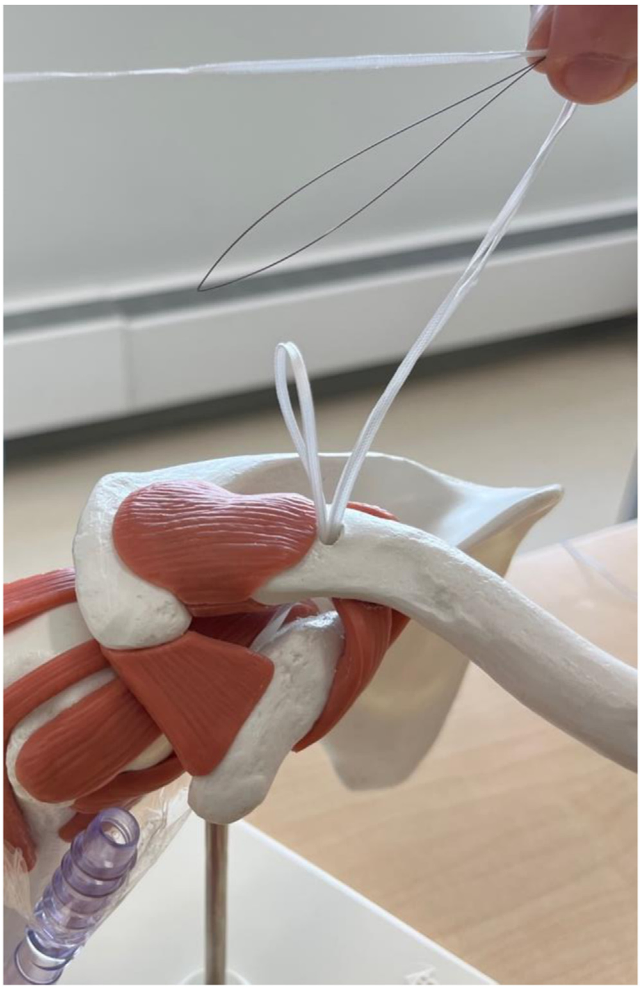

Fig 14. The free loop end of the adjustable loop button has been shuttled around the base of the coracoid.

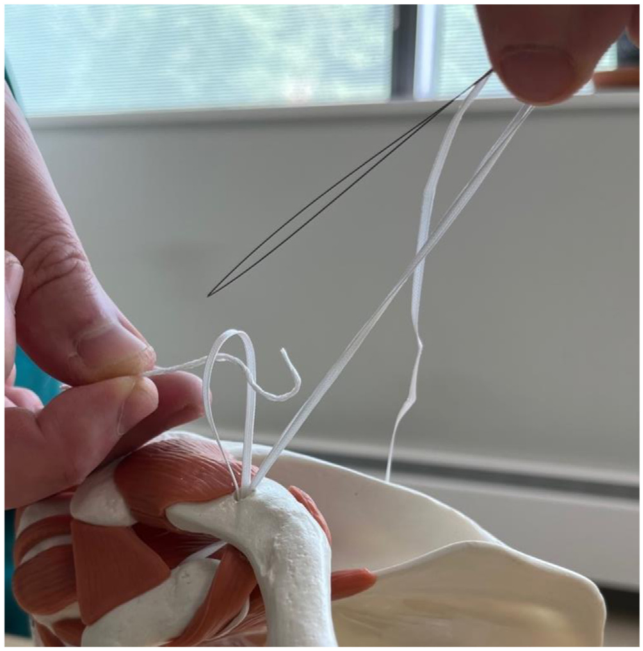

Fig 15. The free limb of the adjustable loop button is passed through the free loop.

Final Tensioning of Adjustable Loop Button

The c-arm is brought in, and the adjustable loop sequentially tightened until satisfactory radiographic reduction is obtained (Figs 18 and 19). The same procedure is repeated with drilling at the trapezoid tunnel,

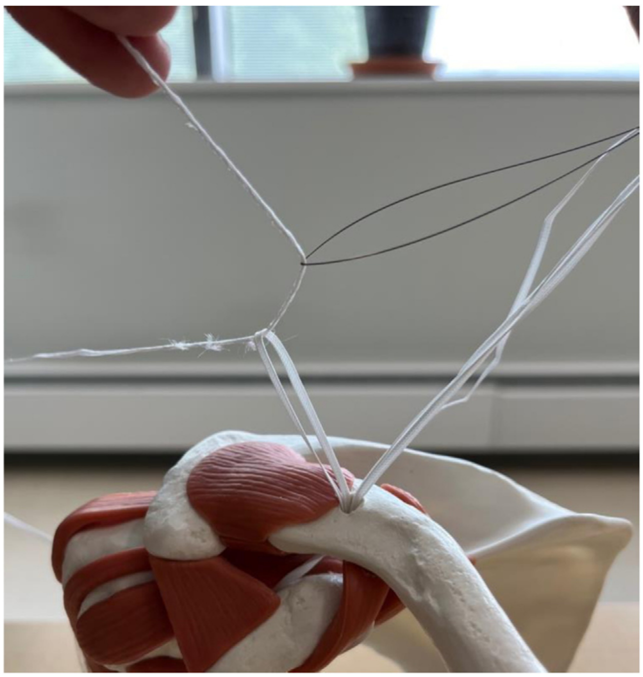

Fig 16. The free limb of the adjustable loop button is passed through the wire loop after it has been passed through the free loop.

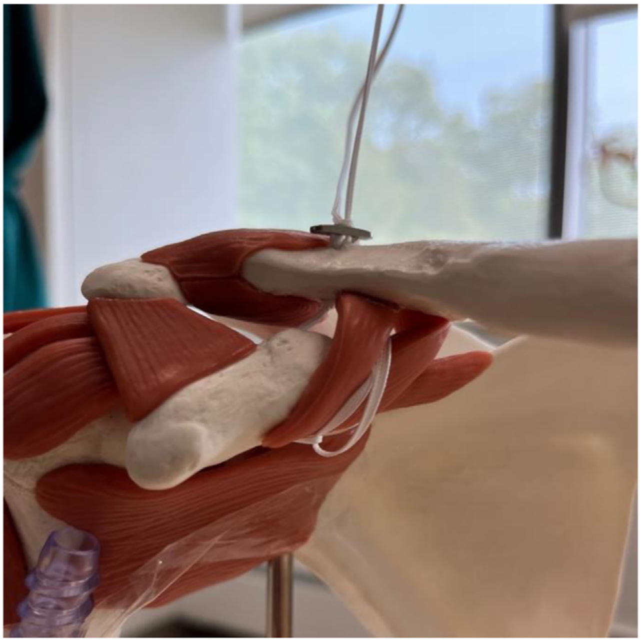

Fig 17. After pulling the wire loop, the adjustable loop button is now loaded as a closed loop around the base of the coracoid and is ready for final tensioning.

shuttling of the free loop of the unassembled adjustable loop button, assembling the adjustable loop, and then sequential tightening to complete the repair.

Coracoclavicular Ligament Reconstruction

If a reconstruction is indicated, a blunt switching stick is placed from the posterior aspect of the clavicle to the medial aspect of the coracoid. A cannulated soft tissue

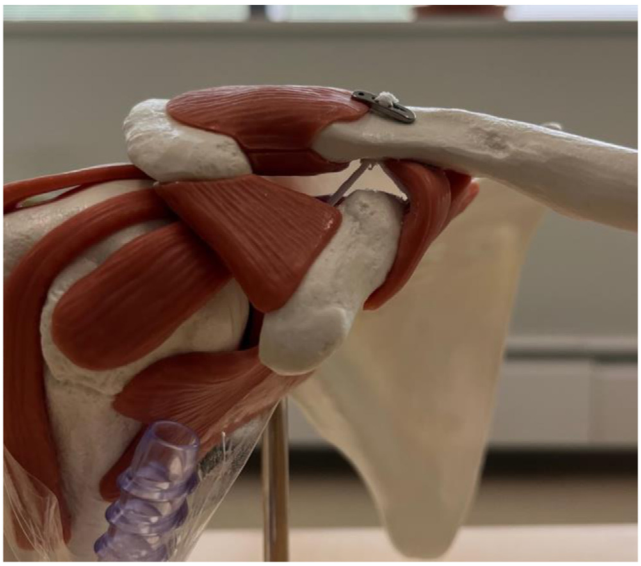

Fig 18. Final tensioning and completion of the low-profile, knotless, fifth-generation adjustable loop button around the coracoid base.

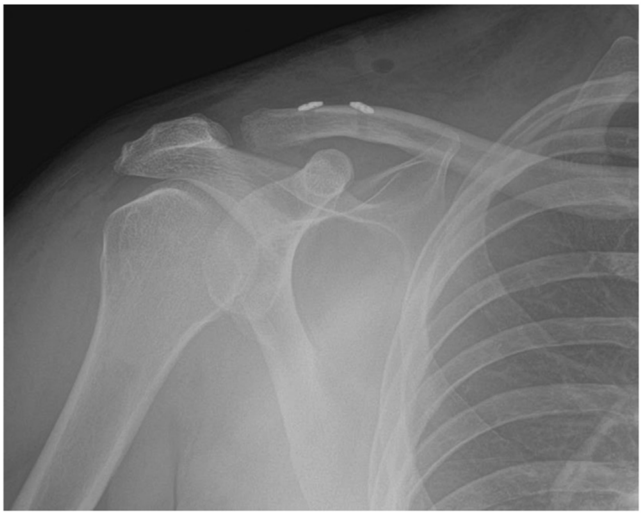

Fig 19. Postoperative anteroposterior radiograph of the right shoulder, demonstrating anatomic clavicular tunnel placement and reduction of the coracoclavicular interval without drilling of the coracoid.

dilator is placed over the switching stick. The same procedure is performed with a blunt switching stick from the anterior border of the clavicle to the lateral aspect of the coracoid. Passing sutures are placed and retrieved out of the accessory anterolateral cannula, and then the graft is shuttled and sewn to itself over the top of the clavicle. To complete the procedure, the overlying deltotrapezial fascia is closed.

Postoperative Rehabilitation

Postoperatively, patients are non-weight bearing in a shoulder immobilizer for the first 6 weeks. Passive range of motion is allowed during this time up to 90° of forward flexion and abduction. At 6 weeks, the sling is discontinued, and the patient is allowed to progress to full passive range of motion; however, the patient is restricted from carrying any objects greater than 5 pounds until 12 weeks postoperation. At 12 weeks, the patient begins gentle progressive strengthening exercises. At 4 months, the patient starts advanced strengthening and sport-specific exercises with return to sport between 6 and 9 months postoperatively.

Discussion

Knotless adjustable loop fixation has been adopted in many surgical techniques used for acromioclavicular joint instability. Early techniques demonstrated high failure rates, with the majority of failures attributed to loss of fixation or slippage of the adjustable loop device.[7,8,15] Suture slippage in the adjustable loop device has been demonstrated in biomechanical studies; however, fifth-generation adjustable loop button devices have added additional locking mechanisms that reduce suture slippage.[16,17] The fifth-generation adjustable loop button with suture tape used in this

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Visualize with a 70° arthroscope through anterior superior portal.	Failure to adequately clear off superior coracoid makes suture shuttling difficult.
Use an accessory portal just superomedial to coracoid to clear off superior coracoid and aid in suture shuttling.	Failure to aim drill at coracoid under c-arm makes shuttle suture trajectory unpredictable and difficult to find arthroscopically.
Use metal ruler and c-arm to mark templated anatomic tunnel position prior to drilling.	Shuttling the free limb instead of the loop around the coracoid will make an incomplete loop around the coracoid.
Lengthen the free loop prior to shuttling for adequate length.	Failure to monitor reduction under c-arm during final tightening may result in overreduction of the AC joint.

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
No drilling of the coracoid	Risk of suture tape sawing through coracoid
Small-diameter tunnels through clavicle	Increased time required to clear tissue superior to coracoid
Fifth-generation adjustable loop buttons with high-strength suture tape	Increased implant cost when using two buttons

technique may add increased stability due to reduced suture slippage compared to previous adjustable loop devices. Additionally, the use of high-strength suture tape with a broader surface area may increase the strength of the construct and limit failures.

Other aspects of this technique that aim to reduce clinical failures are small-diameter tunnel drilling in the clavicle, no drilling of the coracoid, and anatomic conoid and trapezoid tunnel placement in the clavicle. Cadaveric and clinical studies have demonstrated higher risk of postoperative fracture of the clavicle and coracoid with increasing tunnel diameter.[18-20] Drilling small-diameter clavicle tunnels and no drilling of the coracoid in this technique may reduce the risk of postoperative fracture (Table 2). However, although not reported in the literature, there is a risk of the suture tape being sawed through to the coracoid and causing fracturing as the patient returns to activity. Clinical and biomechanical studies are conflicting regarding the need for 2 anatomic tunnels in the clavicle when compared to a single tunnel.[21,22] The clinical benefit of anatomic CC tunnel placement has not yet been established; however, biomechanical studies demonstrate anatomic tunnel placement, as used in this technique, is biomechanically superior to nonanatomic tunnel placement.[23]

Conclusion

This technique aims to avoid common complications seen in surgical management of acromioclavicular joint injuries such as clavicle fracture, coracoid fracture, symptomatic implants, and loss of reduction (Table 3). Using an arthroscopic-assisted technique with small-diameter, anatomically placed tunnels in the clavicle, no drilling of the coracoid and low-profile, fifth-generation knotless devices with stronger suture tape for fixation addresses all of these complications and may lead to improved postoperative outcomes.

References

1. Pallis M, Cameron KL, Svoboda SJ, Owens BD. Epidemiology of acromioclavicular joint injury in young athletes. *Am J Sports Med* 2012;40:2072-2077.
2. Woodmass JM, Esposito JG, Ono Y, et al. Complications following arthroscopic fixation of acromioclavicular separations: a systematic review of the literature. *Open Access J Sports Med* 2015;6:97-107.
3. Neault MA, Nuber GW, Marymont JV. Infections after surgical repair of acromioclavicular separations with nonabsorbable tape or suture. *J Shoulder Elbow Surg* 1996;5:477-478.
4. Yeak RDk, Daud H, Nizlan NM. Osteomyelitis post acromioclavicular joint reconstruction. *Chin J Traumatol* 2019;22:182-185.
5. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. *Am J Sports Med* 2010;38:1179-1187.
6. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med* 2011;39:1507-1516.
7. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR. Complications related to anatomic reconstruction of the coracoclavicular ligaments. *Am J Sports Med* 2012;40:1628-1634.
8. Cook JB, Shaha JS, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM. Early failures with single clavicular transosseous coracoclavicular ligament reconstruction. *J Shoulder Elbow Surg* 2012;21:1746-1752.

9. Frank RM, Cotter EJ, Leroux TS, Romeo AA. Acromioclavicular joint injuries: Evidence-based treatment. *J Am Acad Orthop Surg* 2019;27:e775-e788.
10. Berthold DP, Muench LN, Dyrna F, et al. Current concepts in acromioclavicular joint (AC) instability—A proposed treatment algorithm for acute and chronic AC-joint surgery. *BMC Musculoskelet Disord* 2022;23:1078.
11. Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJP. Acromioclavicular joint injuries: Diagnosis and management. *J Am Acad Orthop Surg* 2009;17:207-219.
12. Williams GR, Nguyen VD, Rockwood CA. Classification and radiographic analysis of acromioclavicular dislocations. *Appl Radiol* 1989;18:29-34.
13. Frank RM, Cotter EJ, Strauss EJ, Jazrawi LM, Romeo AA. Management of biceps tendon pathology: From the glenoid to the radial tuberosity. *J Am Acad Orthop Surg* 2018;26:e77-e89.
14. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. *Am J Sports Med* 2007;35: 811-817.
15. Shin SJ, Kim NK. Complications after arthroscopic coracoclavicular reconstruction using a single adjustable-loop-length suspensory fixation device in acute acromioclavicular joint dislocation. *Arthroscopy* 2015;31: 816-824.
16. Barrow AE, Pilia M, Guda T, Kadrmas WR, Burns TC. Femoral suspension devices for anterior cruciate ligament reconstruction: do adjustable loops lengthen? *Am J Sports Med* 2014;42:343-349.
17. Kusano M, Kazui A, Uchida R, Mae T, Tsuda T, Toritsuka Y. Loop length change of an adjustable-length femoral cortical suspension device in anatomic rectangular tunnel anterior cruciate ligament reconstruction with a bone-patellar tendon-bone graft and associated clinical outcomes. *Arthroscopy* 2018;34:3063-3070.
18. Rylander LS, Baldini T, Mitchell JJ, Messina M, Justl Ellis IA, McCarty EC. Coracoclavicular ligament reconstruction: coracoid tunnel diameter correlates with failure risk. *Orthopedics* 2014;37:e531-e535.
19. Spiegl UJ, Smith SD, Euler SA, Dornan GJ, Millett PJ, Wijdicks CA. Biomechanical consequences of coracoclavicular reconstruction techniques on clavicle strength. *Am J Sports Med* 2014;42:1724-1730.
20. Brady P. Editorial commentary: The larger holes or larger number of holes we drill in the coracoid, the weaker the coracoid becomes. *Arthroscopy* 2016;32:988-989.
21. Eisenstein ED, Lanzi JT, Waterman BR, Bader JM, Pallis MP. Medialized clavicular bone tunnel position predicts failure after anatomic coracoclavicular ligament reconstruction in young, active male patients. *Am J Sports Med* 2016;44:2682-2689.
22. Banffy MB, Uquillas C, Neumann JA, ElAttrache NS. Biomechanical evaluation of a single- versus double-tunnel coracoclavicular ligament reconstruction with acromioclavicular stabilization for acromioclavicular joint injuries. *Am J Sports Med* 2018;46:1070-1076.
23. Geaney LE, Beitzel K, Chowaniec DM, et al. Graft fixation is highest with anatomic tunnel positioning in acromioclavicular reconstruction. *Arthroscopy* 2013;29:434-439.