Technical Note

Arthroscopically Assisted Acromioclavicular and Coracoclavicular Reconstruction with a Looped Braided Polyester Suture Band and Buckle Device

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Abstract: Acromioclavicular (AC) joint injuries occur with a traumatic load to the lateral aspect of the shoulder and account for 9% of all shoulder girdle injuries. Rockwood classified AC joint injuries as type I though type VI, based on severity of injury, radiographic findings, and reducibility of the AC joint. Type I and II injuries are typically managed nonoperatively, whereas type IV, V, and VI are managed operatively to address the significant soft tissue disruption, persistent AC joint instability, and apical shoulder deformation. Treatment of type III injuries remain controversial. Several techniques have been described to treat AC joint injuries with no consensus for optimal treatment. "Anatomic" double-tunnel coracoclavicular ligament reconstruction is one currently popular technique to address AC joint injuries; however, clavicle and coracoid fractures are well-described complications of this technique. The objective of this technical report is to describe our preferred technique to address AC joint injuries. This technique involves using a looped braided polyester prosthetic band and low-profile buckle with allograft augmentation using a device to pass materials around the coracoid process.

Introduction

Injuries to the acromioclavicular (AC) joint are common in the active adult population and most often occur from a fall onto the lateral shoulder. This results in direct force onto the superior aspect of the acromion process, resulting in injury. The Rockwood classification of AC joint injuries helps guide management, with type I and II injuries typically managed conservatively and type IV to VI with surgical intervention. Treatment for type III injuries remains controversial, and choice of treatment depends upon an array of physician and patient related factors.

There is no gold standard for the surgical management of AC joint separations with more than 150 surgical techniques described in the literature.[1] Surgical techniques include open and arthroscopic approaches to reconstruct the coracoclavicular (CC) ligaments and/or AC ligaments with use of tendon autograft or allograft, temporary joint stabilization with hardware, distal clavicle excision, and CC space-stabilizing procedures using suture loop, screw, button, suture anchors, or similar devices. However, surgical treatment of AC joint injuries has been fraught with high rates of failure and complications. Reports show up to 80% of patients have loss of radiographic reduction and 20-30% of patients managed surgically undergo reoperation due to complications.[2,3] Anatomic double-tunnel CC ligament reconstruction is one of the most common techniques to address AC joint injuries, as described by Mazzocca et al.[4] Other techniques use single-drill tunnels into the clavicle and coracoid.[5] Inherent in these techniques are two bone tunnels in the distal clavicle, which have been

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Table 1. Advantages and Disadvantages

Advantages	Disadvantages
1. No bone tunnels are created in the clavicle or coracoid; therefore, the bone is not weakened.	1. More extensive dissection is needed around the clavicle in order to allow passage of the graft and M-fix.
2. M-Fix has a looped woven prosthetic band configuration.	2. In order to successfully pass the graft and M-fix around the coracoid, adequate soft tissue dissection must be done, putting neurovascular structures at risk.
3. The M-Fix can be used as provisional fixation prior to final locking, which enables assessment of reduction on fluoroscopy.	3. There is a risk of hardware prominence on the clavicle.

shown in biomechanical studies to weaken the clavicle, and there have been several case reports of clavicle fractures.[6,7] Other techniques require drilling into the coracoid, which also raises concern for coracoid fractures.[8]

In an effort to mitigate the morbidity of bone tunnels in the distal clavicle and lessen loss of reduction, we describe a tunnel-free technique involving the use of a broad polyester suture band (4 mm or 7 mm) with a preattached metal buckle and allograft augmentation (see Table 1 for advantage and disadvantages).

Surgical Technique

For details on the surgical technique, see Video 1 and Tables 2 and 3.

Device and Implants

J-Pass (Coracoid Solutions, Menlo Park, CA) is a surgical dissector and bidirectional passing tool designed to safely pass suture around the coracoid process and clavicle (Fig 1). It consists of a triggering device and nitinol passer, which has an attached shuttle suture. The J-Pass can perform dissection of the soft tissue above and around the coracoid process, while delivering a passing suture, which subsequently allows passage of the implant and graft.

M-Fix (Coracoid Solutions) is an implant made from woven polyester with an attached stainless-steel metal buckle (Fig 2). The M-Fix is passed under the coracoid process and looped over the clavicle. This obviates the need for drilling tunnels in either the coracoid process or clavicle. Once the M-Fix is deployed under the coracoid process and over the clavicle, manual reduction and the counter brace are used to obtain the appropriate level of tension on the M-Fix. A unique and proprietary feature of the M-Fix is that it holds provisional fixation, while the reduction can be confirmed radiographically. M-Fix accessory tools include the

Table 2. Steps

Step 1: Patient Positioning	• Beach chair • Drape to allow a wide access to the posterior and medial shoulder. • Ensure access for fluoroscopy.
Step 2: Diagnostic Glenohumeral Arthroscopy	• Standard posterior viewing portal • Anterior portal through rotator interval • Perform diagnostic arthroscopy.
Step 3: Coracoid Process Exposure	• Work laterally to medially. • Debride lateral and inferior aspect of coracoid process. • An accessory anterior-inferior portal helps with visualization.
Step 4: Mini-Open Exposure of Clavicle	• Incision is 4 cm medial to the AC joint. • Expose clavicle anteriorly and posteriorly • Clear soft tissue from the clavicle at the level of the coracoid process.
Step 5: Subcoracoid Passage Preparation	• Reinsert arthroscope through posterior portal. • Ensure there is a clear path between clavicle and coracoid process. • May use a blunt obturator through clavicle incision to clear out soft tissue.
Step 6: Subcoracoid Passage of Shuttling Suture	• Load the J-Pass with passing suture and insert around the clavicle down to coracoid pass. • Pass device from medially to laterally and deploy suture.
Step 7: Passage Under the Clavicle	• Use a suture retriever to bring suture through clavicle incision.
Step 8: Passing the M-Fix and Graft	• Use the shuttling suture(s) to pass the M-Fix and graft.
Step 9: AC Reduction and Provisional Fixation	• Reduce the AC joint and provisionally secure with M-Fix. • Confirm reduction on fluoroscopy.
Step 10: Final Fixation of M-Fix and Graft	• Place the tip of the securing punch in the dimple of the flange. • Place downward pressure until a single click is heard. • Cut free end of M-Fix. • Suture graft onto itself and cut excess ends of graft.

AC, acromioclavicular.

Table 3. Pearls and Pitfalls

Pearls	Pitfalls
1. Ensure adequate access to fluoroscopy in order to confirm AC joint reduction.	1. Soft tissue that has been inadequately dissected away from the coracoid obstructing the J-Pass device
2. Release of the CA ligament from its attachment on the superolateral aspect of the coracoid process may help subsequent graft and M-Fix passage.	2. Extensive dissection medial to the coracoid resulting in neurovascular injury
3. Expose the clavicle anteriorly and posteriorly along its length for several centimeters in order to allow passage of graft and M-Fix.	3. Inadequate exposure of AC joint resulting in soft tissue obstruction of reduction
4. AC joint should be easily reducible after exposure.	4. Forcible tension upon the M-Fix to achieve reduction of the coracoclavicular interspace leading to failure or loss of reduction
5. The traction tool can be used to help maintain reduction and facilitate a secure construct.	5. Inadequate graft length that is unable to be passed under the clavicle and coracoid.

AC, acromioclavicular; CA, coracoacromial.

Countertraction Tool and Punch (Fig 2). The Countertraction Tool is used to help in the reduction of the coracoclavicular distance by facilitating countertraction on the metal buckle while increasing tension (pulling) on the M-Fix. The Punch is a tool designed to lock the M-Fix buckle, thus preventing displacement of the M-Fix implant once reduction is achieved.

Patient Positioning

The patient is placed in the beach chair position (Fig 3). Sterile preparation and draping of the surgical field should allow wide access to the posterior and medial shoulder for arthroscopic portals and the middle third of the clavicle to ensure adequate access for intraoperative fluoroscopy, typically from the contralateral side. When available, a mechanical arm-holder is used to facilitate reduction of the AC joint.

Diagnostic Glenohumeral Arthroscopy and Coracoid Process Exposure

A standard posterior viewing portal is established to visualize the glenohumeral joint (Fig 4). Under direct visualization, an anterior portal is established in the rotator interval. A diagnostic arthroscopy is performed to assess any additional intra-articular pathology. Any additional injuries should be addressed now. While viewing from the posterior portal and working through the anterior portal an arthroscopic shaver in combination with radiofrequency/electrocautery are used to debride the rotator interval tissue, working in a lateral to medial direction and exposing the coracoacromial ligament. Once this has been completed, the coracoid process can be visualized and palpated medial to the rotator interval. The conjoined tendon and origin on the lateral coracoid process should be visualized and protected. The lateral and inferior aspect of the coracoid process should be debrided of soft tissue with an electrocautery device in a lateral to medial fashion, taking care not to plunge or sharply dissect medial to the coracoid. The debridement can be facilitated by using an accessory anterior-inferior portal. The anterior-inferior portal is established under direct visualization inferior of the first anterior portal. Using a radiofrequency/electrocautery device, the soft tissue is debrided from the inferior and superior aspects of the body of the coracoid process as well. A shaver may be

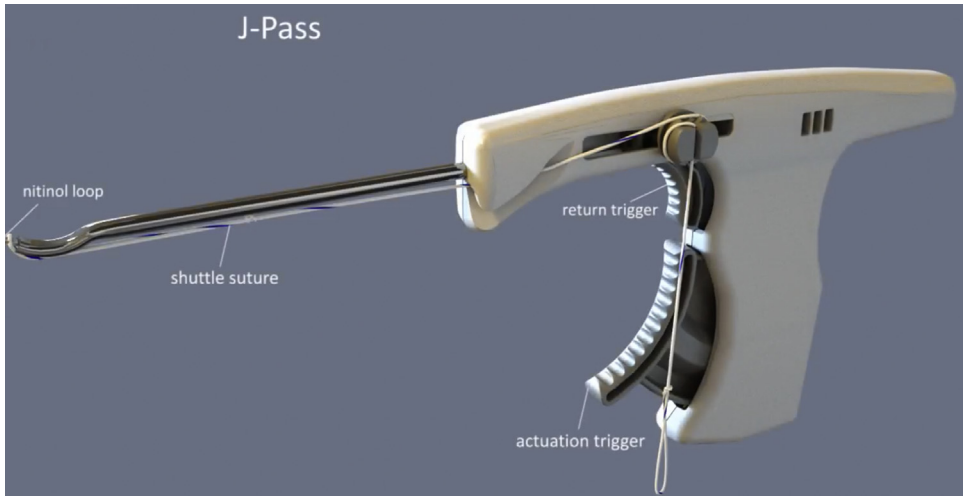

Fig 1. J-Pass (Coracoid Solutions, Menlo Park, CA) is used to dissect around the coracoid process and clavicle and then is used to pass a nitinol wire that has an attached shuttle suture.

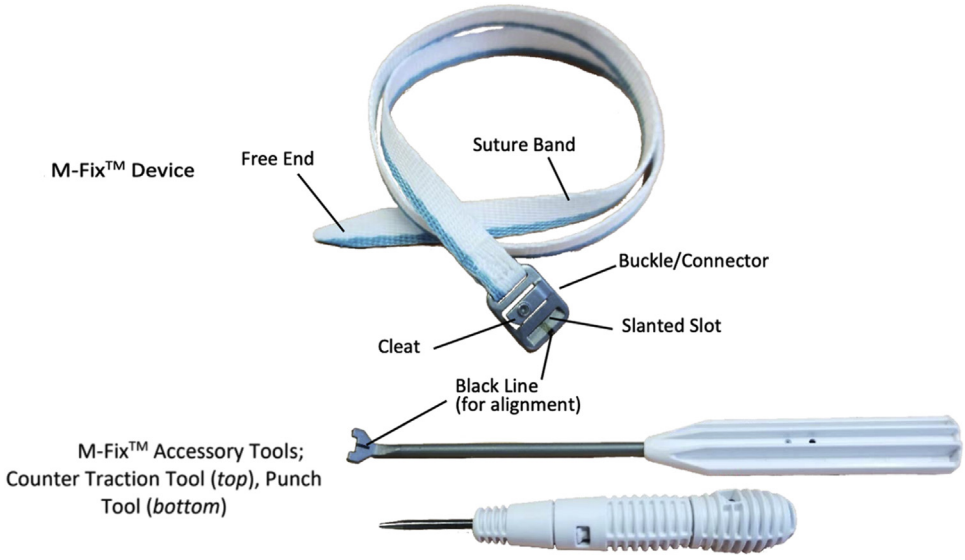

Fig 2. M-Fix (Coracoid Solutions). Implant is woven polyester with an attached metal buckle. This device is passed under the coracoid and clavicle, and it holds provisional fixation, while the reduction can be confirmed radiographically. M-Fix accessory tools include the Countertraction Tool and Punch. The Countertraction Tool is used to reduce the coracoclavicular distance, and the Punch is a tool designed to lock the M-Fix buckle.

used, but care must be taken to visualize the shaver completely and stay on bone. In addition, it may be very helpful to release the coracoacromial ligament from its attachment on the superolateral aspect of the coracoid process. This may help subsequent graft and M-Fix passage.

Mini-Open Exposure of Clavicle

Following arthroscopic coracoid process exposure, a mini-open exposure of the clavicle is performed (Fig 5). A 4-6-cm incision in line with skin lines should be made approximately 4 cm medial to the AC joint (over the AC joint if a chronic case). The clavicle is then exposed by making an incision in the deltotrapezial fascia in line with the clavicle. The clavicle should be exposed anteriorly and posteriorly along its length for several centimeters. It is not necessary to expose the coracoid process. However, it is necessary to make sure that soft tissue has been cleared from the clavicle at the level of the coracoid process. This will facilitate M-Fix passage. At this point, the AC joint should be easily reducible. If it is not, it may be necessary to clear more soft tissue from underneath the clavicle or consider a distal clavicle excision.

Subcoracoid Passage Preparation

The surgeon is now ready to begin the steps for subcoracoid passage of the M-Fix and tendon graft (Figs 6 and 7). The arthroscope is redirected into the glenohumeral joint. Using a 70° scope through the posterior viewing portal or a 30° scope from an anterior portal, the coracoid body is visualized. Care should be taken to ensure that there is a clear path from the clavicle to the coracoid process. A blunt obturator may be used through the mini-open incision to access the coracoid process. The blunt obturator is initially used to confirm proper location of the portal and orientation for the J-Pass. The surgeon then directs the blunt obturator toward the superior aspect of the coracoid. Once the coracoid is encountered, the surgeon should incrementally move the tip of the obturator in a medial direction until it slides down the medial aspect of the coracoid. The obturator should stay in contact with the coracoid during this process. Care is maintained throughout the procedure not to blindly, nor sharply, dissect medial to the coracoid. The orientation and trajectory of the obturator should be noted and later duplicated when directing the J-Pass in a similar fashion. Spinal needle localization should not be

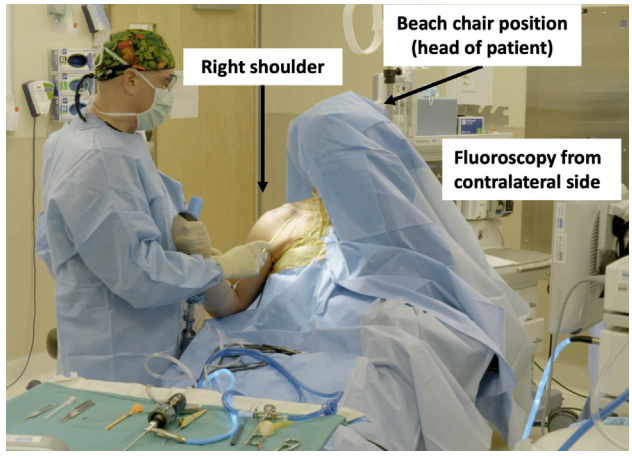

Fig 3. Patient set-up. The patient is placed in the beach chair position. Sterile preparation and draping of the surgical field should allow wide access to the posterior and medial shoulder for arthroscopic portals and the middle third of the clavicle. Ensure adequate access for intraoperative fluoroscopy, typically from the contralateral side.

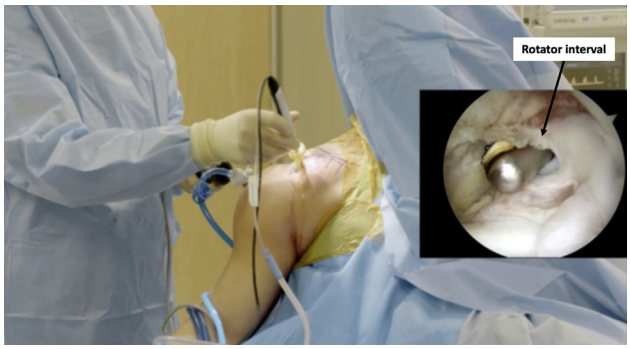

Fig 4. Perform diagnostic arthroscopy. Viewing from the posterior portal and working through the anterior portal, an arthroscopic shaver in combination with radio frequency/electrocautery are used to debride the rotator interval tissue, working in a lateral to medial direction and exposing the coracoacromial ligament.

attempted during this step in the procedure. One should take proper care to use only blunt dissection for this step to avoid any neurovascular injury. It is important to visualize all instruments during this step.

Subcoracoid Passage of Shuttling Suture

Once the surgeon has established a clear path to the coracoid process (Fig 6A), the surgeon then places the J-Pass just medial to the coracoid process. The J-Pass is loaded with no. 2 nonabsorbable suture that will be used to shuttle the M-Fix and graft later in the procedure. The J-Pass is either placed anterior to the clavicle or posterior to the clavicle, based on surgeon preference and ease of passage. If one passes anterior to the clavicle, then it will be necessary to do a separate passage under the clavicle. However, there are times (particularly in larger individuals) when it may be easier to perform subcoracoid passage beginning anterior to the clavicle. When the tip of the J-Pass is visualized arthroscopically below the coracoid (Fig 6B), one may start deploying the passer and suture. It is necessary to make sure that the passer and suture are being passed from medial to lateral at this point. Proper visualization should always be maintained of the passer. If one does not have proper visualization, one should retract the passer, reposition the J-Pass, and ensure that that tip and passer are visualized. Once the tip of the passer is visualized passing beneath the coracoid process, the surgeon should place a suture grasper in the incision lateral to the coracoid process and anterior to clavicle in the deltoid split or use one of the anterior portals (Fig 6C). The surgeon should then release the suture from the attachment on the J-Pass (Fig 6D). If the anterior portal is used, it will be necessary to place a suture retriever lateral to the coracoid process and anterior to the clavicle to retrieve the suture. At this point, the passing suture should be traveling beneath the coracoid with one end exiting medially and one limb passing laterally.

Once subcoracoid passage has been performed (Fig 7), the surgeon may elect to use the passing suture to pass two additional sutures under the coracoid process, as passage of the graft and M-Fix in one step may be difficult. The surgeon should confirm that the passing suture passes easily around the coracoid. Further dissection may be needed to release CA ligament tissue or scar tissue in non-acute cases. This will facilitate smooth passage of the M-Fix and graft.

Passage Under the Clavicle

If the surgeon elects to pass the M-Fix and graft anterior to the clavicle, then a second passage of the passing sutures or graft and M-Fix beneath the clavicle will be required (Fig 8A). The J-Pass can be used to pass a shuttling suture from anterior to posterior beneath the clavicle. Care should be taken to avoid creating a "tissue bridge" during this process. The passing suture may then be used to pass the M-Fix and graft beneath and posterior to the clavicle. It is recommended that the sutures on the medial aspect of the coracoid should be passed under the clavicle. This will allow the M-Fix and graft to be passed from posteromedial to anterolateral, thus recreating the trajectory of the native conoid and trapezoid ligaments. Furthermore, the end of the M-Fix with the buckle should be lateral to the coracoid, as the other "lead" end is easier to pass beneath the clavicle.

Passing the M-Fix and Graft

Once the sutures have been passed around the coracoid process and the clavicle, the M-Fix and graft may be passed (Fig 8B). The graft and the "lead" end of the M-Fix should be passed from the medial side of the coracoid process to the lateral side. The lead end of

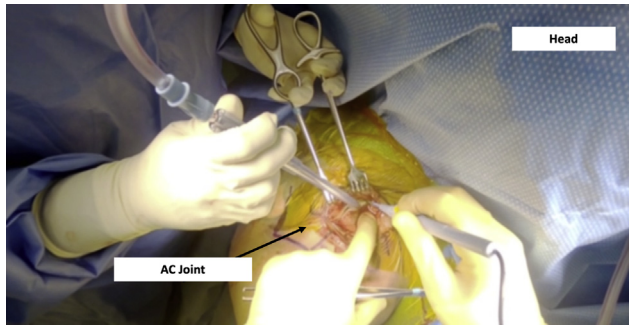

Fig 5. After the coracoid is cleared of soft tissue, the surgeon moves to the open portion of the procedure. A 4-6-cm incision is made approximately 4 cm medial to the acromioclavicular (AC) joint. The clavicle is then exposed by making an incision in the deltotrapezial fascia in line with the clavicle. The clavicle should be exposed anteriorly and posteriorly along its length for several centimeters. Clear the soft tissue from the clavicle at the level of the coracoid process.

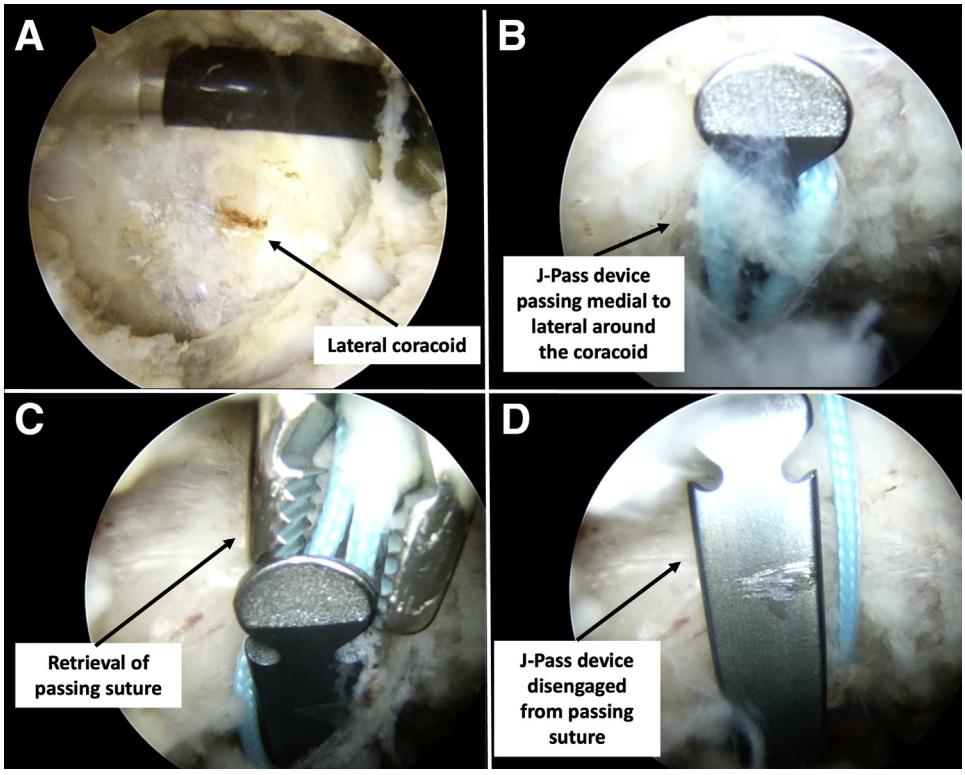

Fig 6. Once the surgeon has established a clear path to the coracoid process (A) and the clavicle using the mini-open approach, the surgeon then places the J-Pass just medial to the coracoid process with the tip of the J-Pass visualized arthroscopically below the coracoid (B). The surgeon should then release the suture from the attachment on the J-Pass. The passing suture is then grasped (C). At this point, the passing suture should be traveling beneath the coracoid with one end exiting medially and one limb passing laterally (D).

the M-Fix should be used for passing to avoid pulling the buckle through soft tissue and under the coracoid process. The M-Fix and graft should be passed in separate steps, using two different sutures. The M-Fix is usually used in conjunction with a soft tissue graft. The graft is whip-stitched on either end with no. 2 nonabsorbable suture. A graft with at least 4 mm in width is used to approximate the normal morphology of the conoid and trapezoid ligaments. The graft should be at least 250 mm in length to allow for passage beneath the coracoid process and over the clavicle and ultimate fixation. Arthroscopic visualization of the subcoracoid passage of the M-Fix and graft ensures that the construct has been placed properly under the coracoid process at its base. If difficulty is encountered with graft passage, one can facilitate passage by shuttling the graft out of the anterior portal and in a subsequent step, grasping the graft from the lateral aspect. This can make the superior passage proceed more smoothly.

AC Reduction and Provisional Fixation

Once the M-Fix and graft have been passed beneath the coracoid and under the clavicle, the AC joint should be reduced, closing the coracoclavicular diastasis. Placing upward pressure on the arm and downward pressure on the clavicle can facilitate reduction of the AC joint. It is emphasized that in chronic cases, soft tissue dissection is typically needed to facilitate reduction. Forcible tension upon the M-Fix to achieve reduction of the coracoclavicular interspace is not advised and may lead to failure or loss of reduction. The lead end of the M-Fix is passed through its slot and below the flange ("diving board") in the buckle (Fig 8, C and D). The traction tool can be used to help maintain reduction and facilitate a secure construct. The laser lines of the traction tool and buckle should align, confirming proper orientation and engagement. The lead

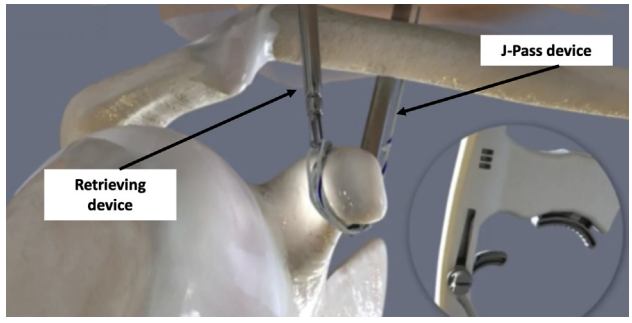

Fig 7. Animation showing the passage of the shuttling suture using the J-Pass device. In this animation the J-Pass is posterior to the clavicle, therefore a second passage around the clavicle is not needed. Once subcoracoid passage has been performed, the surgeon may elect to use the passing suture to pass two additional sutures under the coracoid process, as passage of the graft and M-Fix in one step may be difficult. The surgeon should confirm that the passing suture passes easily around the coracoid.

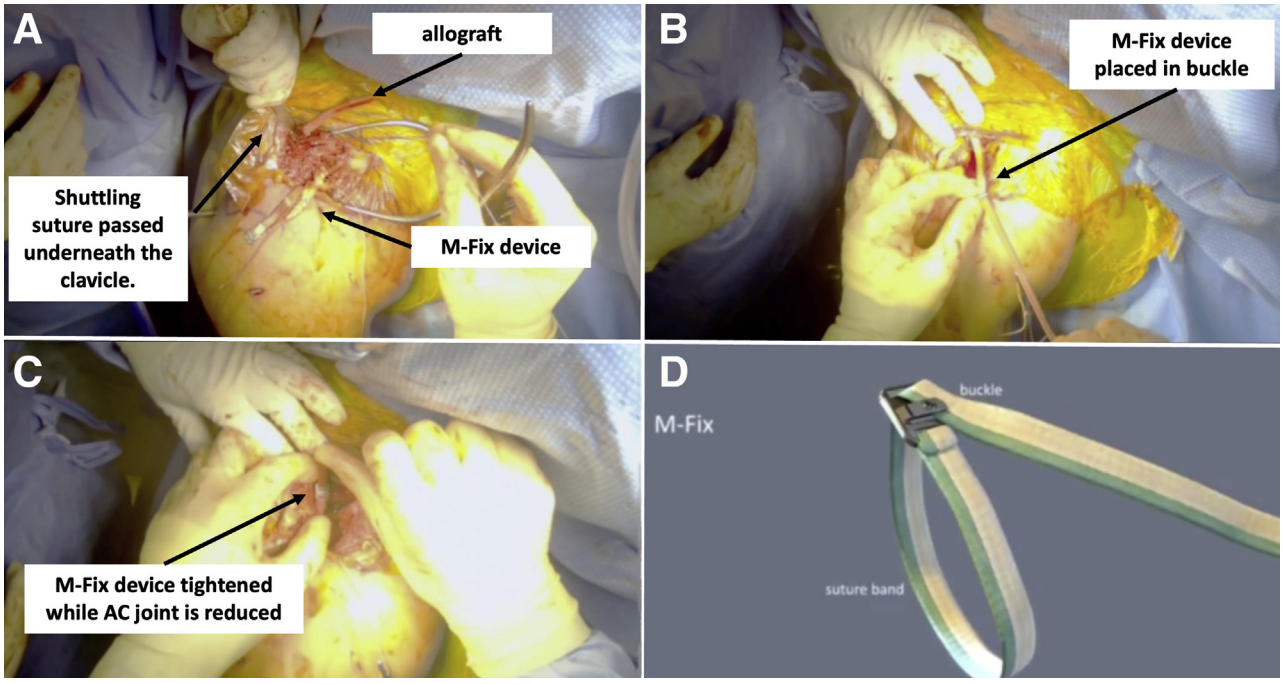

Fig 8. Following passage of the shuttling suture under the coracoid, the suture is then shuttled under the clavicle (A, if the shuttle suture was initially anterior to clavicle). The J-Pass device can be used to pass a shuttling suture from anterior to posterior beneath the clavicle. The sutures on the medial aspect of the coracoid should be passed under the clavicle. The graft and M-Fix device then can be shuttled around the clavicle and coracoid. After the M-fix is passed, the acromioclavicular joint (AC) is reduced the free end of the M-Fix is placed in the buckle (B) and tightened (C). (D) Animation of the free end of the M-Fix being placed in the buckle. If passing a graft, the graft should be whip-stitched on either end with No. 2 nonabsorbable suture. A graft with at least 4 mm in width is used. The graft should be at least 250 mm in length.

end is then tensioned to remove any slack from the system and create a stable construct. The weave is then passed under the flange of the buckle. This will allow for stable provisional fixation and radiographic assessment of the reduction (Fig 9).

Final Fixation of the M-Fix and Graft

Once proper reduction has been confirmed, the tip of the securing punch should be placed in the corresponding dimple in the flange (Fig 10). At this point, the surgeon should place downward pressure on the securing punch. Once a single click is heard, the flange has been secured. It is recommended that the surgeon use two hands to stabilize the securing punch. The leading edge of the flange should be subjacent to the buckle. If not, a second or third deployment of the punch is recommended. The material of the M-Fix beyond the buckle is now cut off. It is recommended to leave approximately 1 cm of band beyond the locked buckle. The weave of the M-Fix is such that there should be little or no fraying of the woven material. The tissue graft may now be fixed to itself. Typically, the graft is sutured onto itself or tied into a knot which is then reinforced with no. 2 nonabsorbable sutures. Once the graft has been secured, the excess ends of the graft are cut.

Fig 9. After the M-Fix is provisionally tightened, fluoroscopy is performed to confirm reduction of the acromioclavicular joint.

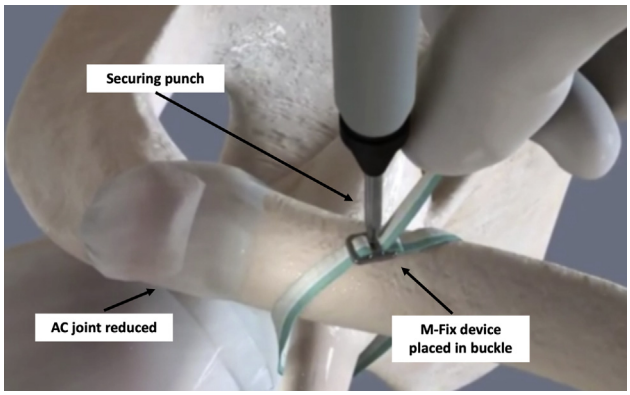

Fig 10. The securing punch should be placed in the corresponding dimple in the flange, and the surgeon should place downward pressure on the securing punch. Once a single click is heard, the flange has been secured. The tissue graft may now be fixed to itself and typically sutured to itself and the excess ends cut (not shown). The incision is then closed.

Closure

A secure, layered closure of the mini-open incision should then be performed. The deltotrapezial fascia is closed over the clavicle. The skin is then closed per surgeon preference.

Postoperative Protocol

The shoulder is protected in a sling (or shoulder cradle) for 6 weeks. Patient education should center on the notion of the surgery being a "resuspension" of the AC joint. Patients should maintain cephalad force on the elbow and arm, avoiding caudal distraction of the coracoclavicular interspace during the first 6 weeks postoperatively. Passive range of motion in the plane of the scapula, pendulums and table slide exercise may be performed during this time. Active range of motion is initiated at 6 weeks. Strengthening is begun at 10−12 weeks and after the patient has achieved full range of motion. Contact sports are discouraged for a minimum of 4-6 months.

Discussion

There are several theoretical advantages of the technique presented in this technical note, including diagnostic glenohumeral arthroscopy, looped woven prosthetic band configuration, and AC joint reduction with buckle and counter traction tool under direct and fluoroscopic visualization. This technique obviates the need for transosseus tunnels in the distal clavicle and coracoid. Short- and long-term outcomes studies will be necessary to determine complication and reoperation rates and to determine the value of this technology, as compared to other currently available techniques.

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