Horizontal and Vertical Stabilization of Acute Unstable Acromioclavicular Joint Injuries Arthroscopy-Assisted

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Abstract: We describe the technical aspects of an arthroscopy-assisted procedure indicated for the management of acute unstable acromioclavicular joint injuries, consisting of a synthetic augmentation of both the coracoclavicular and acromioclavicular ligaments, that anatomically reproduces the coracoclavicular biomechanics and offers fixation that keeps the torn ends of the ligaments facing one another, thus allowing healing of the native structures without the need for a second surgical procedure for metal hardware removal.

Acromioclavicular joint (ACJ) injuries are the most common shoulder injuries in the young athletic population. The treatment indications are an issue of debate because of the lack of consensus regarding the optimal management. It is accepted that some conservatively treated patients might have persistent shoulder pain because of the occurrence of changes in the scapular orientation that lead to kinematic alterations of the muscles’ actions perturbing the shoulder girdle function. These kinematic alterations might also be the reason early surgical treatment has been shown to provide better functional results than late surgical treatment; moreover, delaying surgical treatment could compromise the possibility of obtaining the best result in the late period.

Surgical management of acute unstable ACJ injuries should be focused on realigning the torn ends of the ligaments because it is accepted that in the acute phase, they still have healing potential. The most propagated methods of treatment incorporate the use of metal hardware that alters the biomechanics of the ACJ, implying the need for a second surgical procedure for hardware removal once the ligaments have healed. Fixation with a hook plate, ACJ transfixion with K-wires (Phemister technique), and coracoclavicular (CC) fixation with a screw (Bosworth technique) are recognized as nonanatomic procedures related to high rates of failure of fixation and complications.

Arthroscopy-assisted procedures that incorporate a CC suspension device aim to narrow the CC space, thus allowing the realigning of the torn CC ligaments. The use of one isometric suspension device has shown good clinical outcomes, but secondary subluxations have been a matter of concern. Likewise, biomechanical studies have shown the importance of an anatomic reconstruction of both the conoid and trapezoid ligaments. This issue lies in the fact that they have different functions that depend on their native anatomic locations.

To reproduce the native origins and orientations of both the conoid and trapezoid ligaments and thus improve the biomechanics and stability of the fixation, techniques that incorporate a second CC suspension device have been described. Despite these improvements, horizontal instability remains a matter of concern. We describe the technical aspects of an arthroscopically assisted procedure indicated for the management of acute unstable ACJ injuries, consisting of a synthetic augmentation of both the CC and acromioclavicular (AC) ligaments, that reproduces the ACJ biomechanics and offers fixation that keeps the torn
ends of the CC and AC ligaments aligned, thus allowing healing of the native structures without the need for a second surgical procedure for metal hardware removal.

**Surgical Technique**

Under general anesthesia and an interscalene block, the patient is placed in the beach-chair position with the arm forward flexed up to 50° to 70°, maintained by a weight of 3 kg (Video 1). First, we perform an arthroscopic examination of the glenohumeral joint through the posterior portal to diagnose associated lesions that could require treatment. If there is no concomitant injury to repair, we avoid creating an anterior glenohumeral portal to have better control of the fluids. Afterward, the arthroscope is moved to the subacromial space through the lateral portal (2 cm distal to the lateral border of the acromion).

**Identification of Base of Coracoid Process**

The coracoacromial (CA) ligament is followed until its insertion in the coracoid. Through direct visualization from the lateral portal and using a needle as a guide, we create an anterior working portal, which is located 1 cm lateral to the coracoid. A 5.5-mm full-radius shaver blade (Biomet, Warsaw, IN) is used to perform bursectomy, which allows adequate visualization of the CA ligament. The synovial tissue posterior to the coracoid and anterior to the rotator interval should be cleaned to identify the base of the coracoid. The arthroscope is then directed inferiorly to see the base of the coracoid, which has to be carefully cleaned with a vaporizer (ArthroCare Sports Medicine, Sunnyvale, CA) by removing the synovial tissue that covers the subscapularis. It is important to be aware that the axillary bundle and the brachial plexus are located medial to the coracoid process.

**Tunneling of Clavicle and Coracoid Process**

First, it should be mentioned that the suspension devices could be passed through the tunnels in an antegrade or retrograde direction. This should be decided before drilling to establish the proper diameter of the tunnels. For the purposes of our technique, we advocate the retrograde direction (from coracoid to clavicle), which implies making CC tunnels with a diameter of 3.5 mm, thus minimizing the probability of coracoid fracture. When one is planning to pass the suspension devices in a retrograde direction, the subcoracoid titanium flip device does not pass through the tunnel. When one is using the antegrade direction, the subcoracoid titanium flip device has to pass through the whole CC tunnel, which implies making tunnels with a diameter of 4.5 mm.

A transverse incision with a length of 3 cm is made 2 cm medial to the lateral edge of the clavicle. This incision is made between the locations where the native origins of the conoid and trapezoid ligaments should be in the inferior aspect of the clavicle. The native origin of the conoid is 4.5 cm medial to the lateral edge of the clavicle, and the trapezoid is 2.5 cm medial and slightly anterior when compared with the conoid. A cross section of the deltatorapezial fascia is then performed. The traction is released, and with arthroscopic visualization from the lateral portal, we prepare to pass the K-wire of the conoid tunnel. A Biomet AC drilling guide (reference 909511) with a calibrated angulation of 80° to 90° is placed at the base of the coracoid, adjacent to the wall of the scapula, and 5 mm lateral to the medial border of the coracoid, with the sliding tube of the guide located in the superior aspect of the clavicle. A 4.5-mm cannulated drill is passed over the conoid K-wire until it comes out from the inferior aspect of the clavicle, where the AC guide catches it (Fig 1A). The distance between K-wires in the inferior aspect of the coracoid should be 1.5 cm. A 2.4-mm K-wire is passed from the clavicle to the coracoid, following the anatomic orientation of the trapezoid ligament (Fig 1B). Afterward, a 3.5-mm cannulated drill is passed over the conoid K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide catches it (Fig 1C). The conoid K-wire is removed, and the cannulated drill is kept in position.

A shuttle suture (1-mm polydioxanone suture [PDS]; Ethicon, Somerville, NJ) is passed from the clavicle to the coracoid through the cannulated drill and is then recovered with a grasper from the anterior portal (Fig 1D). A No. 2 MaxBraid suture (Arthrotek [Biomet]) is tied to the distal limb of the PDS that passes through the conoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. This MaxBraid will be used later to pass the conoid suspension device.

Next, the 3.5-mm cannulated drill is passed over the trapezoid K-wire (Fig 1E). The trapezoid K-wire is removed, and the cannulated drill is kept in position. Another 1-mm PDS shuttle suture is passed from the clavicle to the coracoid through the cannulated drill and is recovered with a grasper from the anterior portal. A No. 2 MaxBraid suture is tied to the distal limb of the PDS that passes through the trapezoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. This MaxBraid will be used later to pass the trapezoid suspension device.

The conoid suspension device (ZipTight, reference 904834; Biomet) is first passed through the tunnel. This
is performed in a retrograde direction. The distal limb of the conoid shuttle MaxBraid is provisionally tied to the sliding sutures of the suspension device (Fig 1F). This shuttle MaxBraid, which is coming out from the conoid tunnel in the clavicle, should be pulled out cranially to make the suspension device pass through the tunnel. The white suture of the titanium flip device can now be removed by pulling out 1 of its limbs, which are coming out from the anterior portal. The same procedure of passing the suspension device in a retrograde direction is repeated in the trapezoid tunnel.

The conoid suspension device should not be fixed until the trapezoid suspension device has been passed through its respective tunnel as well (Fig 2 A and B). Once both suspension devices have been passed through each tunnel, the titanium flip devices of both are properly placed in the inferior aspect of the coracoid (Fig 2 C and D). At this point, horizontal stabilization of
the ACJ should be performed before fixation of the 2 suspension devices.

**ACJ Horizontal Stabilization**

To horizontally stabilize the ACJ, we perform a synthetic reconstruction of the AC ligaments by using a JuggerKnot soft anchor (2.9 mm; Biomet), which is inserted on top of the acromion, 1 cm lateral to the ACJ (Fig 2E). Afterward, the AC guide—previously used to make the CC tunnels—is horizontally positioned at the clavicle 1 cm medial to the ACJ. A 2.4-mm universal K-wire with an eyelet at its base (used for anterior cruciate ligament reconstruction) is passed through the AC guide and through the clavicle, from anterior to posterior (Fig 2F). Two MaxBraids (which are going to be used as shuttles) are passed through the hole of the K-wire. The white arrow is pointing to the blue and white sutures of the JuggerKnot anchor that was previously inserted at the superior aspect of the acromion, 1 cm lateral to the AC joint.

![Fig 2](image-url)

**(A)** Arthroscopic visualization from the lateral portal. The suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction. The white arrow is pointing to the sliding sutures of the suspension device. The black arrow is pointing to the titanium flip device of the conoid suspension device, which was previously placed. **(B)** Acromioclavicular (AC) Sawbones model, in which the suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction, once the titanium flip device of the conoid suspension device has been placed. **(C)** Arthroscopic visualization from the lateral portal. Once the flip devices of the 2 suspension devices have been placed in the inferior aspect of the coracoid, proper positioning between them is achieved by using a palpation device, which is introduced through the anterior portal. **(D)** Arthroscopic visualization from the lateral portal. The flip devices of the 2 suspension devices are properly placed and positioned in the inferior aspect of the coracoid. **(E)** AC Sawbones model, in which a JuggerKnot soft anchor is being inserted on top of the acromion, 1 cm lateral to the AC joint. **(F)** Rear perspective of a left shoulder. The K-wire with an eyelet at its base was passed through the clavicle in an anteroposterior direction. Two shuttle MaxBraids (red arrow) were passed through the hole of the K-wire. The white arrow is pointing to the blue and white sutures of the JuggerKnot anchor that was previously inserted at the superior aspect of the acromion, 1 cm lateral to the AC joint.
the transverse tunnel created in the clavicle. The 2 white limbs (the surgeon could also use the 2 blue limbs) of the JuggerKnot are tied with a double knot to the posterior limb of 1 of the MaxBraids. This MaxBraid is pulled out from the anterior aspect of the shoulder to make the 2 white limbs of the JuggerKnot pass from posterior to anterior and emerge from the anterior aspect of the transverse clavicle tunnel. The 2 blue limbs of the JuggerKnot are also tied with a double knot but are tied to the anterior limb of the other MaxBraid. This MaxBraid should be retrieved from the posterior aspect of the shoulder to make the 2 blue limbs of the JuggerKnot pass from anterior to posterior and emerge from the posterior aspect of the clavicle tunnel. At this stage, the sutures of the JuggerKnot already have a triangular configuration. The base is represented by the sutures passing through the transverse clavicle tunnel, and the apex is represented by the acromial insertion of the JuggerKnot.

**CC Reduction**

Before tensioning of the ZipTights is performed, the sliding sutures of the system should be threaded in the washers to make them descend until they touch the clavicle. We prefer to first do this with the conoid suspension device (Fig 3A).

Afterward, the surgical assistants should reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. Once the flip device of the conoid ZipTight has been properly supported in the inferior aspect of the coracoid, it is tied and fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction to make the washer go down until it touches the clavicle and self-locks. The fixation achieved when the conoid suspension device has been locked is enough to maintain the reduction, so the fixation and locking of the trapezoid ZipTight can be performed without needing to push the elbow upward and the clavicle downward. Once the 2 ZipTights have been locked (Fig 3B), the final CC interval reduction can be checked with intraoperative radiographs. The ACJ reduction is checked by direct palpation, direct arthroscopic visualization (Fig 3C), or intraoperative radiographs (or some combination thereof). Special attention should be paid to avoid overcorrection.

**Ensuring CC and AC Fixation**

To complete the narrowing of the CC space and the anatomic reduction of the ACJ, the surgical assistants should again reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. Afterward, the 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot (Fig 3D). This triangular configuration of the fixation (Fig 3E and F) aims to stabilize the ACJ and thus maintain the torn ends of the native AC ligaments properly aligned during the healing process.

Both ZipTights are completely fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction. The remnants of the sliding sutures are now cut, and the blue traction sutures of the clavicle washers are removed.

The deltotrapezial fascia is carefully closed and reconstructed with No. 1 Vicryl (Ethicon). Finally, the shuttle suture that was coming out from the inferior aspect of the coracoid is removed, and the skin is closed.

Table 1 shows tips, pearls, pitfalls, risks, key points, indications, and contraindications of the technique.

**Rehabilitation Protocol**

The shoulder should be maintained in a sling for 4 to 6 weeks to facilitate healing. Patients are allowed immediately postoperatively to fully and actively move the elbow, wrist, and hand and are allowed to passively move the shoulder to no more than 90° of elevation in the plane of the scapula. Participation in an exercise program is started after the fourth week. Active range of motion begins in the sixth week onward. Exercises to regain strength are initiated once the patient has full, pain-free passive and active range of motion; they are primarily directed toward scapular stabilization. Return to work without restrictions is allowed at 12 to 16 weeks after surgery, and contact sports or major efforts should be avoided for 4 to 6 months after surgery.

**Patients**

The described procedure has been performed in 9 patients diagnosed with unstable ACJ injuries. The time from injury to surgery was less than 3 weeks in all cases. Clinical and radiographic assessments were performed in all cases at a minimum follow-up time of 12 months. The preliminary results are considered excellent because all patients had complete functional recovery with no residual pain. No secondary subluxations of the ACJ have been observed on the Zanca or Alexander view.

**Discussion**

The presented procedure overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of nonanatomic techniques, and the saw effect and anterior loop translation that can be seen with those systems that surround the base of the coracoid. Our technique incorporates an ACJ fixation with an all—suture anchor method that guarantees horizontal stability, as well as the use of 2 CC suspension devices that are anatomically placed and emulate the function and biomechanics of both the conoid and trapezoid ligaments during the healing process of the torn native structures.
Surgeons’ understanding of the shoulder biomechanical consequences that result from unstable ACJ injuries has increased significantly over recent years. It has been shown that in many patients with unstable ACJ injuries that are managed nonoperatively, the development of scapular dyskinesis might be involved—a situation that could result in loss of strength and weakness. Likewise, it has been shown that the prevalence of scapular dyskinesis in patients who have been treated operatively is lower than that in patients managed nonoperatively.

The fact that many different surgical techniques have been described indicates that there is also a lack of consensus regarding the optimal surgical management, and the clinical result depends directly on the type of technique performed. The literature is full of descriptions regarding treatment options for patients with ACJ injuries. The 5 main alternatives are (1) conservative measures based on scapular stabilization; (2) ACJ fixation with metal hardware, such as K-wires (as in the Phemister technique) or a hook plate; (3) CA ligament transfer (Weaver-Dunn procedure); (4) CC ligament transfer (Weaver-Dunn procedure); (5) AC ligament transfer (Weaver-Dunn procedure).

Fig 3. (A) Acromioclavicular (AC) Sawbones model, in which the ZipTight is being fixed by pulling alternatively on both limbs of the sliding sutures (white arrow) in a cranial direction to make the washer go down until it touches the clavicle and self-locks. (B) AC Sawbones model, in which both washers are supported in the superior aspect of the clavicle. The remnants of the sliding sutures (red arrows) should not be cut until step 5 of the technique. (C) Arthroscopic visualization from the lateral portal. Once the 2 suspension devices have been locked and fixed, AC joint reduction is checked by direct arthroscopic visualization. (D) Top perspective of a left shoulder. The 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot. (E) Top perspective of a left shoulder. The clavicle washers of the 2 suspension devices are properly locked on top of the clavicle, with the red arrow indicating the washer of the conoid suspension device and the white arrow indicating the washer of the trapezoid suspension device. One should note that the washer of the trapezoid suspension device is slightly anterior when compared with the washer of the conoid suspension device. The 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot (black arrow). (F) Superior aspect of AC Sawbones model, in which the synthetic reconstruction of the AC ligaments in a triangular configuration can be appreciated.
Table 1. Pearls, Pitfalls, Risks, Key Points, Indications, and Contraindications of Technique

**Pearls**
- The base of the coracoid should be properly debrided to guarantee the correct positioning of the AC guide.
- To establish the proper diameter of the tunnels, the direction (antegrade or retrograde) for passing the suspension devices should be decided before surgery.
- When the surgeon is making the CC tunnel of the conoid, the tip of the caudal portion of the AC guide should be located adjacent to the wall of the scapula and 5 mm lateral to the medial border of the coracoid, with the sliding tube of the guide located at the superior aspect of the clavicle, 4.5 cm medial to its lateral border.
- When the surgeon is making the CC tunnel of the trapezoid, the tip of the caudal portion of the AC guide should be located 5 mm medial to the lateral border of the coracoid and slightly anterior when compared with the location of the conoid K-wire.
- At the inferior aspect of the coracoid, the distance between the K-wires should be 1.5 cm.
- If there is any doubt when checking the ACJ reduction through straight visualization, the use of fluoroscopy may be considered.
- Traction should be released before reduction.
- The deltotrapezial fascia should be carefully reconstructed to achieve the best horizontal and vertical stabilization.

**Pitfalls and risks**
- Orthopaedic surgeons who are not well familiarized with arthroscopic techniques should be aware of the potential risks related to the neurovascular structures underneath the clavicle and medial to the coracoid.
- There is a risk of fracture in the lateral aspect of the coracoid when tunneling its base if the AC guide is placed too laterally.
- Implant cost is a consideration when using CC suspension devices.
- The correct placement of the coracoid tunnels and the correct distance between them are crucial to prevent tunnel coalition and coracoid fracture.

**Key points**
- Nonoperative management of unstable ACJ injuries might cause changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain.
- Surgical management of acute unstable ACJ injuries should be focused on realigning the torn ends of the ligaments, because it is accepted that in the acute phase, they still have healing potential.
- The most propagated methods of treatment in cases of unstable ACJ injuries incorporate the use of metal hardware that alters the biomechanics of the ACJ, implying the need for a second surgical procedure for hardware removal once the ligaments have healed.
- Anatomic reconstruction techniques have shown biomechanical and clinical advantages over nonanatomic techniques in cases of unstable ACJ injuries.
- Our technique incorporates an ACJ fixation with an all—suture anchor method that guarantees horizontal stability, as well as the use of 2 anatomically placed CC suspension devices that emulate the function and biomechanics of both the conoid and trapezoid ligaments during the process of healing of the torn native structures.

**Indications**
- Unstable ACJ injuries in acute phase (within first 3 weeks after injury)
- Elderly patients
- Patients with comorbid factors that contraindicate the need for elective surgery

**Contraindications**
- AC, acromioclavicular; ACJ, acromioclavicular joint; CC, coracoclavicular.
technique offers over other techniques is that we advocate using the retrograde direction (from coracoid to clavicle) for passing the suspension devices, which implies making CC tunnels with a diameter of 3.5 mm instead of 4.5 mm, thus minimizing the probability of coracoid fracture. When one is planning to pass the suspension devices in a retrograde direction, the subcoracoid titanium flip device does not pass through the tunnel. When one is using the antegrade direction (which we do not recommend when making 2 CC tunnels), the subcoracoid titanium flip device has to pass through the whole tunnel, a situation that implies making tunnels with a diameter of 4.5 mm. Use of the described technique should be considered only by experienced shoulder surgeons to avoid potential complications and so guarantee the safety of the procedure.

Regarding the fixation method for CC implants in the coracoid, it has been reported that subcoracoid loops might involve the development of bony erosions because of a “sawing” effect. Our procedure overcomes this issue by incorporating tunnel creation both in the coracoid and in the clavicle for implant fixation.

It has been reported that patients with unstable ACJ injuries showing remaining horizontal instability have significantly inferior clinical results. Scheibel et al. observed remaining horizontal instability in 42.9% of patients managed with 2 anatomically placed suspension devices. Likewise, horizontal instability has been described as the only factor showing a negative influence on patients’ score results; for this reason, authors are starting to recommend an additional horizontal augmentation to address this specific problem. To our knowledge, our technique represents one of the first in vivo descriptions including an AC augmentation in addition to the anatomic CC synthetic reconstruction. The fact that both vertical and horizontal stability could be properly controlled by synthetic augmentations allows the native structures to be properly reduced to heal.

It is important to bear in mind that our procedure is an arthroscopy-assisted approach, and it is critical to ensure that the deltotrapezial fascia is not interposed between the clavicle and the acromion. This can only be achieved by using a mini-open approach on top of the ACJ. Once the joint surfaces of the clavicle and the acromion are properly faced, the deltotrapezial fascia should be carefully reconstructed to guarantee proper horizontal and vertical stability. Our surgical technique provides excellent primary horizontal and vertical stabilization and restores the anatomy and biomechanics by synthetically reconstructing the torn CC and AC ligaments.

References
17. Clevenger T, Vance RE, Bachus KN, Burks RT, Tashjian RZ. Biomechanical comparison of acromioclavicular joint...

