Technical Note

Combined Vertical, Horizontal, and Rotational Acromioclavicular Joint Stabilization: "Closing the Circle" Technique

Ana Catarina Ângelo, M.D., Carlos Maia Dias, M.D., and Clara de Campos Azevedo, M.D.

Abstract: The biomechanical and anatomical complexity of the acromioclavicular joint makes its repair techniques particularly challenging. High rates of reduction subsidence and construction failures transversally affect both anatomic and nonanatomic repair techniques. The importance of addressing both vertical and horizontal instability has been highlighted in recent years. The authors aim to describe a surgical technique that combines vertical, horizontal, and rotational stabilization, in an attempt to restore the coracoacromioclavicular circle of stability.

The complexity of the tridimensional behavior of the acromioclavicular joint (ACJ) and its close relationship with the coracoid process have been a matter of debate in the last decade. The progressive understanding of the biomechanics involved in ACJ injuries has made clear that the restoration of both coracoclavicular and acromioclavicular ligaments is of major importance, as the ACJ clearly extends beyond the articulation between the distal end of the clavicle and the articular end of the acromion.[1-5] In recent years, many studies have pointed out the importance of addressing both vertical (Fig 1) and horizontal (Fig 2) instability to obtain a favorable outcome in the surgical treatment of acute grade IIIB-V ACJ dislocations, but there is still no consensus regarding a gold standard technique.[3,4,6] Acknowledging that the ACJ is part of a coracoacromioclavicular ligamentous complex, and that its integrity is paramount to the correct biomechanical behavior of the joint itself, may be the key to correctly addressing these lesions.

Surgical Technique (With Video Illustration)

An exemplification of the surgical technique is presented in Video 1 and Figures 3-9. Figure 10 depicts the final construct. Detailed informed consent was obtained for the described procedure.

Patient Setup

The patient is placed in the beach-chair position, using a radiotransparent or a surgical table equipped with a removable shoulder support. The fluoroscope is positioned contralaterally to the operated shoulder, and its position and ability to obtain a clear 10° cephalic tilt view of the operated ACJ is assessed before surgical draping. The upper limb and ipsilateral upper hemithorax are prepared and draped in a sterile fashion. A mechanical arm positioner is used to hold the limb in an anatomically advantageous position, which can vary throughout the procedure. Anatomic landmarks are drawn with a dermographic pen (Fig 3).

Surgical Approach

At the beginning of the procedure, the arm is positioned at the side, in neutral flexion/extension and rotation of the shoulder, with the elbow flexed at 90°. A longitudinal medial to lateral 5- to 6-cm skin incision is made over the lateral third of the clavicle, extending laterally over the ACJ and ending on top of the anterior

From the Hospital CUF Tejo, Lisbon (A.C.A., C.M.D., C.d.C.A.); Hospital dos SAMS de Lisboa, Lisbon (A.C.A., C.d.C.A.); Hospital CUF Santarém, Santarém (C.M.D.); UCMA Fidelidade, Lisbon (C.M.D.); and iBB Institute for Bioengineering and Biosciences, Instituto Superior Técnico, Lisbon (C.M.D.), Portugal.

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Address correspondence to Ana Catarina Ângelo, M.D., Avenida de Roma 56 3Dto PC 1700-348 Lisboa, Portugal. E-mail: anacatarinaangelo@shoulder.pt or ana_angelo@msn.com

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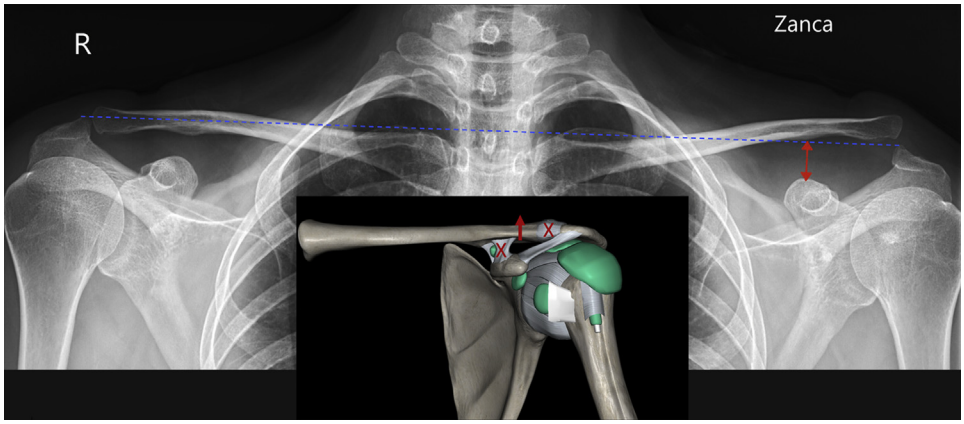

Fig 1. A radiographic 10° cephalic tilt view of both shoulders should be obtained to compare the coracoclavicular distance of both acromioclavicular joints, thereby assessing vertical stability. The figure depicts a vertically unstable acromioclavicular joint on the left shoulder, where the clavicle is elevated above the superior border of the acromion (dotted blue line), denoting a tear of the coracoclavicular ligaments and acromioclavicular ligaments and capsule, marked with a red X in the overlying figure that represents a left shoulder.

border of the acromion (Fig 3). The platysma muscle and deltotrapezial fascia are carefully dissected, and the latter is referenced for further incorporation in the final repair construct. The lateral third of the clavicle is released of soft-tissue attachments, while sparing the trapezius insertion near the posterior capsule of the ACJ (Fig 4). The coracoid process and coracoclavicular ligaments remnants are visualized and palpated anteriorly to the distal third of the clavicle, avoiding exhaustive dissection in this area to spare the remaining torn coracoclavicular ligaments (Table 1 and Video 1).

Coracoclavicular Preparation

This step should occur before ACJ reduction, as the posterior displacement of the clavicle facilitates both the coracoid process approach and anchor placement. Under fluoroscopic guidance, 2 bicortical tunnels are drilled with a 2.8-mm drill, and 2 YKnot RC (ConMed, Utica, NY) 2.8-mm all-suture anchors are placed and armed underneath the inferior cortex of the coracoid process (Figs 5 and 10). The first anchor, double-loaded with one suture and one tape (YKnot RC with Hi-Fi Tape), should be placed approximately 1 cm posteriorly to the tip of the coracoid. The second anchor, triple-loaded with 3 sutures (YKnot RC triple loaded #2 Hi-Fi Sutures), is placed posteriorly, close to the base of the coracoid. Care should be taken not to place the 2 anchors too close to one another to avoid the risk of coracoid fracture (Table 1). Immediately after placement, the anterior anchor is referenced with a hemostat clamp and the posterior anchor is referenced with a Kocher clamp. With the same 2.8-mm drill, 2 vertical tunnels are drilled on the clavicle, approximately 2.5 and 3.5-cm medially to the ACJ line, respectively (Fig 6).

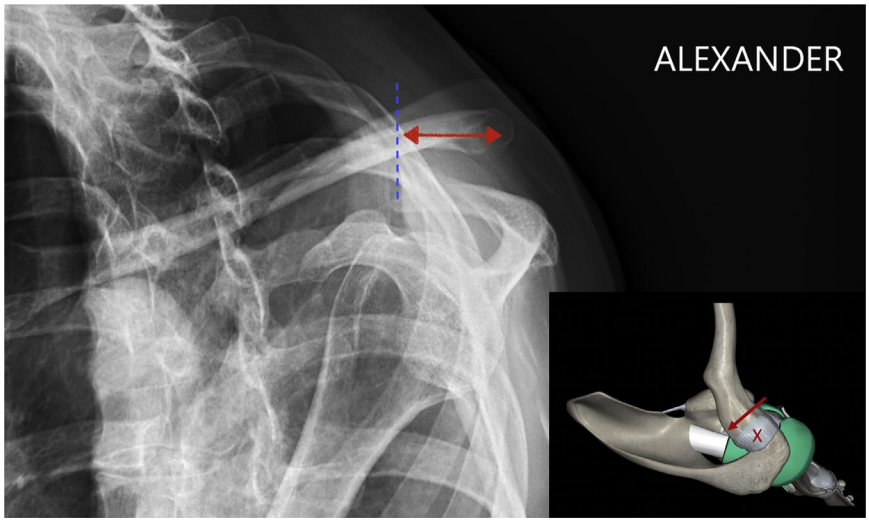

Fig 2. Radiographic Alexander (Basamania) view of the left shoulder of the same patient. This view should be obtained to assess the position of the clavicle in relation to the acromion, evaluating horizontal acromioclavicular stability. The figure shows a horizontally unstable acromioclavicular joint, where the clavicle extends posteriorly to the acromion (dotted blue line), denoting a tear of the acromioclavicular ligaments and capsule marked with a red X in the overlying figure that represents a left shoulder.

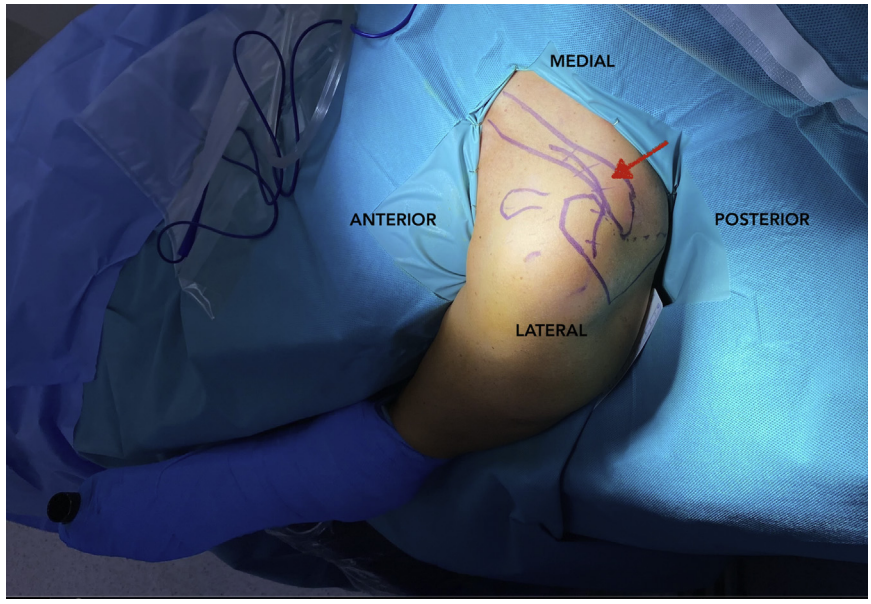

Fig 3. Superolateral view of a left shoulder with an acromioclavicular joint dislocation. Before the surgical stabilization procedure, the patient is positioned in the beach-chair position and a mechanical arm is used to hold and place the upper limb in a mechanically advantageous position. The anatomic landmarks are drawn and the surgical incision is marked with a dermographic pen (red arrow).

Acromioclavicular (AC) Preparation

The ACJ meniscus, if present, is identified and excised (Table 1). Two tunnels are drilled in the anterior-to-posterior direction, one crossing the lateral edge of the clavicle and another crossing the anterior acromion.

Coracoacromioclavicular Complex Repair

Using a nitinol wire, 2 sutures of the posterior coracoid anchor (4 limbs) are passed through the medial vertical clavicular tunnel. The remaining suture from the posterior anchor and 1 suture from the anterior anchor are passed through the lateral vertical clavicular tunnel (4 limbs). One of the limbs of the anterior anchors' tape is passed over the clavicle and introduced into the clavicular horizontal tunnel, from posterior to anterior (Fig 7). The remaining limb of tape is introduced into the acromion's horizontal tunnel, from anterior to posterior.

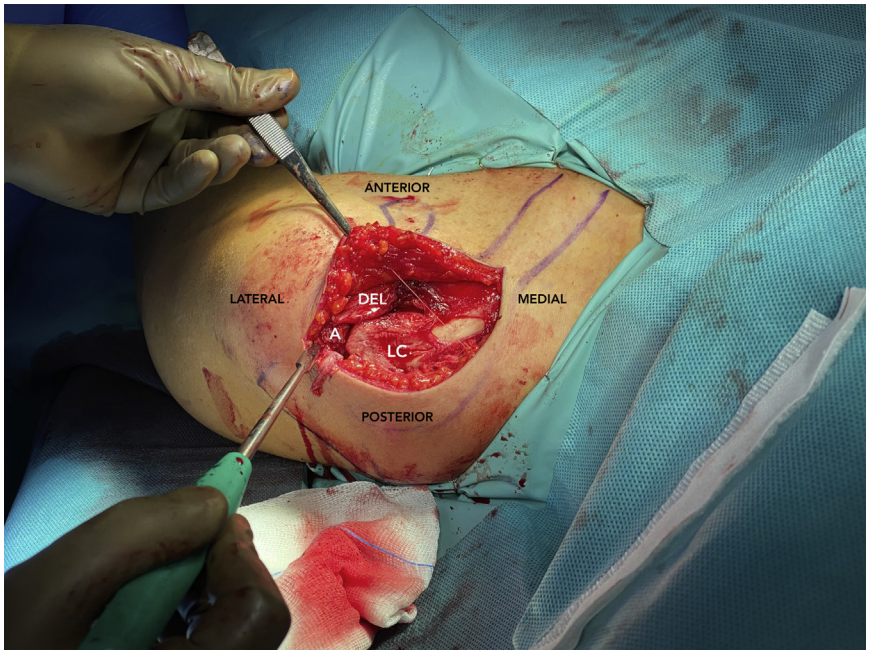

Fig 4. Superior view of the surgical approach in a left shoulder depicting the lateral clavicle (LC), the acromion (A), and the detached anterior deltoid (DEL). Traumatic anterior deltoid detachment is characteristic of grade IIIB-V acromioclavicular joint dislocations, in the Rockwood classification, facilitating the access to the coracoid process.

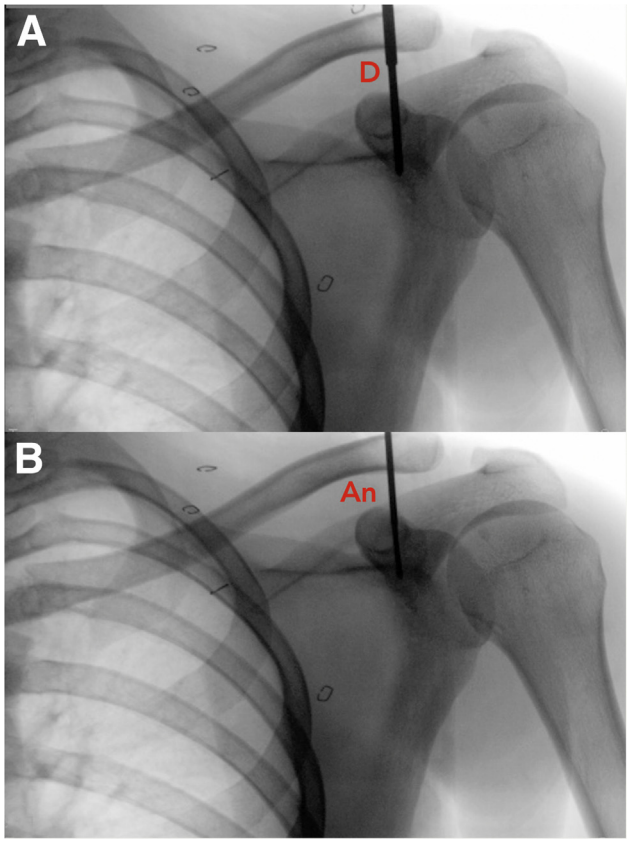

Fig 5. Fluoroscopic 10° cephalic tilt view of a left shoulder showing a vertically unstable acromioclavicular joint. (A) A 2.8-mm drill (marked as D) is passed through both cortices of the coracoid process, under fluoroscopic view. (B) An all-suture 2.8-mm anchor (marked as An) is passed through the tunnel, making sure that entirety of the anchor is placed underneath the inferior cortex prior to arming the anchor. This step is repeated so that a total of 2 anchors are placed underneath the coracoid process as part of the coracoacromioclavicular complex surgical stabilization procedure.

The arm is positioned in a "shoulder shrug" position to facilitate ACJ reduction under minimum tension. The ACJ is then manually reduced under fluoroscopic control, and the suture limbs from the vertical tunnels are passed and tied over two 1.4-mm Infinity cortical buttons (ConMed), each one carefully placed over each drill hole. The tape is tied in a figure of 8 around the ACJ, incorporating the capsular remnants, if possible. To reinforce the circular construct, the tape limbs of the figure of 8 knot are tied to the suture limbs of the lateral button (Fig 8). Dynamic joint stability is tested under direct visualization, moving the arm throughout the shoulder girdle range of motion.

Closing and Dressing

The deltotrapezial fascia is closed and plicated over the ACJ capsule. The platysma is repaired if possible and the skin is closed using an intradermal suture technique (Fig 9). Steri-Strips are carefully placed on the wound to avoid skin tension and minimize the formation of hypertrophic scar tissue.

Postoperative Rehabilitation Protocol

The patient is instructed to wear a sling for 3 weeks to protect the repair and active elbow mobilization is encouraged. Active unresisted shoulder range of motion below the level of the shoulder is allowed between weeks 3 and 6. From weeks 6 to 12, the patient starts formal rehabilitation focused on scapulohumeral re-education and scapular stabilizers strengthening.

Discussion

Several techniques have been proposed to restabilize the ACJ following grade IIIB-V acute dislocations, with an historical high grade of reduction

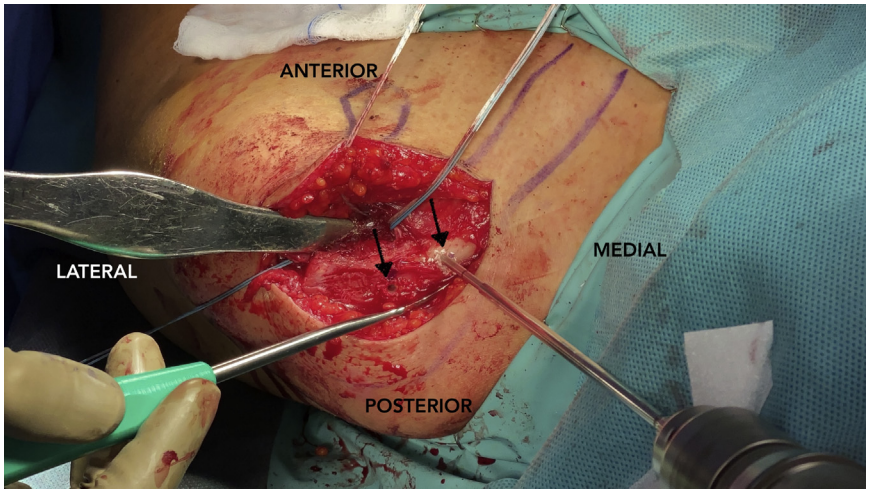

Fig 6. Intraoperative superior view of the left shoulder of a patient undergoing a coracoacromioclavicular complex stabilization procedure, showing the two 2.8-mm lateral clavicle vertical tunnels (black arrows), made approximately 2.5 and 3.5 cm medially to the acromioclavicular joint line and oriented slightly anteriorly, in an attempt to reproduce the anatomical orientation of the coracoclavicular ligaments.

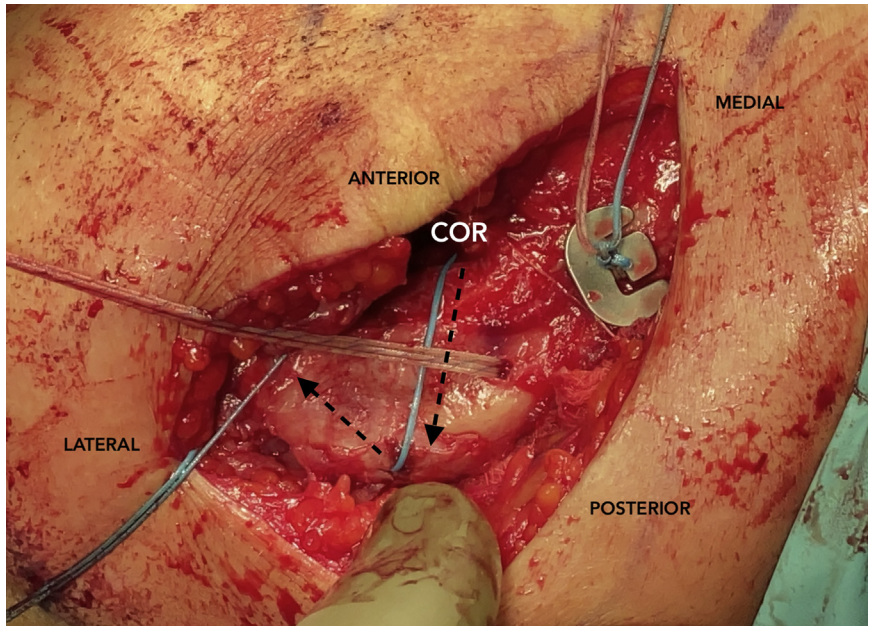

Fig 7. Intraoperative superior view of the left shoulder of a patient undergoing a coracoacromioclavicular complex stabilization procedure; One blue suture (or tape) limb from the anterior coracoid double loaded anchor passes over the lateral clavicle, entering into the horizontal clavicle tunnel posteriorly in a posterior to anterior direction (dotted arrow), pulling the lateral clavicle inferiorly and anteriorly into its native position, counteracting upper trapezius vectorial forces. (COR, coracoid process.)

subsidence and constructs failure.[6,7] Classically, ACJ repair has been centered on the restoration of coracoclavicular integrity. More recently, the importance of AC ligaments and capsule repair has been highlighted due to their central role in ACJ horizontal and rotational stability, and many different stabilization methods have been proposed.[3,8] In the current Technical Note, the authors describe a technique designed to stabilize both the coracoclavicular and the acromioclavicular

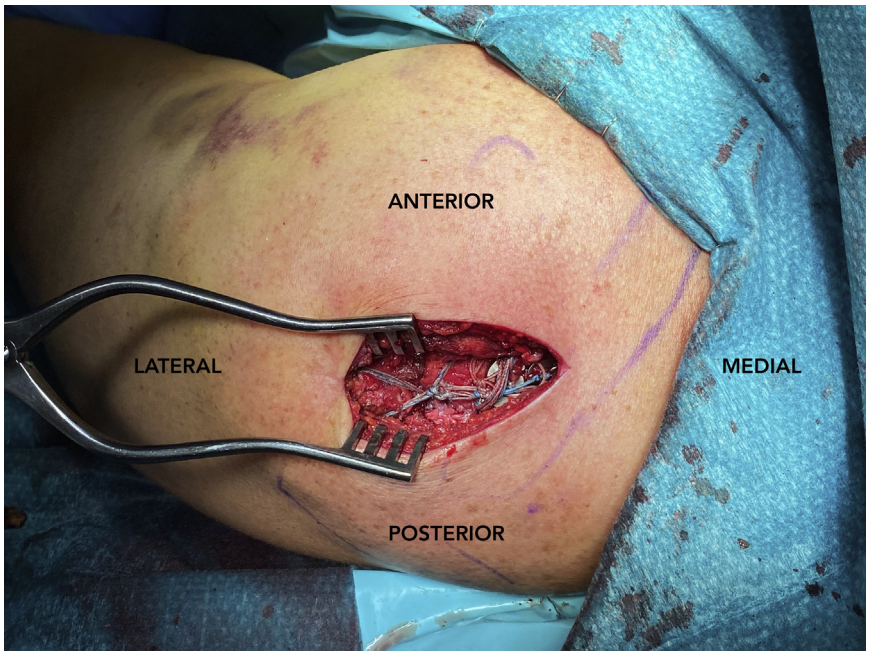

Fig 8. Intraoperative superior view of the left shoulder of a patient showing the coracoacromioclavicular complex reconstruction final construct, after tying the knots over the 2 cortical buttons on the lateral clavicle and the acromioclavicular figure-of-8, closing of the coracoacromioclavicular circle. Under direct visualization, the arm is passively mobilized, testing the efficacy of the final construct.

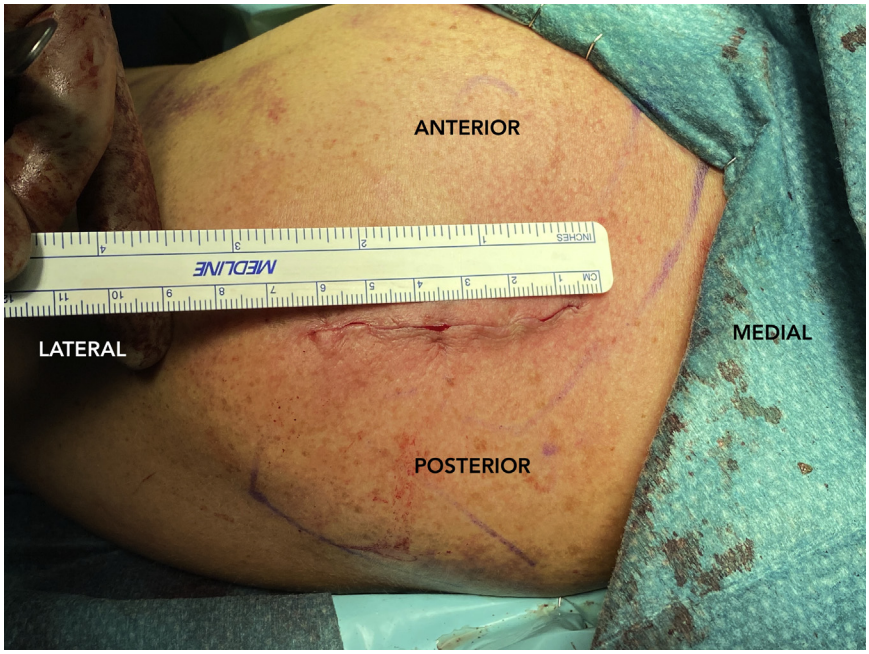

Fig 9. Intraoperative superior view of a left shoulder of a patient after undergoing a coracoacromioclavicular complex surgical repair; After carefully repairing the deltotrapezial fascia, a longitudinal medial to lateral 5- to 6-cm skin incision is closed with an intradermal suture under minimum tension to minimize scar tissue formation.

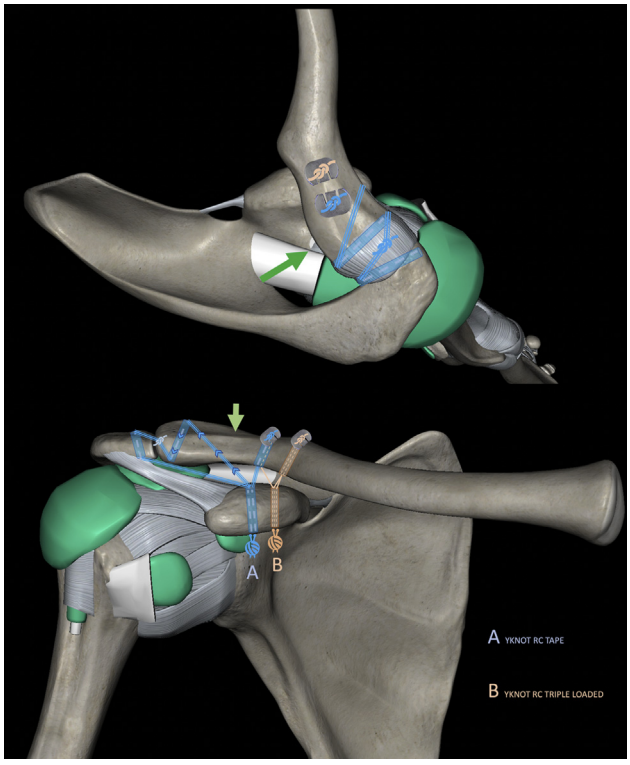

Fig 10. Superior and frontal view representations of the final construct on a right shoulder. The correct joint reduction vectors are represented by the green arrows. (A) Anterior anchor armed underneath the coracoid process, double loaded, each blue line representing 1 limb of the tape; (B) posterior anchor armed underneath the coracoid process, triple loaded, each orange line representing 2 limbs of the same suture. The dotted lines represent sutures or tapes passing inside a bone tunnel.

components, addressing the joint as a coracoacromioclavicular osteoligamentous complex, closing the circle of tridimensional stability. When both coracoclavicular and acromioclavicular ligaments are compromised, the clavicle is pulled upwards and backwards by the unopposed action of the upper trapezius. This deformity is aggravated by active scapular protraction, as the clavicle becomes completely detached from the scapula and is unable to follow scapular motion.[2] The current technique offers a strong, nonrigid, multivectorial stabilization that is designed to not only re-establish coracoclavicular and acromioclavicular attachments, but also to directly counteract upper trapezius vectorial forces, simultaneously bringing the clavicle anteriorly and inferiorly (Fig 10) and simulating the circle of stability brought together by the lateral clavicle, the acromion, the coracoid process and the coracoclavicular, acromioclavicular and coracoacromial ligaments. This is an open technique with no need for a time- and resource-consuming arthroscopic setting (Table 2). In fact, most arthroscopically assisted techniques require an equally invasive open approach to the lateral clavicle, the AC ligaments and capsule, and the deltotrapezial fascia. The use of all-suture anchors as a cortical buttress in the inferior surface of the coracoid process allows for an easy fluoroscopic-guided implant positioning, with no need for arthroscopic visualization, and avoids the use of metallic hardware and the potential complications that can follow (Table 2).

Table 1. Pearls and Pitfalls of the CTC Technique

Pearls	Pitfalls
During patient positioning, be sure that you can get a clear 10° cephalic tilt view with the fluoroscope.	Make sure to drill the coracoid tunnels at least 1 cm apart from each other to minimize fracture risk.
Use a mechanical arm to help you position the shoulder in an advantageous manner, depending on the surgical step.	Avoid extensive debridement in the coracoclavicular space to avoid damaging the coracoclavicular ligaments remnants.
Identify and reference the deltotrapezial fascia, if possible.	During dissection and tunnel placement, avoid damaging the upper trapezius insertion on the posterosuperior aspect of the ACJ capsule and lateral clavicle.
With the help of the fluoroscope, identify both the coracoid and the anterior acromion to perform a precise and small incision.	Always control coracoid tunnel drilling with fluoroscopy.
Use your finger to palpate the coracoid limits and to position the drill tunnels.	Aim the drill slightly laterally during coracoid drilling to avoid any nerve damage.
If you find a damaged ACJ meniscus remove it, as it can be a pain generator.	Before assembling the coracoid anchors, make sure that the entire anchor has passed the distal cortex.
Both coracoclavicular and acromioclavicular preparations should be done before ACJ reduction.	Always arm and test anchor strength by pulling it with a continuous movement and stable force until you feel it locked.
Use the same drill to perform all tunnels: coracoid, vertical clavicle, and ACJ.	
Use different clamps to reference and differentiate the sutures from the 2 coracoid anchors to make the CTC assembly easier.	
Use a nitinol wire and a small curved hemostatic clamp to shuttle the suture limbs through the correct tunnels.	
Carefully dissect the soft tissues around the lateral clavicle to facilitate ACJ reduction and placement of tunnels.	
Reduce the joint in a "shoulder shrug" position.	
Start by tying the upper coracoclavicular knots over the 2 buttons, and afterwards proceed to the ACJ figure of 8 tying, incorporating all possible AC capsuloligamentous remnants.	

AC, acromioclavicular; ACJ, acromioclavicular joint; CTC, closing the circle.

Table 2. Advantages and Disadvantages of the CTC Technique

Advantages	Disadvantages
Does not need an arthroscopic setting, which makes it a less-invasive and a less time- and material-consuming technique.	Does not address the glenohumeral joint and thereby may miss concomitant lesions.
With the exception of the lateral clavicle cortical buttons, this is an all-suture technique.	Two tunnels in the coracoid may theoretically increase fracture risk.
It has 3 different coracoclavicular points of fixation, with different force vectors.	
Separate coracoid and clavicle drilling allows for a more anatomic tunnel placement.	
Addresses all three instability vectorial forces: vertical, horizontal and rotational.	
Allows direct repair of the deltotrapezial fascia over the construct.	

CTC, closing the circle.

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