Technical Note

Acromioclavicular Joint Reconstruction With Acromioclavicular Ligament Augmentation Using a Knotless, All-Suture Anchor Construct

Charles C. White, IV, M.D., and Brandon A. Cincere, M.D.

Abstract: Many techniques and combinations of procedures exist for reconstruction of an injured acromioclavicular (AC) joint. Recently, there has been a focus on controlling anterior and posterior translation of the AC joint after the reduction of superior translation and coracoclavicular (CC) ligament stabilization. Diagnosis and treatment of anterior and posterior instability of the AC joint is critical, yet when AC/CC ligament reconstruction fails, this is often the result of recurrent superior migration of the clavicle relative to the acromion. We present a technique using knotless, all-suture anchor technology intended for higher-grade, operative AC joint injuries in "high-risk" patients, i.e., those returning to a collision sport such as football, rugby, hockey, or wrestling. Consideration also could be given to those performing a high-demand occupation, such as overhead work or manual labor. In addition, this technique could be employed in patients at risk for delayed or nonhealing, such as those with diabetes or who are smokers, those at risk of noncompliance, and revision cases. The all-suture anchor, knotless "suture staple" technique can be implemented easily to provide backup fixation of the AC joint directly as an augmentation to CC reconstruction, preferably arthroscopic-assisted reduction, and fixation with a cortical button and, when indicated, concomitant allograft reconstruction.

Many techniques exist for the stabilization of acromioclavicular (AC) joint dislocations. Even among specific techniques, a wide variety of nuance and variability is present. Patients with Rockwood grade IV-VI injuries are candidates for surgery.[1] Those with type III injuries also can be candidates if they are high-level athletes, laborers, or are not satisfied with nonoperative treatment because of residual pain, scapular dyskinesis, or continued instability.[2] Recently, arthroscopic-assisted stabilization of these injuries with coracoclavicular (CC) ligament reconstruction has become a reproducible and reliable technique.[3] This technique uses suspensory type fixation with a cortical button and a heavy, nonabsorbable suture bridge spanning from the base of the coracoid to the distal clavicle. The device is secured to the superior aspect of the clavicle with various knotless devices or by tying knots over a metallic implant or bony bridge. This repair is often reinforced with autograft or allograft to induce biologic healing, especially in chronic injuries.

Augmentation or repair of the AC joint ligaments and capsule in concert with CC ligament reconstruction has been discussed and debated significantly. There are multiple techniques able to reduce anteroposterior stability after repair.[4] Biomechanical testing has shown that suture augmentation of the AC joint improves resistance to both translational and rotational forces after CC ligament reconstruction.[5] Studies have found a decrease in failure rate after combined AC/CC reconstruction when compared with CC reconstruction alone.[6,7] These augmentation techniques have generally employed solid-anchor technology and/or graft reconstruction of the AC joint. The sizing of these anchors creates a level of difficulty and risk when placing them in an anterior to posterior direction because of the shape of the acromion and distal clavicle. In addition, placing these anchors superior to inferior leaves part of the hard body anchor in the subacromial space.

Although stabilization of anterior to posterior instability is certainly important, failure either

From the Department of Orthopaedic Surgery, University of Tennessee College of Medicine Chattanooga, Chattanooga, Tennessee, U.S.A.

Received April 23, 2024; accepted July 20, 2024.

Address correspondence to Charles C. White, IV, M.D., Department of Orthopaedic Surgery, University of Tennessee College of Medicine Chattanooga, 975 East Third St., Hospital Box 260, Chattanooga, Tennessee, 37403, U.S.A. E-mail: whiteccody@gmail.com

2212-6287/24688
https://doi.org/10.1016/j.eats.2024.103226

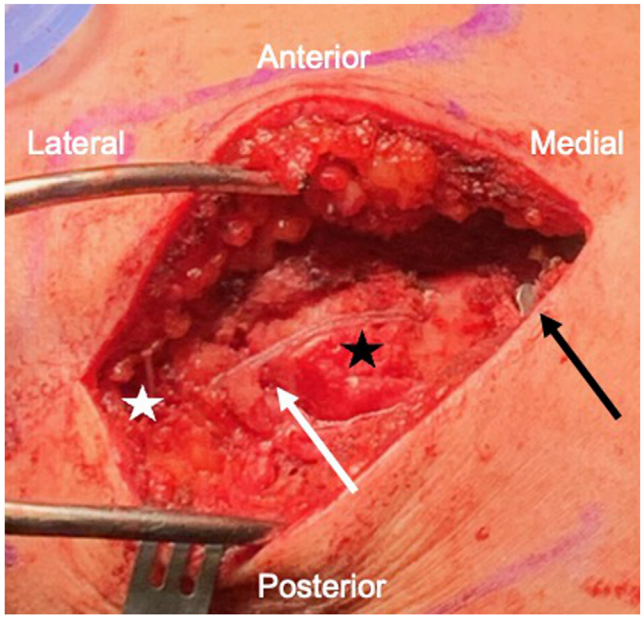

Fig 1. Superior view of an open approach to the left acromioclavicular joint (white arrow) with the final suture staple construct in place across the distal clavicle (black star) and acromion (white star) during a case for an acute (<6 weeks acuity) injury, seen here with a coracoclavicular Dog Bone (black arrow), but without graft augmentation.

radiographically or clinically typically results in recurrent superior dislocation of the distal clavicle relative to the acromion.[8] This can be of varying clinical importance ranging from subtle loss of CC implant fixation as the result of graft and/or suture bridge creep or complete breakage as the result of recurrent trauma.

High-risk sports such as wrestling, hockey, football, rugby, or mixed martial arts pose a greater risk for AC joint injuries and therefore subsequent failure of fixation after repair and return to sport. In addition, AC joint reconstruction frequently occurs greater than 6 weeks from injury, especially type III injuries that attempt nonoperative treatment initially. It has been postulated that beyond 3 weeks, the native AC and CC ligaments are unlikely to heal.[9] Thus, graft augmentation is generally recommended for injuries older than 3 to 6 weeks.[10]

Regarding outcomes, Spencer et al.[11] demonstrated a lower radiographic failure rate, survivorship, and need for reoperation with the cortical button/allograft reconstruction combination for chronic AC joint injury fixation compared with Weaver-Dunn and 2 variations of allograft-only reconstruction. Arthroscopic-assisted techniques have the advantages of smaller incisions, less blood loss, decreased risk to neurovascular structures, shorter operative times, no need for hardware removal, and identification of concomitant intra-articular injuries.[12] The addition of graft augmentation, particularly for chronic cases, allows for biologic healing of the tissues while relying on the strength of a suspensory or nonabsorbable suture fixation method to maintain reduction.[12] This Technical Note describes our preferred technique using a knotless, all-suture anchor construct for AC joint augmentation using a "suture staple" technique (Fig 1, Video 1) (Tables 1 and 2).

Table 1. Pearls and Pitfalls of the AC Joint Augmentation Technique

Pearls	Pitfalls
1. Use of a clamp for reduction rather than manual reduction by an assistant can offer a more reliable and reproducible reduction. 2. Maintain the clamp until both the CC and AC suture constructs are fully tightened and relieved of as much creep as possible. 3. Use of intraoperative fluoroscopy with contralateral comparison views to gauge reduction quality. 4. Gradual and sequential cinching of the 1.8 knotless FiberTak anchors after conversion allows for maximal tension and decreases chance of breakage	1. "Final" tensioning of the CC ligament suspensory device (Dog Bone) before carrying out the suture staple technique may place increased stress on the suture staple construct. 2. Attempted anchor placement too close to the AC joint (<1 cm) or too close to the anterior or posterior margin of the acromion or distal clavicle can lead to cortical blowout with drilling and anchor pullout.

AC, acromioclavicular; CC, coracoclavicular.

Table 2. Advantages and Disadvantages of the AC Joint Augmentation Technique.

Advantages	Disadvantages
1. Low-profile, knotless construct that provides robust fixation of the AC joint and serves as backup fixation of the CC ligament reconstruction. 2. Reproducible, efficient, and easily implementable technique 3. Familiar implant (1.8-mm FiberTak) to surgeons performing arthroscopic hip and shoulder labral repair/reconstruction 4. Option to include graft limbs beneath the suture staple provides use for excess allograft	1. Requires an open surgical approach 2. Slight learning curve with FiberTak anchors when converting knotless mechanism 3. Increased operative time (~10 min)

AC, acromioclavicular; CC, coracoclavicular.

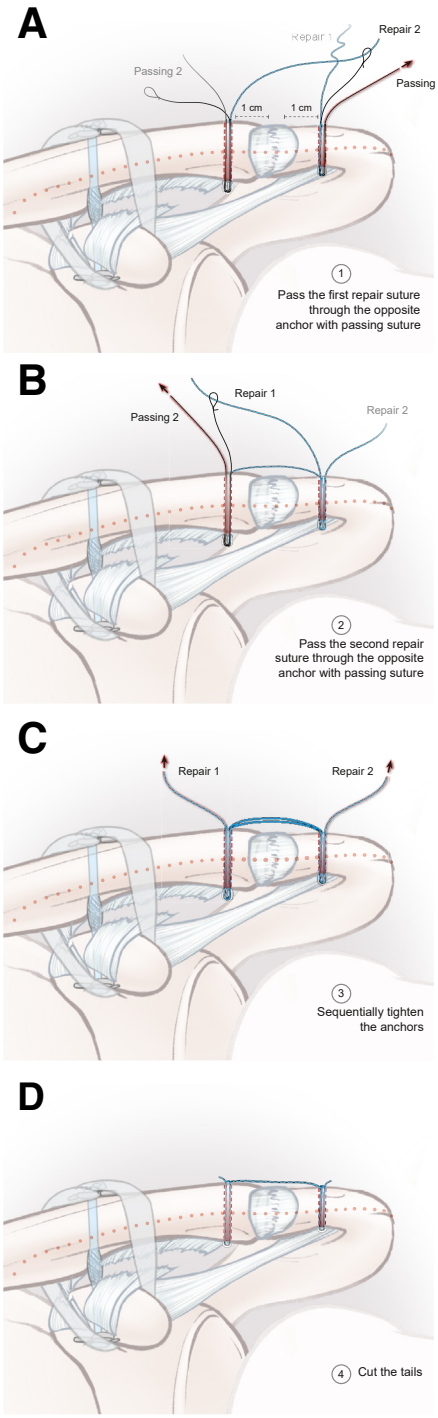

Fig 2. (A) Two 1.8-mm knotless, all-suture anchors are placed approximately 1 cm from the acromioclavicular joint, with care taken not to penetrate the joint or anterior/posterior cortex when drilling. After anchor placement, proceed with suture passing by shuttling the repair stitch through the opposite anchor's passing suture. (B) Repeat suture passage for the opposite anchor. Passing can be completed beginning with either acromial or the clavicular anchor. (C) Using gentle, sequential pulls on the tails, secure the construct until satisfactory tension. (D) Cut the remaining tails once final tension has been achieved to complete the knotless construct. Printed with permission from © Sarah M. Quattrocki.

Surgical Technique

The patient is positioned beach chair per the senior author's preference; however, lateral decubitus positioning also can be used. Before draping, fluoroscopic anteroposterior and Zanca views of the contralateral shoulder are obtained for future comparison and to aid with restoration of a normal CC distance on the affected side. We then begin with diagnostic arthroscopy of the glenohumeral joint. Concomitant pathology, particularly SLAP tears, can be present in patients with an AC joint injury.[13,14] We recommend a thorough diagnostic evaluation of both the intra-articular and subacromial space, even when magnetic resonance imaging is obtained preoperatively. Any concomitant pathology is typically addressed before the AC/CC portion of the procedure.

We then proceed with arthroscopic-assisted CC reconstruction using a single knotless, suture suspension device via a quadra-cortical tunnel through the clavicle and coracoid with a cortical button or "Dog Bone" (Arthrex, Naples, FL). Gracilis allograft looped underneath the coracoid is added for any cases presenting greater than 6 weeks from injury. The surgical exposure involves standard arthroscopic portals and viewing of the coracoid base from the intra-articular space. Exposure is gained using an arthroscopic ablator to dissect through the anterior capsule and interval tissue. A 70° scope is then introduced to visualize the coracoid base.

The open portion of the approach is a 4- to 5-cm incision beginning 1 cm lateral to the AC joint carried medial to expose the acromion, AC joint, and distal clavicle (Fig 1). We recommend raising full-thickness flaps of delto-trapezial fascia and muscle for later repair with imbrication. The location of the trapezoid and conoid insertions is then marked, roughly 3 and 4.5 cm medial to the lateral edge of the clavicle.

Once full exposure is attained, we proceed with AC joint reduction using a medium "Matta" pelvic reduction clamp (Stryker, Kalamazoo, MI) (Video 1, 00:43). The inferior limb is introduced through an accessory anteromedial portal and placed on the inferior aspect of the base of the coracoid using arthroscopic and fluoroscopic guidance. The superior limb is then placed on the superior aspect of the clavicle roughly 2 to 3 cm medial to the AC joint, with care taken to leave space for the Dog Bone suspensory device and allograft loop. Using both visual inspection of the joint and fluoroscopic assistance, the clamp is tightened until a slight over-reduction is achieved. Reduction is confirmed using multiple fluoroscopic views with comparison to saved images of the nonoperative side. The clamp

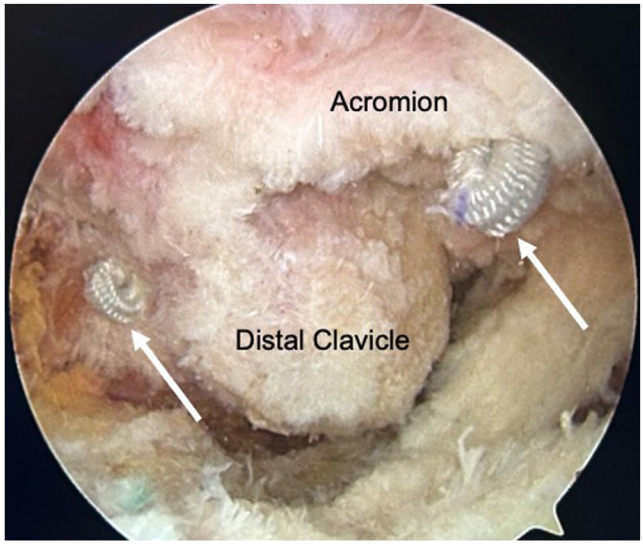

Fig 3. Arthroscopic view from a standard posterior portal of the subacromial space and inferior acromioclavicular joint after anchor passage and deployment on the undersurface of the distal clavicle and acromion revealing the low-profile nature of the FiberTak anchors (arrows) and lack of any hard body material in the subacromial space.

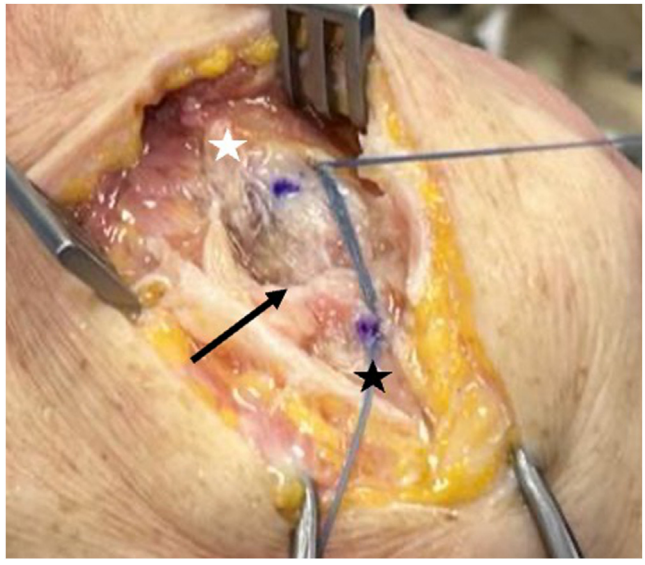

Fig 4. Open, superior view of the acromioclavicular joint (black arrow) demonstrating the suture staple configuration linking the distal clavicle (white star) and acromion (black star), after repair suture shuttling through the adjacent anchor and preliminary tightening.

will be left in place until the completion of the procedure to ensure maintained reduction during instrumentation. CC ligament reconstruction is then carried out in a fashion similarly described by Hassebrock et al.[15] One difference from their technique is the docking of the graft limbs into a suture anchor in the acromion, which is not typically done by the senior author. Any excess graft is incorporated into the AC joint repair portion of the procedure.

Finally, we perform the knotless "suture staple" technique. It is important to note the sequence of events in reduction and fixation. After clamp reduction, suspensory fixation deployment, and graft passage around the coracoid, we proceed with this step. The Dog Bone device can be tightened, but knots should not yet be tied to allow for final tensioning. In addition, the graft limbs should not yet be sewn together to achieve optimal tension throughout the final construct.

First, two 1.8-mm knotless, all-suture anchors (FiberTak; Arthrex) are placed in the lateral clavicle and acromion, each approximately 1 cm from the AC joint (Fig 2A). If desired, 4 total anchors can be used to increase the strength of the construct in a box or cruciate formation. Anchors are to be placed in a parallel manner across the AC joint. Viewing of anchor deployment arthroscopically is optional and typically not carried out by the senior author (Fig 3).

Once anchors are placed with confirmation of adequate purchase, the "repair" or static suture is loaded through the passing suture of the other anchor (Fig 2 A and B). Once each is passed, cinch each suture limb down in a similar fashion to a knotless PASTA (partial articular supraspinatus tendon avulsion) repair from the bursal surface or remplissage (Video 1, Figs 2 C and D and 4). Once desired tension is reached, the CC suspensory fixation can be tightened and relieved of as much creep as possible before knot tying. Allograft limbs are then pulled tight and sutured together with nonabsorbable suture (Fig 5 A and B). Finally, the clamp is removed, and final radiographs are obtained. Excess graft limbs are brought over the AC joint and incorporated into the capsular closure to add biologic healing to the AC joint capsule itself. The deltotrapezial fascia is then closed, followed by the skin.

An optional modification is to suture the graft limbs together after final tightening of the Dog Bone but before final tightening of the suture staple. Excess graft can then be routed underneath the suture staple to reconstruct the superior AC ligament (Video 1, 03:40).

Discussion

The "suture staple" technique for AC joint augmentation after CC fixation differs from previously described techniques with the use of all-suture, knotless anchors, excluding the risk of hard anchor

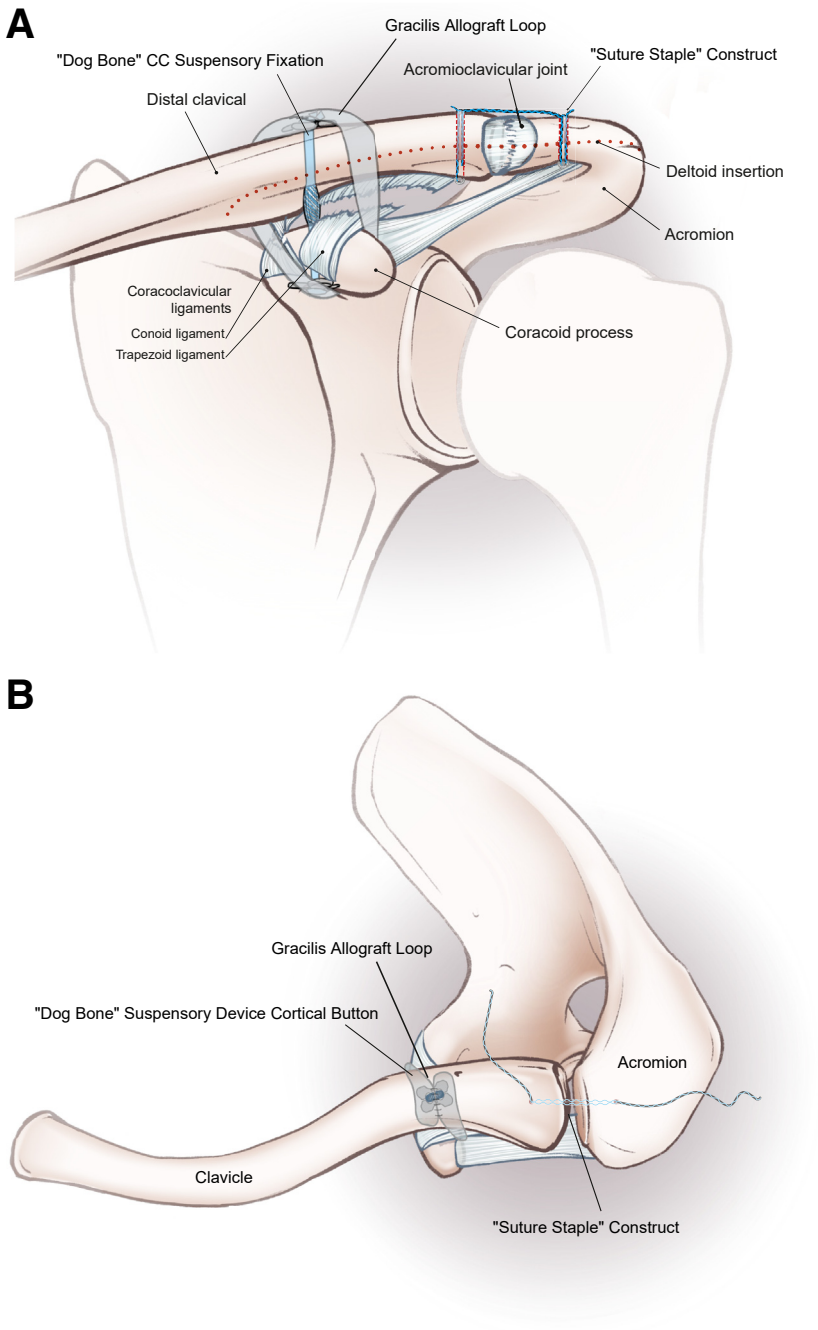

Fig 5. (A) Illustrated anterior view of the final construct showing the complete coracoclavicular fixation with Dog Bone suspensory device and looped gracilis allograft with anterior and posterior limbs sutured together. (B) Illustrated superior view of the construct again demonstrating the completed coracoclavicular fixation with Dog Bone and gracilis allograft as well as the suture staple across the AC joint before cutting of the excess suture limbs. Printed with permission from © Sarah M. Quattrocki.

material entering the subacromial space and thereby decreasing the potential for cuff irritation or damage, subacromial impingement, or loose body formation. The knotless, low-profile design, using a readily available biomechanically tested anchor, eliminates a prominent knot stack superiorly and decreases the risk of stress riser in the acromion and distal clavicle compared to larger, solid body anchors. Overall, the "suture staple" augmentation for AC/CC reconstruction is a safe, reproducible, and quickly accomplished technique aimed to decrease loss of fixation and failure in higher-risk patients.

Disclosures

All authors (C.C.W., B.A.C.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Li X, Ma R, Bedi A, Dines DM, Altchek DW, Dines JS. Management of acromioclavicular joint injuries. *J Bone Joint Surg Am* 2014;96:73-84.
2. Beitzel K, Mazzocca AD, Bak K, et al. ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. *Arthroscopy* 2014;30:271-278.
3. Nolte PC, Ruzbarsky JJ, Elrick BP, Woolson T, Midtgaard KS, Millett PJ. Mid-term outcomes of arthroscopically-assisted anatomic coracoclavicular ligament reconstruction using tendon allograft for high-grade acromioclavicular joint dislocations. *Arthroscopy* 2021;37:3025-3035.
4. Beitzel K, Obopilwe E, Apostolakos J, et al. Rotational and translational stability of different methods for direct acromioclavicular ligament repair in anatomic acromioclavicular joint reconstruction. *Am J Sports Med* 2014;42:2141-2148.
5. Dyrna F, Imhoff FB, Haller B, et al. Primary stability of an acromioclavicular joint repair is affected by the type of additional reconstruction of the acromioclavicular capsule. *Am J Sports Med* 2018;46:3471-3479.
6. Tauber M, Valler D, Lichtenberg S, Magosch P, Moroder P, Habermeyer P. Arthroscopic stabilization of chronic acromioclavicular joint dislocations: Triple- versus single-bundle reconstruction. *Am J Sports Med* 2016;44:482-489.
7. Walters JD, Ignozzi A, Bustos F, Werner BC, Brockmeier SF. Better radiographic reduction and lower complication rates with combined coracoclavicular and acromioclavicular ligament reconstruction than with isolated coracoclavicular reconstruction. *Arthrosc Sports Med Rehabil* 2021;3:e441-e448.
8. 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.
9. Flint JH, Wade AM, Giuliani J, Rue JP. Defining the terms acute and chronic in orthopaedic sports injuries: A systematic review. *Am J Sports Med* 2014;42:235-241.
10. Borbas P, Churchill J, Ek ET. Surgical management of chronic high-grade acromioclavicular joint dislocations: A systematic review. *J Shoulder Elbow Surg* 2019;28:2031-2038.
11. Spencer HT, Hsu L, Sodl J, Arianjam A, Yian EH. Radiographic failure and rates of re-operation after acromioclavicular joint reconstruction: A comparison of surgical techniques. *Bone Joint J* 2016;98-B:512-518.
12. 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.
13. Jensen G, Millett PJ, Tahal DS, Al Ibadi M, Lill H, Katthagen JC. Concomitant glenohumeral pathologies associated with acute and chronic grade III and grade V acromioclavicular joint injuries. *Int Orthop* 2017;41:1633-1640.
14. Tischer T, Salzmann GM, El-Azab H, Vogt S, Imhoff AB. Incidence of associated injuries with acute acromioclavicular joint dislocations types III through V. *Am J Sports Med* 2009;37:136-139.
15. Hassebrock JD, Stokes DJ, Cram TR, Frank RM. Arthroscopic repair and reconstruction of coracoclavicular ligament. *Clin Sports Med* 2023;42:599-611.