Anatomic Reconstruction of Chronic Coracoclavicular Ligament Tears: Arthroscopic-Assisted Approach With Nonrigid Mechanical Fixation and Graft Augmentation

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Abstract: It has recently been suggested that all coracoclavicular ligament tears could be considered for surgery because nonoperative management might result in irreversible changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain. In this technical note we describe an anatomic technique for the treatment of chronic coracoclavicular ligament tears that overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid. Our technique incorporates the use of a tendon graft and a nonrigid mechanical stabilizer that protects the graft from stretching during the process of healing and integration into bone, guaranteeing the maintenance of a reduced acromioclavicular joint.

The coracoclavicular (CC) ligaments are the main suspensory elements of the upper limb, and the synchronized motion between the clavicle and the scapula occurs through the link that they represent.

Treatment guides base indications on the radiologic magnitude of displacement between the clavicle and the acromion, which at the end is the indicator of a tear or not in the CC ligaments with affection or not of the deltotrapezial fascia.

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Biomechanical studies have shown the importance of an anatomic reconstruction of the CC ligaments in cases of high-grade acromioclavicular joint (ACJ) dislocations, which indicates the presence of a tear in the CC ligaments and/or affection of the deltotrapezial fascia. This issue relates to the fact that the conoid and trapezoid ligaments have different functions that depend on their native anatomic locations. Many of the currently accepted treatments for chronic CC ligament tears do not contemplate CC reconstruction, and authors frequently do not specify whether these techniques have been used in acute cases or in chronic cases.

The few arthroscopic approaches that have described a reconstruction technique that can be used in cases of high-grade ACJ dislocations either are nonanatomic or lack a primary mechanical stabilizer.

We describe the technical aspects of an anatomic reconstruction of the CC ligaments assisted by arthroscopy for cases of chronic CC ligament tears that incorporates a tendon graft and a nonrigid mechanical stabilizer that protects the graft during the process of healing and integration into bone.

Surgical Technique

The steps of our technique are shown and explained in Video 1, following the sequence of the text. 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. First, we perform an arthroscopic
examination of the glenohumeral joint through the posterior portal to detect associated lesions that could require treatment. If there is not any concomitant injury to repair, we avoid placing 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 make an anterior working portal that is located 1 cm lateral to the coracoid. A 5.5-mm shaver is used to perform bursectomy; this 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 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.

Releasing Distal Third of Clavicle
Under arthroscopic control, the distal third of the clavicle must be released to achieve an anatomic reduction. Because the ACJ has been chronically dislocated, if the reduction cannot be achieved by applying direct pressure above the distal third of the clavicle and pushing the elbow upward, it could be necessary to excise 5 mm of the distal third of the clavicle.

Preparation of Tendinous Allograft
We prefer to use semitendinosus tendon allograft. Its length should be about 12 to 14 cm, and its diameter should be about 4.5 to 5.5 mm. The diameter has to be carefully probed by passing the graft without resistance through the measuring device. The allograft is prepared by placing a Krackow suture with a No. 2 metal-core suture (FiberWire; Arthrex, Naples, FL) in both of its limbs.

Tunneling Clavicle and Coracoid Process
A transverse incision with a length of 4 cm is made 3 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 from the lateral edge and slightly anterior when compared with the conoid. Cross sectioning of the deltotrapezial fascia is then performed. The traction is released, and under arthroscopic visualization from the lateral portal, a Biomet acromioclavicular (AC) drilling guide (reference 909511; Biomet, Warsaw, IN) with a calibrated angulation of 80° to 90° is placed at the base of the coracoid, 10-mm anterior to the wall of the scapula, with the sliding tube of the guide located in the superior aspect of the clavicle, 4.5 cm medial to its lateral border (conoid native origin). A 2.4-mm K-wire is passed through the AC guide (Fig 1A). A cannulated 4.5-to 6-mm (depending on the graft diameter) drill is passed over the K-wire until it comes out from the inferior aspect of the coracoid (Fig 1B), where the AC guide catches it. The K-wire is removed, and the cannulated drill is kept in position. A shuttle suture (1-mm polydioxanone [PDS]) is passed from the clavicle to the coracoid through the cannulated drill, and it is then recovered with a grasper from the anterior portal. Two No. 2 FiberWire sutures are tied to the distal limb of the PDS that passes through the coracoid. One of these FiberWire sutures will be used to pass the graft and the other to pass the fixation device (ZipTight, reference 904834; Biomet). Afterward, the AC guide is lateralized.

Fig 1. (A) The AC drilling guide is placed at the coracoid base with the sliding tube of the guide in the superior aspect of the clavicle, 4.5 cm medial to its lateral border (conoid native origin). A 2.4-mm K-wire is passed through the AC guide. (B) A cannulated 4.5- to 6-mm (depending on the graft diameter) drill is passed over the K-wire and comes out from the inferior aspect of the coracoid. (C) A shuttle 1-mm PDS suture is passed through the cannulated drill located in the trapezoid tunnel. The PDS is recovered with a grasper from the anterior portal.
to perform the tunneling of the trapezoid. The 2.4-mm K-wire is passed from the clavicle to a point lateral to the coracoid without perforating it, and afterward, the cannulated 4.5- to 6-mm drill is passed through the clavicle. The K-wire is removed, and the cannulated drill is kept in position. A shuttle 1-mm PDS suture is passed through the cannulated drill and then recovered with a grasper from the anterior portal (Fig 1C).

One of the FiberWire sutures that passes through the conoid tunnel is provisionally tied with a simple knot to the FiberWire of 1 of the limbs of the graft. The FiberWire of the other limb of the graft is provisionally tied with a simple knot to the PDS that comes from the trapezoid tunnel in the clavicle and comes out from the anterior portal. At this stage, both limbs of the graft are provisionally tied: 1 of the limbs to the FiberWire that comes from the conoid tunnel and the other limb to the PDS that comes from the trapezoid tunnel. In the conoid tunnel, there is still a free FiberWire that will be used for passing the ZipTight once the graft has been passed. To pass the graft through both tunnels, the FiberWire that comes out from the conoid tunnel in the superior aspect of the clavicle is pulled out. Afterward, the PDS that arises from the trapezoid tunnel in the clavicle is pulled out in a cranial direction to recover the limb of the graft that is going then to surround the base of the coracoid at its lateral aspect, coming from its tunnel and then being directed laterally and superiorly (Fig 2A), configuring the anatomic “V” shape of the graft. Once the graft has passed through both clavicle tunnels, the ZipTight is tied to the distal limb of the shuttle FiberWire that is still free in the conoid tunnel (Fig 2B). The FiberWire is pulled cranially to pass the ZipTight in a retrograde direction. Once the titanium flip button of the ZipTight has blocked in the inferior aspect of the coracoid, final reduction and fixation can be performed.

**ACJ Reduction and Stabilization**

Before the ZipTight is tensioned, the sliding sutures of the system should be threaded in the washer to make it descend until it touches the clavicle, and afterward, the graft should be fixed in the clavicular portion of the conoid tunnel with a 4.5- to 5.5-mm (same diameter of the tunnel) Bio-Tenodesis interference screw (Arthrex) (Fig 2C). To avoid any harm to the sutures of the ZipTight with the screw, the graft should be placed in an intermediate position between the screw and the sutures. Afterward, the surgical assistants should reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. The limb of the graft that corresponds to the trapezoid is then fixed with another 4.5- to 5.5-mm Bio-Tenodesis interference screw. Once both limbs of the graft have been fixed and the flip is properly supported in the inferior aspect of the coracoid (Fig 3A), the ZipTight is tied by pulling alternatively on both limbs of the blue traction sutures in a cranial direction (Fig 3B) to make the washer go down until it touches the clavicle and self-locks, providing mechanical stabilization of the reconstruction. The reduction is checked with direct palpation, direct arthroscopic visualization, and/or intraoperative radiographs. The traction suture is then removed. Both limbs of the graft are crossed to each other and sutured to themselves with No. 1.0 Vicryl (Ethicon, Somerville, NJ) (Fig 3C). The remnant of the graft is sectioned and removed. The deltotrapezial fascia is carefully closed with No. 1.0 Vicryl. Finally, the shuttle suture that was coming out from the inferior aspect of the coracoid is removed, and the skin is closed with No. 4-0 Prolene (Ethicon).

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

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**Fig 2.** (A) The PDS that arises from the trapezoid tunnel in the clavicle is pulled out in a cranial direction to recover the limb of the graft that is going to surround the base of the coracoid at its lateral aspect, coming from its tunnel and then being directed laterally and superiorly, configuring the anatomic V shape of the graft. (B) Once the graft has passed through both clavicle tunnels, the ZipTight is tied to the distal limb of the shuttle FiberWire that is still free in the conoid tunnel. (C) Before the ZipTight is tensioned, the graft should be fixed in the clavicular portion of the conoid tunnel with a 4.5- to 5.5-mm (same diameter of the tunnel) Bio-Tenodesis interference screw.
Fig 3. (A) Final arthroscopic view from lateral portal. The graft is coming out from the coracoid tunnel, ascending toward the trapezoid tunnel in the clavicle. The flip of the ZipTight is supported in the inferior aspect of the coracoid. (B) Both limbs of graft coming out from clavicle once fixed in both tunnels with Bio-Tenodesis interference screws. The ZipTight is tied by threading the sliding suture in the washer. (C) Final anatomic V configuration of reconstruction with flip of ZipTight in inferior aspect of coracoid and both limbs of graft crossed to each other and sutured to themselves.

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.
- The ends of the graft should be properly sharpened, and suturing should be carefully performed to avoid an “accordion” effect when the graft is passed through the tunnels.
- The proper reduction of the ACJ can be controlled by fluoroscopy in case there is any doubt when ensuring the proper reduction through straight visualization.
- The traction should be released before reduction.
- The deltotrapezial fascia should be carefully sutured to achieve the best vertical and horizontal control of the ACJ.
- To avoid any harm to the sutures of the suspension device with the Bio-Tenodesis screw, the graft should be placed in an intermediate position between the screw and the sutures.

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 of 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 a CC nonrigid suspension device.
- Allografts are not available in some countries, so in these cases the use of palmaris longus or semitendinosus autografts could be necessary to consider.
- Correct anatomic placement of the clavicle tunnels and the correct distance between them are crucial to prevent fractures when using large drills.

Key points
- Nonoperative management of CC ligament tears might result in irreversible changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain.
- Anatomic reconstruction techniques have shown biomechanical and clinical advantages over nonanatomic techniques in cases of high-grade ACJ dislocations.
- Our technique incorporates the use of a tendon graft and a nonrigid mechanical stabilizer that protects the graft from stretching during the process of healing and integration into bone.
- Our technique overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid.

Indications
- Chronic CC ligament tears (high-grade ACJ dislocations considered to be treated 3 weeks after injury)
- Acute CC ligament tears in cases of patients with high functional demands

Contraindications
- Elderly patients
- Patients with comorbid factors that contraindicate the need for elective surgery
Rehabilitation Protocol

The shoulder is maintained in a sling for 4 to 6 weeks to facilitate the healing period of the reconstruction. Patients are allowed from the very beginning to fully and actively move the elbow, wrist, and hand and are allowed to passively move the shoulder into no more than 90° of elevation in the plane of the scapula. The exercise program is started after the sixth week. Pendulum exercises begin in the fourth week, and active range of motion is allowed from the sixth week onward. Exercises to regain strength are initiated once the patient achieves 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 and tasks requiring major effort should be avoided for 4 to 6 months after surgery. Achieving a full recovery and returning to maximum strength and function can take 9 to 12 months.

Patients

The described procedure has been performed in 10 patients with a diagnosis of a chronic CC ligament tear. The time from injury to surgery was greater than 3 weeks in all cases. Clinical outcomes and radiographic controls were obtained in all cases at a minimum follow-up time of 6 months. The preliminary results are described as excellent because all patients have had complete functional recovery and have no residual pain.

Discussion

The procedure presented in this technical note overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid.

Regarding the approach to the coracoid, some authors have described placement of a skin incision over the coracoid tip to bluntly dissect and then palpate its base for placement of a drill guide. Such a technique is performed in a blind manner and lacks the precision that straight visualization can offer. For improved visualization of the inferior aspect of the coracoid, different arthroscopic techniques that facilitate tunneling and implant placement have been described.

The subacromial approach has an advantage over the glenohumeral approach because there is no need to release the superior and middle glenohumeral ligaments to allow access to the coracoid.

Regarding the strategy for reconstruction, biomechanical studies have shown that the structure of the CA ligament offers inferior resistance to vertical translation when compared with graft reconstructions. The arthroscopic technique for both acute and chronic ACJ dislocations described by Lafort et al., in which the CA ligament transfer is proposed to reconstruct the torn CC ligaments, could theoretically involve the disadvantage in terms of strength that would arise from a Weaver-Dunn procedure. We use a semitendinosus graft placed in the anatomic location of the native ligaments, which restores the anatomy and makes our technique more faithful to the biomechanical concepts that are currently accepted.

Regarding the fixation method of the reconstruction in the coracoid, it has been described that subcoracoid loops that surround its base tend to dislocate anteriorly because of the ascending slope of the inferior aspect of the coracoid. It has also been shown that the placement of CC loops could involve the development of bony erosions because of a "sawing" effect. Our procedure overcomes this issue by incorporating tunnel making both in the coracoid and in the clavicle for graft passage and implant fixation.

Regarding the primary stability of the construct and the possibility of a secondary displacement developing, 1 advantage that our procedure can offer, among others, is that we combine a mechanical primary nonrigid stable fixation, provided by the suspension device, and a biological and permanent fixation that will be represented by the graft once integrated into bone. In the nonanatomic open technique described by LaPrade and Hilger, in which they propose the use of a semitendinosus graft that passes through 1 tunnel in the clavicle and 1 in the coracoid, which does not include any primary mechanical fixation and does not take into consideration the native origins of the CC ligaments, they recognize that in some patients stretching of the graft can occur, causing a subtle superior subluxation of the clavicle. Yoo et al. recently described an anatomic technique that attempts to make transossous tunnels within the natural footprints of the CC ligaments, but they also did not contemplate the use of any mechanical stabilizer that protects the graft from stretching during the healing process.

Another advantage that arthroscopy can offer over open surgery in cases of CC ligament reconstruction is that glenohumeral-associated lesions can be diagnosed and treated, which is not possible through open surgery. Some authors have reported that the incidence of associated lesions in cases of high-grade ACJ dislocations is as high as 30%. If the tunneling of the coracoid, there is a potential risk of fracture creation if the tunnel placement is improper. Use of this technique should be considered only by experienced arthroscopic surgeons to avoid these complications and thus guarantee the safety of the procedure.

It is important to keep in mind that the described procedure is an arthroscopic-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 a mini-open approach on top of the ACJ. Once the join surfaces of the clavicle and the acromion are properly faced, the deltotrapezial fascia should be carefully reconstructed to guarantee proper vertical stability. When the reconstructed deltotrapezial fascia is healed over the ACJ, it also plays a role in the horizontal control and stabilization of the ACJ in the anteroposterior plane.

Our surgical technique provides excellent initial fixation and restores the anatomy by reconstructing the torn CC ligaments by placing tunnels in their native locations. We must evaluate the clinical outcome of our series of patients once follow-up for a minimal period of 2 years has been accomplished.

References