



Arthroscopic-Assisted Management of Unstable Distal-Third Clavicle Fractures: Conoid Ligament Reconstruction and Fracture Cerclage With Sutures

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Abstract: Surgical treatment is usually indicated for the management of Neer type IIB fractures of the distal third of the clavicle. These unstable injuries have shown a rate of nonunion that oscillates around 30% to 45% when managed conservatively, and surgical strategies often require a second operation for implant removal. We describe an arthroscopic-assisted technique for the treatment of Neer type IIB unstable distal-third clavicle fractures that overcomes the issues related to open surgery, metal hardware, and implant irritation. This technique increases the load to failure of the construct by means of adding a synthetic conoid ligament reconstruction with a nonrigid suspension device, and it allows the diagnosis and treatment of associated glenohumeral injuries. Our technique incorporates a fracture interfragmentary fixation with sutures, thus avoiding a second operation for implant removal.

Surgical treatment is usually indicated for the management of Neer type IIB fractures of the distal third of the clavicle. These unstable injuries have shown a rate of nonunion that oscillates around 30% to 45% when managed conservatively.^{1,2} Nonunion is attributable to opposing forces that act on the fragments and condition displacement. The trapezius attached to the medial fragment displaces the medial clavicle superiorly, and the weight of the arm draws the lateral fragment inferiorly. This results in interfragmentary distraction and subsequent nonunion. In addition, the associated disruption of the conoid ligament has a determinant role in the superior displacement of the medial fragment.³

It has been shown that if conoid ligament disruption is left untreated, the risk of nonunion increases,⁴ so to avoid superior migration of the medial fragment, surgical strategies should include reconstruction of the

disrupted conoid ligament. Likewise, biomechanical studies have shown that greater fracture stability is achieved when combining fracture fixation with coracoclavicular (CC) fixation than with either method alone.⁵

Although several techniques have been used for the treatment of these types of injuries, no consensus has been reached regarding the optimal surgical strategy.¹ The hook-plate system implies a mandatory need for implant removal because, otherwise, it would alter the clavicle biomechanics and cause subacromial impingement.⁶ The lower profile of superior locked distal clavicle plates may eliminate the mandatory need for hardware removal, but they have been associated with failure because of poor fixation in the comminuted lateral fragment.⁷

On the other hand, techniques that consist of interfragmentary fixation with a suture cerclage have been described as reliable procedures that minimize the probabilities of implant irritation. Likewise, these techniques have shown good clinical and radiologic outcomes.^{4,8}

In this article we describe the technical aspects of an arthroscopically assisted procedure that uses a synthetic conoid ligament reconstruction and fracture-site fixation with suture cerclage, indicated for the management of Neer type IIB unstable distal-third clavicle fractures. The described procedure minimizes the probabilities of implant irritation related to plate fixation systems, and it increases the load to failure of the construct by adding a nonrigid mechanical stabilizer that emulates the

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function of the conoid ligament during the healing process of the fracture and the native ligament. Likewise, this procedure allows the diagnosis and treatment of intra-articular associated lesions.

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. The injured shoulder is prepared and draped in sterile fashion with the arm forward flexed up to 50° to 70° maintained by a weight of 3 kg. Three standard arthroscopic portals are used: posterior, anterolateral, and lateral. First, we perform an arthroscopic examination of the glenohumeral joint through the posterior portal to detect associated lesions that could require treatment. 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 ligament is followed until its insertion at 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 full-radius shaver blade (Biomet, Warsaw, IN) is used to perform the bursectomy that allows adequate visualization of the coracoacromial ligament. The synovial tissue 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 ([Fig 1A](#)). It is important to be aware that the axillary bundle and the brachial plexus are located medial to the coracoid process.

Tunneling Clavicle and Coracoid Process

A transverse incision with a length of 3 cm is made on top of the fracture. A cross section of the deltoid fascia is then performed. The traction is released, and under arthroscopic visualization from the lateral portal, an acromioclavicular (AC) drilling guide (reference 909511; Biomet) 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. The native origin of the disrupted conoid ligament is 4.5 cm medial to the lateral edge of the clavicle and slightly posterior when compared with the trapezoid.⁹ To make the tunnel in the anatomic location of the conoid ligament, the sliding tube of the guide is located in the superior aspect of the clavicle, 4.5 cm medial to its lateral border ([Fig 1B](#)). A 2.4-mm K-wire is passed through the AC

guide. A 3.5-mm cannulated drill is passed over the K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide catches it ([Fig 1 C and D](#)). The K-wire is removed, and the cannulated drill is kept in position. A shuttle suture (1-mm PDS; Ethicon, Somerville, NJ) is passed from the clavicle to the coracoid through the cannulated drill, and it is then recovered with a grasper from the anterior portal. One No. 2 FiberWire suture (Arthrex, Naples, FL) is tied to the distal limb of the PDS that passes through the coracoid. The FiberWire will be used to pass the fixation device (ZipTight, reference 904834; Biomet). The PDS is retrieved from the superior aspect of the clavicle, so the FiberWire passes through the tunnels. The ZipTight is tied to the distal limb of the shuttle FiberWire that is free in the tunnel. The FiberWire is pulled cranially to pass the ZipTight in a retrograde direction. Once the titanium flip of the ZipTight is supported in the inferior aspect of the coracoid ([Fig 2A](#)), final reduction and fixation can be performed.

Medial Fracture Fragment Stabilization and Reduction

Before the ZipTight is tensioned, the sliding sutures of the system should be threaded in the washer (which is attached to the blue traction sutures) to make it descend until it touches the clavicle ([Fig 2B](#)). Afterward, the surgical assistants should reduce the distal-third clavicle fracture by means of pushing the elbow upward and the medial fragment of the fracture downward at the same time ([Fig 2C](#)). Once the flip is properly supported in the inferior aspect of the coracoid, the ZipTight is tied by means of pulling alternatively on both limbs of the sliding sutures in a cranial direction to make the washer descend until it touches the clavicle and self-locks ([Fig 2D](#)). The blue traction suture of the washer is removed, and the shuttle suture that was coming out from the inferior aspect of the coracoid is also removed. The reduction achieved with the stabilization of the medial fragment is checked with direct palpation or intraoperative radiographs (or both).

Fracture Interfragmentary Fixation

Fixation of the fracture is performed by means of a suture cerclage made with a No. 5 FiberWire without a needle. The sutures of the cerclage could be passed through the clavicle by making tunnels with a drill or by using a 2.4-mm K-wire with an eyelet at its base. For both options, a No. 2 Ethibond Excel (Ethicon) will be used as a shuttle. When the tunnels are being made with a drill, the shuttle Ethibond should keep its needle (useful for passing the sutures through the tunnels); when the 2.4-mm K-wire with a hole at its base is being used, the Ethibond should not have a needle.

If the surgeon decides to make the tunnels with a drill, 2 clavicle bone tunnels should be created in an

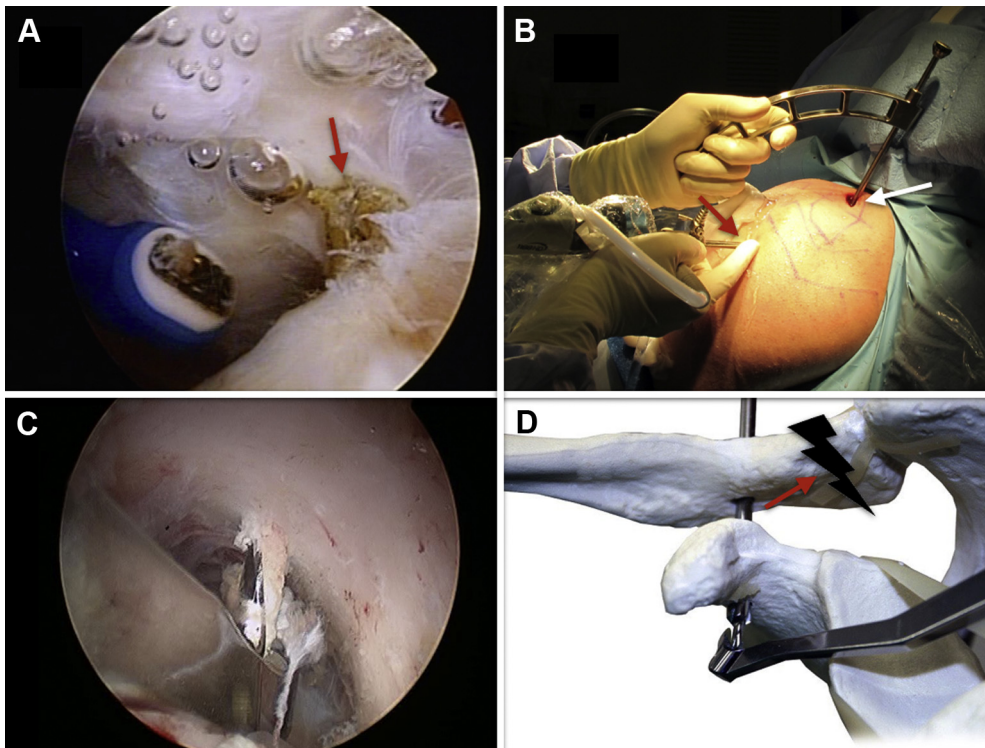


Fig 1. (A) Arthroscopic view of a left shoulder from the lateral portal. The synovial tissue (red arrow) anterior to the rotator interval is cleaned with the vaporizer to identify the base of the coracoid. (B) Perspective from the lateral aspect of a left shoulder. The arthroscope is in the anterolateral portal (red arrow). The acromioclavicular (AC) drilling guide is introduced through the anterior portal and placed at the base of the coracoid. The sliding tube of the AC guide is located in the superior aspect of the clavicle (white arrow), 4.5 cm medial to its lateral border, to place the tunnel in the anatomic location of the conoid ligament. (C) Arthroscopic view of a left shoulder from the lateral portal. The AC guide is introduced through the anterior portal and placed in the inferior aspect of the base of the coracoid, 10 mm anterior to the wall of the scapula. A 3.5-mm cannulated drill passes over the K-wire and comes out from the inferior aspect of the coracoid. (D) AC Sawbones model (Pacific Research Laboratories, Vashon, WA) showing a general perspective of the AC guide placement in the inferior aspect of the coracoid. The AC guide receives the cannulated drill. The lightning bolt represents the location of the distal-third clavicle fracture.

anteroposterior direction with a 2.5-mm drill: 1 tunnel at each side of the fracture. The free limb of a No. 2 Ethibond shuttle suture with a needle is tied in the middle of the FiberWire (Fig 3A). The FiberWire is folded onto itself so that it creates a loop where the Ethibond is tied. The Ethibond is passed through the bone tunnels in a figure-of-8 fashion, with the tied folded FiberWire.

If the surgeon decides to use the 2.4-mm K-wire for passing the sutures through the clavicle, this K-wire with an eyelet at its base should be passed through the clavicle, medial to the fracture site, from anterior to posterior. A No. 2 Ethibond without a needle (which will be used as a shuttle) is passed through the eyelet located at the base of the K-wire, which is crossing the clavicle. The K-wire is pulled from its tip and then recovered from the posterior aspect of the shoulder to make the shuttle Ethibond pass through the transverse tunnel created in the clavicle. The same procedure is repeated but this time lateral to the fracture site and medial to the AC joint. At this time, 2 free Ethibonds

are crossing the clavicle from anterior to posterior: 1 medial and 1 lateral to the fracture site. Afterward, a No. 5 FiberWire without a needle (definitive cerclage suture) is folded onto itself. The medial shuttle Ethibond is tied to the loop of the FiberWire. This Ethibond is now pulled from its posterior limb to make the folded FiberWire pass through the tunnel in an anteroposterior direction. It is very important to be sure that the 2 free limbs of the FiberWire remain in the anterior aspect of the clavicle tunnel. Afterward, the anterior free limb of the lateral shuttle Ethibond is tied to the loop of the FiberWire (which is now posterior to the clavicle). Once the Ethibond has been tied to the loop of the folded FiberWire, this Ethibond should be pulled from its posterior free limb to make the FiberWire pass through the lateral clavicle tunnel from anterior to posterior. At this time, cerclage in a figure-of-8 fashion has been achieved.

Both options (drill and Ethibond with needle or K-wire with eyelet) lead to this point. A simple knot is now made. Because the FiberWire was folded onto

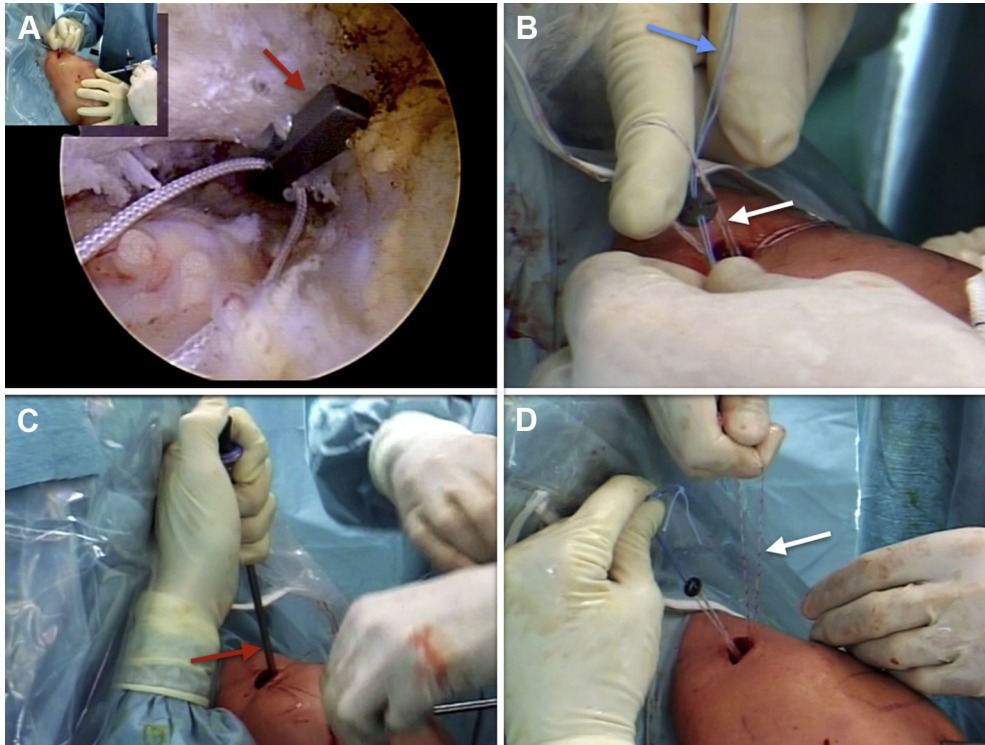


Fig 2. (A) Arthroscopic view of a left shoulder from the lateral portal. The flip of the ZipTight (red arrow) is supported in the inferior aspect of the coracoid. (B) Perspective from the superior aspect of a left shoulder. Before the ZipTight is tensioned, the sliding sutures of the system (white arrow) should be threaded in the washer to make it descend until it touches the clavicle. The blue arrow indicates the blue traction sutures of the washer. (C) Perspective from the anterolateral aspect of a left shoulder. One of the assistants reduces the fracture by pushing the medial fragment downward (red arrow). Ideally, the other assistant should help in the reduction by pushing the elbow upward at the same time. (D) Perspective from the anterolateral aspect of a left shoulder. The ZipTight is tied by pulling alternatively on both limbs of the sliding sutures (white arrow) in a cranial direction to make the washer descend until it touches the clavicle and self-locks.

itself, we have a loop in one of the ends and 2 free limbs in the other end. To achieve fracture compression, a Boileau doubled-suture Nice knot¹⁰ is made by means of introducing the 2 free limbs of the FiberWire through the loop. The 2 free limbs are alternatively pulled until the loop touches the first knot. Fracture compression is then observed (Fig 3B). In the case of a fracture that is too oblique, it is sometimes necessary to add an extra circumferential cerclage. Reconstruction of the deltotrachezial fascia with No. 1 Vicryl (Ethicon) is carefully performed to increase the vertical stability. The skin is sutured or stapled, and the arm is placed in a sling. Tips, pearls, pitfalls, risks, key points, indications, and contraindications of the technique are shown in Table 1.

Rehabilitation Protocol

The shoulder should be maintained in a sling for 4 to 6 weeks to facilitate the healing period of the fracture and the native conoid ligament. Patients are allowed to fully and actively move the elbow, wrist, and hand

immediately after surgery. The exercise program should be started after the sixth week. Pendulum exercises begin from the fourth week and active range of motion from the sixth week onward. Exercises to regain strength are initiated once the patient has full, pain-free passive and active range of motion. A 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. Full recovery and return to maximum strength and function can take 9 to 12 months.

Patients

The described procedure has been performed in 9 patients diagnosed with Neer type IIB unstable distal-third clavicle fractures (Fig 3 C and D). Concomitant glenohumeral injuries were detected and treated in 22.22% of the patients (2 of 9): 2 rotator cuff tears. Clinical and radiologic outcomes were prospectively obtained in all cases with a minimum follow-up period of 24 months. The results are described as excellent

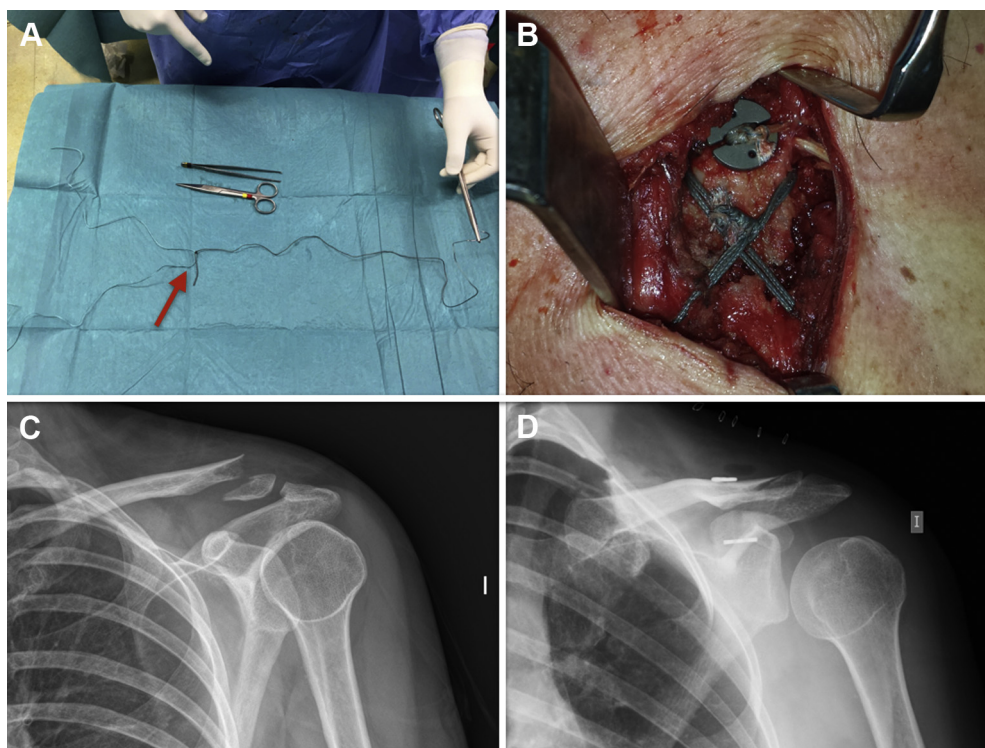


Fig 3. (A) The free limb of a No. 2 Ethibond suture with a needle (which will be used as a shuttle) is tied in the middle of the No. 5 FiberWire without a needle (red arrow). The FiberWire is folded onto itself so that it creates a loop where the Ethibond is tied. (B) Superior perspective of a left shoulder once the procedure is completed. Fracture fixation and compression are achieved by the suture cerclage tied with the Boileau doubled-suture Nice knot. (C) Anteroposterior clavicle radiograph showing a Neer type IIB unstable distal-third clavicle fracture. One should observe that the medial fragment is superior when compared with the lateral fragment. The trapezius displaces the medial clavicle superiorly, and the weight of the arm draws the lateral fragment inferiorly. (D) Final anteroposterior radiograph showing fracture fixation and conoid ligament reconstruction with the nonrigid suspension device. One should observe that the medial and lateral fragments are properly reduced. The distraction forces that conditioned displacement have been stabilized.

because all patients had complete functional recovery and have no residual pain. A second operation was not required in any patient.

Discussion

The described procedure overcomes the issues related to open surgery, metal hardware, and implant irritation. This technique increases the load to failure of the construct by adding a synthetic conoid ligament reconstruction with a nonrigid suspension device, and it allows the diagnosis and treatment of associated glenohumeral injuries. Our technique incorporates a fracture interfragmentary fixation with sutures, thus avoiding a second operation for implant removal.

Arthroscopic-assisted procedures to stabilize distal-third clavicle fractures and reconstruct the disrupted conoid ligament have been previously described.^{3,11,12} They consist of sutures loops, suture anchors, and nonrigid suspension devices. Limited outcome data exist, but good outcomes at medium-term follow-up have been reported.¹² It has been described that

subcoracoid loops that surround the coracoid's base tend to dislocate anteriorly because of the ascending slope of the inferior aspect of the coracoid.¹³ In addition, it has been shown that the placement of CC loops could involve the development of bony erosions because of a "sawing" effect.¹⁴ It has recently been described that CC fixation devices with cortical buttons are actually the most preferred methods for the management of distal-third clavicle fractures because surgeons agree on avoiding second surgical procedures for mandatory hook-plate removal.¹⁵

It has been shown that CC fixation increases the stability in type IIB distal clavicle fractures and also increases the load to failure.¹⁶ Biomechanical studies have shown that the combination of fracture-site fixation and CC fixation is superior to either method alone.⁵ CC fixation techniques could be seen by many surgeons as risky procedures because of the supposed potential risk of fracture when tunneling the coracoid. This risk only exists if the tunnel placement is improper, so the technique we are describing should be

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.
	It is critical to ensure that the deltotrapezial fascia is not interposed between the fracture fragments.
	The 2.5-mm tunnels must be sufficiently distant from the fracture to avoid coalitions.
	The traction should be released before fracture reduction.
	The deltotrapezial fascia should be carefully sutured to achieve the best vertical stability of the fracture.
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.
	If the distal-third clavicle fracture is too comminuted and has a medial extension, the anatomic positioning of the conoid tunnel can be compromised.
	Implant cost is a consideration when using a CC nonrigid suspension device.
Key points	
	Nonoperative management of distal-third clavicle fractures has shown a rate of nonunion—a situation that results in chronic pain—that oscillates around 30% to 45%.
	If conoid ligament disruption is left untreated, the risk of nonunion increases.
	Biomechanical studies have shown that in cases of unstable distal-third clavicle fractures, greater stability is achieved when combining fracture fixation with CC fixation than with either method alone.
	Our technique overcomes the issues related to open surgery, metal hardware, and implant irritation, as well as the sawing effect and anterior loop translation that can be seen in those systems that surround the base of the coracoid.
	Our technique incorporates a fracture interfragmentary fixation with sutures, thus avoiding a second operation for implant removal.
	Our surgical technique provides excellent initial fixation and restores the anatomy by reconstructing the torn conoid ligament by placing a nonrigid suspension device that ensures the narrowing of the CC space while the torn ends of the native ligament heal.
	Glenohumeral joint-associated lesions can be diagnosed and treated, which may not be possible through open surgery.
Indications	
	Unstable distal-third clavicle fractures with conoid ligament disruption and superior displacement of the medial fragment (Neer type IIB)
Contraindications	
	Elderly patients
	Comorbid factors that contraindicate the need for surgery
AC, acromioclavicular; CC, coracoclavicular.	

considered only by experienced shoulder surgeons to avoid these complications and thus guarantee the safety of the procedure. So far, the incidence of global complications reported for CC reconstruction procedures has been only 4.8%.¹

Few authors have combined the biomechanical advantages of fracture-site fixation plus CC fixation, and they have reported good clinical and radiologic outcomes.^{16,17} Shin et al.⁴ have reported successful union rates after performing interfragmentary fixation using 2 nonabsorbable suture tension bands in a figure-of-8 configuration plus CC fixation using 2 suture anchors. They argued that the posteromedial suture anchor in position of the torn conoid ligament plays an important role by restraining the medial clavicle from vertical displacement.

The surgical strategy described in this technical note uses fracture-site fixation with the figure-of-8 cerclage described by Levy⁸ combined with CC fixation with a nonrigid suspension device. The rationale of this combination of techniques is to increase the load to failure of the construct by adding the CC fixation and avoiding implant irritation problems.

It must be recognized that with the addition of an arthroscopic-assisted CC fixation, the surgical time and the instrumentation cost can be increased. We believe that the fact that there is no need for a second operation for implant removal, the fact that the surgical approach is less aggressive, and the fact that the deltotrapezial fascia (which plays an important role in the vertical stability of distal-third clavicle fractures with conoid ligament disruption) is more preserved are some of the reasons that make arthroscopic-assisted CC fixation procedures theoretically more suitable than plate fixation procedures.

Another advantage that arthroscopy can offer over open surgery in cases of unstable distal-third clavicle fractures is that glenohumeral joint-associated lesions can be diagnosed and treated, which may not be possible through open surgery. To our knowledge, there have been no previous studies that described the possibility of detecting and treating associated lesions in cases of unstable distal-third clavicle fractures.

It is important to bear 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 fracture fragments. This can be achieved only by means of a mini-open approach on top of the distal-third clavicle fracture. Once the fracture has been fixed, the deltotrapezial fascia should be carefully reconstructed to guarantee proper vertical stability.

Our surgical technique provides excellent initial fixation and restores the anatomy by reconstructing the torn conoid ligament by placing a nonrigid suspension device that ensures the narrowing of the CC space while the torn ends of the native ligament heal. The clinical and radiologic outcomes of our series of patients are excellent, with a minimum follow-up period of 24 months.

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