BiPOD Arthroscopic Acromioclavicular Repair Restores Bidirectional Stability

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abstract

Stabilizing the acromioclavicular joint in the vertical and horizontal planes is challenging, and most current techniques do not reliably achieve this goal. The BiPOD repair is an arthroscopically assisted procedure performed with image intensifier guidance that reconstructs the coracoclavicular ligaments as well as the acromioclavicular ligaments to achieve bidirectional stability. Repair is achieved with a combination of 2-mm FiberTape (Arthrex, Naples, Florida) and 20-mm Poly-Tape (Neoligaments, Leeds, England) to achieve rigid repair, prevent bone abrasion, and promote tissue ingrowth. This study is a prospective review of the first 6 patients treated for high-grade acute acromioclavicular injury with the BiPOD technique. The study included 6 men who were 21 to 36 years old (mean, 27 years). At 6-month follow-up, complications were recorded and radiographic analysis was used to determine the coracoclavicular distance for vertical reduction and the amount of acromioclavicular translation on the Alexander axillary view was used to determine horizontal reduction. One patient had a superficial infection over the tape knot. The difference in coracoclavicular distance between the operated side and the uninvolved side was 9±2 mm preoperatively and 0.3±2 mm at 6-month follow-up. On Alexander axillary view, all 6 patients showed stable reduction, which is defined as a clavicle that is in line with the acromion. The findings show that BiPOD acromioclavicular reconstruction restores bidirectional stability of the acromioclavicular joint at 6 months. [*Orthopedics.* 2017; 40(1):e35-e43.]

Acromioclavicular joint injuries are frequent, with an incidence of 3 to 4 per 100,000 in the United States.[1] More than half of all acromioclavicular joint disruptions occur as a result of sports activities, and athletes who participate in contact sports and sports that involve overhead throwing are at highest risk.[2] The most common mechanism of injury is a direct blow to the lateral aspect of the shoulder with an adducted arm. This injury results in anteroinferior translation of the scapula relative to the clavicle. Rockwood[2] expanded Tossy's original classification to 6 grades.

Nonoperative management of low-grade injuries is widely accepted (Rockwood types I and II).[2] Type III injuries can be managed nonoperatively with acceptable results, although some authors have reported continuous pain and weakness.[3] Clinical results are better in patients with radiologic evidence of horizontal stability on follow-up.[4] Therefore, operative treatment may be advisable in young, athletic

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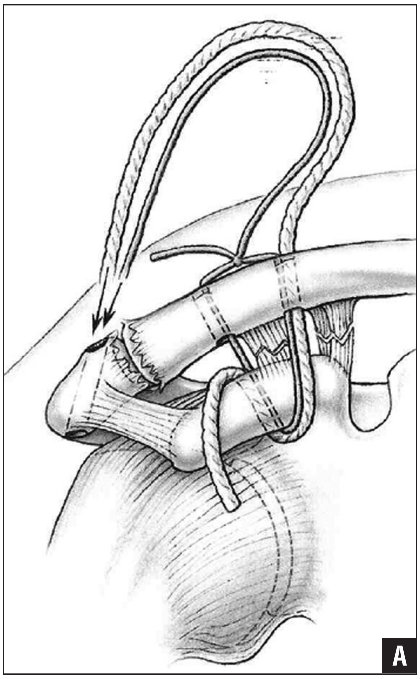

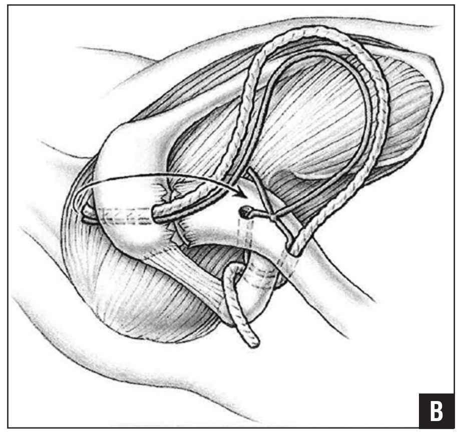

Figure 1: The FiberTape (Arthrex, Naples, Florida) is brought through both tunnels, and the vertical direction is reduced and fixed. The Poly-Tape (Neoligaments, Leeds, England) is brought through only the medial tunnel (A). Both limbs are then passed over the acromioclavicular joint and through the acromion tunnel before the combination is shuttled back to fix the horizontal direction (B). The arrows indicate the passage of the FiberTape and Poly-Tape through the bone tunnels.

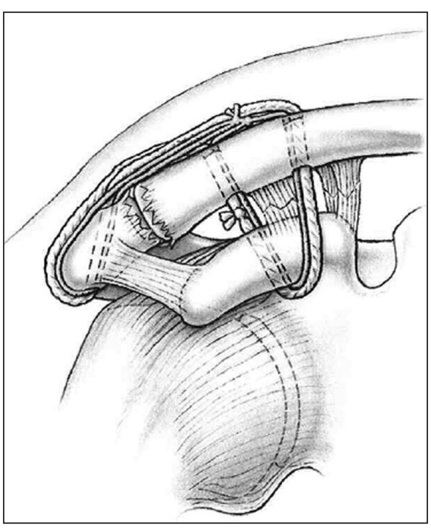

Figure 2: Final configuration of BiPOD acromioclavicular reconstruction. The FiberTape (Arthrex, Naples, Florida) and Poly-Tape (Neoligaments, Leeds, England) are passed vertically and horizontally in different paths to prevent subcutaneous prominence of the Poly-Tape suture knot.

patients and patients with Rockwood type III dislocations and horizontal instability. Weinstein et al[5] showed significantly better results with early stabilization of type III dislocations (<3 weeks postinjury) compared with surgery performed after 3 months. Type IV and type VI injuries involve significant disruption of the deltotrapezial fascia and almost always require operative management.[6,7] Associated traumatic intra-articular lesions, which may benefit from arthroscopic treatment, are found in 15% of patients with high-grade disruptions.[8]

The goals of operative management of acromioclavicular joint disruption are to restore normal anatomy, obtain full return of function and strength, and improve the cosmetic appearance of the shoulder girdle.[9] Where possible, treatment should avoid the morbidity associated with autografts and should be managed with a single procedure. Functional results after acromioclavicular stabilization have been correlated to the adequacy of reduction achieved at final follow-up, with coracoclavicular distance of less than 5 mm achieving better Constant scores than coracoclavicular distance of greater than 10 mm.[6] None of the procedures described to date achieve all of these goals.

This article reports a new technique for arthroscopically assisted stabilization of acromioclavicular joint disruption with a combination of 2-mm ultra–high-weight polyethylene-polyester tape (FiberTape; Arthrex, Naples, Florida) and 20-mm open-weave polyester tape (Poly-Tape; Neoligaments, Leeds, United Kingdom). This repair has 2 distinct limbs, addressing both the coracoclavicular and acromioclavicular ligaments, and therefore is known as "BiPOD" repair (**Figures 1-2**). This procedure is intended to restore both vertical and horizontal instability. The FiberTape provides the required stiffness to the repair, and the Poly-Tape is placed to prevent abrasion and provide a scaffold for fibrous tissue ingrowth.[10] The procedure is minimally invasive, with image intensifier control, and does not require secondary hardware removal.

The goal of this study was to present the technique and evaluate early clinical and radiographic results in the first 6 patients undergoing this procedure for acute acromioclavicular joint dislocation. The authors hypothesized that this anatomic reconstruction leads to better functional results, compared with other techniques as well as with nonoperative management, by restoring radiographic horizontal and vertical stability of the acromioclavicular joint.

Surgical Technique

Surgical Approach

Surgery is performed in the beach chair position with the use of a Spider limb positioner (Smith & Nephew, Andover, Massachusetts). The anatomic landmarks are drawn after standard preparation and draping. A 3-cm sagittal saber incision is placed 3 cm medial to the acromioclavicular joint, with full-thickness skin flaps. The deltotrapezial raphe is identified and incised. Epiperiosteal dissection is performed to the anterior and posterior borders of the clavicle. Limited release of the anterior deltoid fibers just above the coracoid is performed in a 20- to 40-mm interval measured from the acromioclavicular joint (**Figures 3-4**).

Preparation of the Coracoclavicular Ligament Tunnel

The ideal positions of the coracoclavicular ligament insertions and subsequent drill sites for the trapezoid and conoid tunnels are marked at 24 mm and 44 mm from the acromioclavicular joint, respectively. It is important to ensure the central position of the tunnel sites on the clavicle in the anteroposterior direction. The location of these tunnels matches the location of the coracoclavicular ligaments, as shown by Rios et al.[11] A 4.5-mm drill is used to create a first tunnel 24 mm medial to the acromioclavicular joint, angling 30° from posterosuperior to anteroinferior, with a 45° medial tilt toward the coracoid, re-creating the axis of the trapezoid ligament. The second conoid tunnel is drilled 44 mm from the acromioclavicular joint, angling 30° from posterosuperior to anteroinferior. Structures on the undersurface of the clavicle are protected with a blunt subtilis bone lever Hohmann (Accuratus AG, Berne, Switzerland) during drilling. A Richard-Allan needle (3/8 Circle Trocar Point May Catgut; Aspen Surgical, Caledonia, Michigan) is then used backward to pass a No. 2 FiberWire (Arthrex) through the conoid tunnel around the anterior edge of the clavicle. The ends are clipped to allow subsequent shuttling of FiberTape and Poly-Tape. This step is repeated with passage of 2 No. 2 FiberWires through the trapezoid tunnel for subsequent shuttling.

Arthroscopically Assisted Preparation of the Coracoid

Arthroscopic evaluation of the shoulder is completed with a 70° scope with a standard posterior portal. Clinically relevant glenohumeral lesions are treated.[8] An anterolateral portal is created under direct vision just above the subscapularis and medial to the biceps pulley, angling toward the undersurface of the coracoid. The rotator interval is cleared with electrocautery, and the undersurface of the coracoid is visualized with a 70° arthroscope. The undersurface of the coracoid is cleared of soft tissue with electrocautery. Care is taken to avoid the fat medial to the coracoid to protect important neurovascular structures, including the brachial

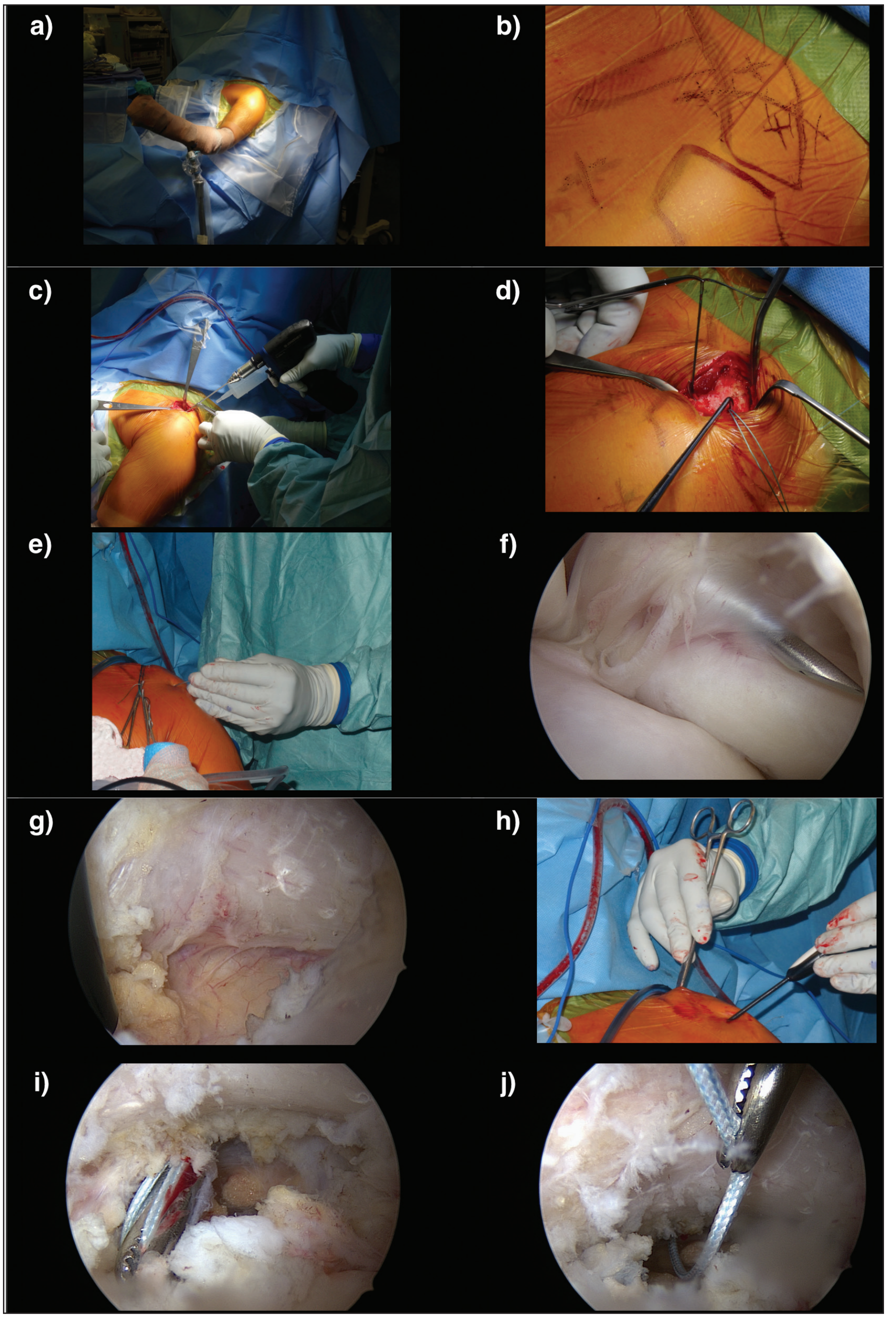

Figure 3: Placement in the beach chair position with a Spider limb positioner (Smith & Nephew, Andover, Massachusetts) (A). Saber skin incision 3 cm medial to the acromioclavicular joint (B). Drilling of the trapezoid and conoid tunnels (C). Passage of shuttling sutures through the coracoclavicular ligament tunnels and around the anterior aspect of the clavicle (D). Arthroscopic evaluation of the shoulder, with creation of an anterolateral working portal (E, F). Subcoracoid soft tissue clearance with a 70° arthroscope in the posterior portal and electrocautery in the anterolateral portal (G). Passage of the shuttling suture around the coracoid with an O'Shaughnessy clamp (Gemini 200-mm dissecting forceps; Aesculap, Tuttlingen, Germany) through the wound (H). Arthroscopic view of the shuttling suture passed on the medial side of the coracoid and then picked up on the lateral side of the coracoid to complete the loop (I, J).

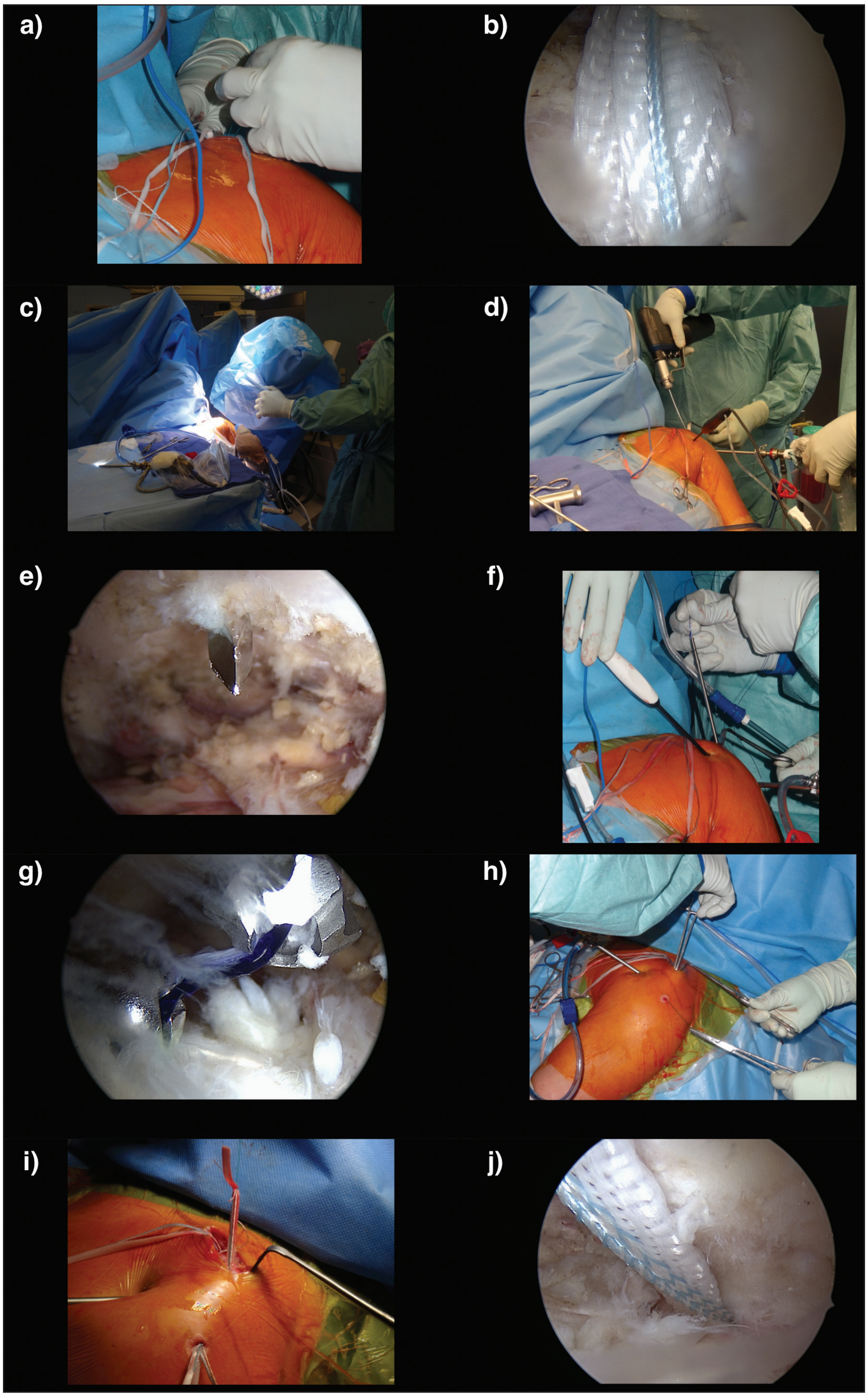

Figure 4: Shuttling of FiberTape (Arthrex, Naples, Florida) and Poly-Tape (Neoligaments, Leeds, England) around the coracoid and through the coracoclavicular ligament tunnels (A, B). Reduction of the acromioclavicular joint with image intensifier guidance to restore vertical stability (C). Drilling of the K-wire through the acromion and into the subacromial space under arthroscopic guidance (D). Overdrilling of the K-wire with a cannulated drill bit and passage of a polydioxanone shuttling suture into the subacromial space (E, F). Passage of the polydioxanone shuttling suture through the acromial tunnel and around the lateral border of the acromion into the subcutaneous space (G, H). Shuttling of the definitive combination of FiberTape and Poly-Tape through and around the acromion to restore horizontal stability (I, J).

plexus and the suprascapular nerve. The coracoacromial ligament is preserved, but the coracohumeral ligament, which is deep and posterior to the coracoacromial ligament, can be debrided. Once the undersurface of the coracoid is cleared, a long O'Shaughnessy clamp (Gemini 200-mm dissecting forceps; Aesculap, Tuttlingen, Germany) is used to pass a No. 2 FiberWire from the anterior aspect of the clavicle via the wound around the medial aspect of the coracoid under arthroscopic guidance. This shuttling suture is grasped from the anterolateral portal. The long O'Shaughnessy clamp is passed through the open wound around the lateral aspect of the coracoid to pick up the No. 2 FiberWire and complete its loop around the coracoid.

Passage of FiberTape and Poly-Tape

The definitive combination of FiberTape and Poly-Tape is then tied to the medial end of the No. 2 FiberWire and shuttled around the coracoid. The combination of FiberTape and Poly-Tape is then passed through the conoid (medial) tunnel with the previously placed No. 2 FiberWire (**Figure 1**). Only the FiberTape is then shuttled through the trapezoid (lateral) tunnel, and the Poly-Tape is left behind so that it can be tied under the clavicle (**Figure 2**). The previously passed second No. 2 FiberWire shuttle suture remains in situ for later passage of the Poly-Tape from above the clavicle to its undersurface once it has been looped through the acromion.

Reduction and Vertical Stabilization of the Acromioclavicular Joint

The acromioclavicular joint is slightly overreduced (2 mm) with an anteroinferior force under image intensifier guidance, and the 2 ends of the FiberTape are tied to maintain reduction and restore vertical stability. This overreduction is necessary because previous biomechanical data showed that the construct loosens approximately 2 mm in the first 20 cycles. The ends are not cut short. The lateral end is trimmed shorter than the medial end of the tied FiberTape, and both are clipped to the Poly-Tape that has already passed through the conoid (medial) tunnel for passage through the acromion.

Arthroscopically Assisted Acromial Tunneling

The subacromial space is visualized through a lateral portal with a 30° arthroscope. Subacromial decompression is performed via the anterolateral working portal. A K-wire is inserted into the center of the acromion at least 1 cm lateral to the acromioclavicular joint through the saber incision under arthroscopic guidance. A cannulated 4.5-mm drill bit is used to overdrill the K-wire. A polydioxanone suture (PDS II; Ethicon, Somerville, New Jersey) is passed through the cannulated drill bit into the subacromial space. The polydioxanone suture is grasped through the anterolateral working portal. The arthroscope is then swapped into the posterior portal. An O'Shaughnessy clamp is used to enter the subacromial space from the lateral edge of the acromion via the wound. The polydioxanone suture is grasped and pulled around the lateral edge of the acromion into the subcutaneous space.

Passage of FiberTape and Poly-Tape

The Poly-Tape and the medial (longer) end of the previously tied FiberTape are then tied to the polydioxanone suture and shuttled into the subacromial space via the acromion tunnel and around its lateral edge. Then the medial (longer) end of the FiberTape is tied to the previously tied lateral (shorter) end of the FiberTape over the clavicle. The acromial end of the Poly-Tape is then passed through the trapezoid tunnel and into the subclavicular position with the previously placed No. 2 FiberWire shuttle suture.

Reduction and Horizontal Stabilization of the Acromioclavicular Joint

The ends of the Poly-Tape are tied under the clavicle to complete the BiPOD acromioclavicular joint reconstruction. The differential paths of the suture limbs prevent subcutaneous prominence of the suture knots, especially the Poly-Tape. This second limb prevents horizontal displacement of the clavicle at the acromioclavicular joint and further reinforces the vertical reduction. Confirmation of the horizontal component of the reduction is done by clinical palpation of the acromioclavicular joint before both tapes are cut. The wound is closed in layers, with repair of the deltotrapezial fascia. The key steps in successful BiPOD acromioclavicular joint reconstruction are listed in **Table 1**.

Table 1

Tips and Tricks for Successful BiPOD Acromioclavicular Joint Reconstruction

Plan the skin incision with the trapezoid and conoid tunnels in mind.
Take off the anterior deltoid fibers in a small area just above the coracoid to allow passage of the sutures.
Drill the trapezoid and conoid tunnels 24 mm and 44 mm, respectively, from the acromioclavicular joint, and place a needle in the acromioclavicular joint as a marker.
Place 1 shuttling suture in the conoid tunnel and 2 shuttling sutures in the trapezoid tunnel.
Use a Richard-Allan needle (3/8 Circle Trocar Point May Catgut; Aspen Surgical, Caledonia, Michigan) backward or a curved suture passer to place the shuttling sutures into the tunnels with a blunt subtilis bone lever Hohmann (Accuratus AG, Berne, Switzerland) placed to protect the subclavicular structures.
Use a 70° arthroscope to aid visualization of the subcoracoid region.
Create an anterolateral portal that allows easy access to the coracoid.
Do not enter the fat medial to the coracoid to protect the neurovascular structures.
Preserve the coracoacromial ligament.
Pass the shuttling suture around the coracoid under arthroscopic guidance through the wound.
Both the FiberTape (Arthrex, Naples, Florida) and the Poly-Tape (Neoligaments, Leeds, England) go through the conoid tunnel, but only the FiberTape goes through the trapezoid tunnel initially (Figure 1).
Overreduce the acromioclavicular joint by 2 mm with an anteroinferior force under image intensifier guidance before tying knots to maintain vertical stability.
Insert a K-wire into the center of the acromion under arthroscopic guidance at least 1 cm from the lateral edge to prevent fracture.
Pass a shuttling suture through a cannulated drill bit into the subacromial space.
Shuttle FiberTape and Poly-Tape through the acromion tunnel into the subacromial space and then around the lateral edge of the acromion into the wound.
Ensure that the Poly-Tape is shuttled through the trapezoid tunnel and into the subclavicular space before tying it under the clavicle to prevent knot prominence and irritation.

Postoperative Protocol

The shoulder is immobilized for 6 weeks in adduction. Physiotherapy begins early, with passive and active assisted range of motion, with flexion and abduction limited to 60° for 3 weeks and gradually increasing to 90° between 3 and 6 weeks. Patients cannot perform activities that stress the acromioclavicular joint for the first 12 weeks. No weights are allowed during the first 6 weeks. Heavy lifting resumes at 12 weeks.

Table 2

BiPOD Arthroscopically Assisted Acromioclavicular Joint Repair: Indications and Contraindications

Indications	Contraindications
Acute acromioclavicular joint dislocation (<3 weeks)	Chronic acromioclavicular joint dislocation (>3 weeks)
Grade III, IV, or V acromioclavicular joint dislocation	Acromioclavicular joint arthritis
Clinically reducible acromioclavicular joint preoperatively	Clinically irreducible acromioclavicular joint preoperatively
	Grade VI acromioclavicular joint dislocation

Materials and Methods

Prospective follow-up of the first 6 consecutive patients who underwent the BiPOD procedure from June 2011 to October 2012 was performed. One patient had a Rockwood type IV disruption, and 5 had a type V injury.[2] Injuries resulted from a winter sport accident (ski or snowboard) in 3 patients and a road traffic accident (bicycle or motorcycle) in the remaining 3 patients. All 6 patients were men, with mean age of 27 years (range, 21-36 years).

Preoperative clinical assessment confirmed the reducibility of the acromioclavicular joint in all patients; the senior authors (J.D., M.A.Z.) consider this a prerequisite for successful stabilization with this technique. Initial radiographs included a true anteroposterior view of the affected shoulder, bilateral axillary views, and bilateral anteroposterior stress (Zanca) views with a 10-kg load. Diagnosis of type III dislocation was confirmed on stress views by a 25% to 100% increase in coracoclavicular distance, and type V injury was confirmed when the coracoclavicular distance was increased by 100% to 300% compared with the opposite shoulder on anteroposterior stress views. Indications for BiPOD acromioclavicular joint reconstruction and contraindications to this procedure are listed in **Table 2**.

Approval for the study was obtained from the institutional review board. Informed consent was obtained for all patients, including use of data for research purposes. All procedures were performed by 1 of the 2 senior authors (J.D., M.A.Z.) at their respective institutions.

Patients were reviewed at regular intervals, and final follow-up occurred 6 months postoperatively. Radiographic evaluation was performed by a single examiner (S.R.) other than the operating surgeon. All complications were recorded. Radiographic series of the shoulder, including a panoramic view in the anteroposterior plane and an axillary Alexander view, were obtained pre- and postoperatively and at final follow-up. Vertical stability was assessed with coracoclavicular distance (distance between the inferior rim of the clavicle and the superior rim of the coracoid). Horizontal stability was assessed, as previously described, with Alexander views.[12] Stable reduction was defined as a clavicle found to be in line with the acromion. Subluxation was defined as a distance to the acromion of less than 1 clavicle shaft width, and dislocation was defined as a distance of more than 1 width of the clavicle.

Nonparametric statistical analysis was performed with SPSS version 18.0 software (SPSS, Chicago, Illinois). Data are represented as mean and standard deviation. Mean values were compared with the Wilcoxon test for paired groups for continuous variables, and chi-square test or Fisher's exact test was used for categorical variables. A difference of $P<.05$ was considered statistically significant.

Results

Six men (mean age, 27 years; range, 21-36 years) were treated surgically a mean of 9 days after injury (range, 3-18 days). Mean surgical time was 90 minutes (range, 75-105 minutes). All patients were followed for a minimum of 6 months (mean, 7.4 months; range, 6.3-8.7 months). No patients were lost to follow-up. No intraoperative complications were recorded. One reoperation was performed because of an early infection that was debrided and treated with oral antibiotics.

Coracoclavicular distance on the involved side improved from 21±5 mm preoperatively to 13±6 mm at 3 months and 14±6 mm at the last follow-up ($P<.001$). The difference in coracoclavicular distance between the operated side and the uninvolved side was 9±2 mm preoperatively and 0.3±2 mm at 6-month follow-up. On Alexander view, all 6 patients showed stability, which was defined as a clavicle that was in line with the acromion.

Discussion

The BiPOD technique restores bidirectional stability of the acromioclavicular joint. Arthroscopic assistance allows a minimally invasive procedure with visualization of the coracoid process. Image intensifier control ensures that maximum correction is achieved at surgery. The FiberTape provides stiffness to the repair, and the Poly-Tape prevents cutout through the bones and provides a scaffold for fibrous ingrowth, augmenting the repair. The use of synthetic materials avoids donor site morbidity associated with autologous grafts, and there is no need for hardware removal. The advantages of the BiPOD acromioclavicular joint reconstruction are summarized in **Table 3**.

Early results showed excellent radiographic outcomes. All patients showed improvement, and 1 infection was reported in the first patient. This patient had a lengthier surgery and a knot tied on top of the clavicle, increasing the risk of infection.[13] This study is limited by small numbers and short follow-up. Long-term complications, such as ligamentous calcification or acromioclavicular osteoarthritis, could not be assessed, although these may occur as a consequence of the initial injury. These complications include residual subluxation and subsequent loss of reduction, or a combination of these. The senior authors (J.D., M.A.Z.) have since performed more than 45 BiPOD procedures for both acute and chronic injuries. These patients are being followed and will be described in a subsequent report.

A variety of techniques have been described to repair or reconstruct the acromioclavicular joint after a high-grade injury (Rockwood type III or VI). None of the approximately 70 procedures proposed can claim to be the gold standard that restores normal function and appearance of the shoulder. Complication rates with many of these techniques are high. A variety of implants have been used for stabilization. They include K-wires, the Bosworth screw, Hook plates, autologous ligament graft, synthetic prosthetic ligaments, and both open and arthroscopically assisted synthetic coracoclavicular augmentation. K-wire fixation is complicated by early degenerative changes and migration,[14] with potentially disastrous consequences.[15] Leidel et al[16] reported long-term outcomes of temporary K-wire fixation. Although the functional results were generally good, 4% of patients had K-wire migration and 11% had secondary acromioclavicular dislocation. Tsou[17] reported a technical failure rate of 32% in a series of 53 patients who underwent fixation with a Bosworth screw. Weitzman[18] reported loss of reduction in 16% of patients treated with a Bosworth screw. In addition, both techniques require routine implant removal.[9]

Table 3

Advantages of BiPOD Reconstruction

Procedure restores vertical and horizontal stability of the acromioclavicular joint
Arthroscopic assistance allows a minimally invasive procedure, with visualization of the coracoid process
Image intensifier control ensures maximum correction at surgery
FiberTape (Arthrex, Naples, Florida) provides stiffness to the repair, and Poly-Tape (Neoligaments, Leeds, England) prevents cutout through the bones
Procedure avoids the donor site morbidity associated with autologous grafts
Procedure eliminates the need for secondary hardware removal

The Hook plate provides rigid fixation across the acromioclavicular joint and enhances horizontal stability of the clavicle. In a nonrandomized study, Gstettner et al[3] showed better results with a Hook plate and open suturing of the coracoclavicular ligaments compared with conservative management of Rockwood type III injuries. They reported an 11% complication rate, including 1 plate that cut through the acromion. Although no loss of reduction was reported, all patients required routine implant removal at 12 weeks. In a series of 16 patients treated for acute and chronic disruptions, Ejam et al[19] reported 2 patients with an unstable distal end of the clavicle after plate removal and 1 patient with plate displacement after 3.5 months that required early implant removal.

Bhattacharya et al[20] used a custom-designed braided polyester looped ligament fixed to the clavicle with a screw in open procedures for chronic acromioclavicular joint disruption combined with distal clavicle excision. In their series of 11 patients, 1 had ligament rupture and 4 showed screw loosening on radiographs; coracoclavicular distance was not reported. In 11 similarly treated patients, Jeon et al[21] reported 1 moderate subluxation (increased coracoclavicular distance of 4-8 mm) and 1 dislocation, in addition to 1 patient who had a fracture of the base of the coracoid and 2 patients who required further procedures. Although these procedures were performed for chronic disruption, the technique can be used for acute disruption as well.

Lädermann et al[7] performed open stabilization that combined augmented repair of both coracoclavicular and acromioclavicular ligaments. In their series, patients had 4 Ethibond No. 6 sutures (Ethicon) passed around the base of the coracoid and sutured through 2 holes in the clavicle and further cerclage of the acromioclavicular joint with 2 Ethibond No. 6 sutures in the anteroposterior plane passed through drill holes in the distal clavicle and acromion. In these open repairs performed without image intensifier control, 40% of acromioclavicular joints showed radiographic evidence of subluxation or dislocation at final follow-up. Greiner et al[6] reported a coracoclavicular cerclage technique performed with 7.5-mm polydioxanone tape. These authors reported very high clinical satisfaction, correlated to the degree of reduction. In their series, 14% of patients had an increase in coracoclavicular distance of 5 to 10 mm, and 6% had an increase of greater than 10 mm. A variation of this technique by Dimakopoulos et al[22] used 4 Ethibond Excel No. 5 sutures (Ethicon), and both halves of the open coracoclavicular cerclage repair were channeled in front of and behind the clavicle to add horizontal stability. In that study, 5% of patients had documented loss of reduction of less than

50% of the width of the clavicle. Weinstein et al[5] reported 15% loss of reduction of less than the width of the clavicle in 27 acute type III injuries treated with a variation of coracoclavicular cerclage.

Arthroscopically assisted coracoclavicular repair with image intensifier control performed with a double TightRope (Arthrex) was recently advocated, and this technique does not require a secondary procedure.[4,23] However, Salzmann et al[23] reported unacceptable alignment of the acromioclavicular joint in 34% of patients in the coronal plane, the axillary plane, or both. Scheibel et al[4] reported signs of posterior instability in 42.9% of patients treated with a similar technique. The double TightRope arthroscopic technique does not address horizontal plane instability that is also present in acromioclavicular joint disruptions, and Scheibel et al[4] now add percutaneous acromioclavicular cerclage to coracoclavicular stabilization under image intensifier control.

Several studies have shown the safe use of synthetic braided polyester prosthetic ligaments, such as Surgilig, in acromioclavicular joint reconstruction.[20,21,24] More than 11,000 have been implanted worldwide for acromioclavicular joint reconstruction. A recent retrieval study examined the biologic response to failed extra-articular polyester ligaments used for acromioclavicular joint reconstruction of the shoulder girdle.[25] This study analyzed the histologic features of 5 implants retrieved from 5 patients over the past 7 years. Routine analysis was carried out in all 5 cases, and immunohistochemical analysis was performed in 1. The device acts as a scaffold for connective tissue and forms an investing fibrous pseudoligament. The immunologic response at the histologic level is favorable, with limited histiocytic and giant cell response to 1-μm wear particles. The connective tissue envelope around the implant is less organized than a native ligament. The implants provide strong, nonrigid support for the acromioclavicular joint and allow clavicular rotation during elevation of the arm.[20]

Conclusion

The goals of treatment in acromioclavicular joint dislocations are to restore normal anatomy, obtain full return of function and strength, and re-establish the normal appearance of the shoulder.[9] The BiPOD technique may achieve these 3 goals. A forthcoming study with a larger group of patients and longer follow-up will address the limitations of this study and provide further evidence to determine whether this technique is a superior treatment to other surgical techniques for acromioclavicular joint disruption.

References

1. Kocher MS, Dupré MM, Feagin JA Jr. Shoulder injuries from alpine skiing and snowboarding: aetiology, treatment and prevention. *Sports Med.* 1998; 25(3):201-211.
2. Rockwood CA Jr. Injuries to the acromioclavicular joint. In: Rockwood CA Jr, Green DP, Wilkins KE, King Re. *Fractures in Adults.* 2nd ed. Philadelphia, PA: JB Lippincott; 1984:860-910, 974-882.
3. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. *J Shoulder Elbow Surg.* 2008; 17(2):220-225.
4. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med.* 2011; 39(7):1507-1516.
5. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. *Am J Sports Med.* 1995; 23(3):324-331.
6. Greiner S, Braunsdorf J, Perka C, Herrmann S, Scheffler S. Mid to long-term results of open acromioclavicular-joint reconstruction using polydioxansulfate cerclage augmentation. *Arch Orthop Trauma Surg.* 2009;129(6):735-740.
7. Lädermann A, Grosclaude M, Lübbeke A, et al. Acromioclavicular and coracoclavicular cerclage reconstruction for acute acromioclavicular joint dislocations. *J Shoulder Elbow Surg.* 2011; 20(3):401-408.
8. Pauly S, Gerhardt C, Haas NP, Scheibel M. Prevalence of concomitant intraarticular lesions in patients treated operatively for high-grade acromioclavicular joint separations. *Knee Surg Sports Traumatol Arthrosc.* 2009; 17(5):513-517.
9. Powers JA, Bach PJ. Acromioclavicular separations: closed or open treatment? *Clin Orthop Relat Res.* 1974; 104:213-223.
10. Amis AA, Camburn M, Kempson SA, Radford WJ, Stead AC. Anterior cruciate ligament replacement with polyester fibre: a long-term study of tissue reactions and joint stability in sheep. *J Bone Joint Surg Br.* 1992; 74(4):605-613.
11. Rios CG, Arciero RA, Mazzocca A. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. *Am J Sports Med.* 2007; 35(5):811-817.
12. Alexander OM. Dislocation of the acromioclavicular joint. *Radiography.* 1949; 15(179):260.
13. Neault MA, Nuber GW, Marymont JV. Infections after surgical repair of acromioclavicular separations with nonabsorbable tape or suture. *J Shoulder Elbow Surg.* 1996; 5(6):477-478.
14. Lindsey RW, Gutowski WT. The migration of a broken pin following fixation of the acromioclavicular joint: a case report and review of the literature. *Orthopedics.* 1986; 9(3):413-416.
15. Lyons FA, Rockwood CA Jr. Migration of pins used in operations on the shoulder. *J Bone Joint Surg Am.* 1990; 72(8):1262-1267.
16. Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. *J Trauma.* 2009; 66(6):1666-1671.
17. Tsou PM. Percutaneous cannulated screw coracoclavicular fixation for acute acromioclavicular dislocations. *Clin Orthop Relat Res.* 1989; 243:112-121.
18. Weitzman G. Treatment of acute acromioclavicular joint dislocation by a modified Bosworth method: report on twenty-four cases. *J Bone Joint Surg Am.* 1967; 49(6):1167-1178.
19. Ejam S, Lind T, Falkenberg B. Surgical treatment of acute and chronic acromioclavicular dislocation Tossy type III and V using the Hook plate. *Acta Orthop Belg.* 2008; 74(4):441-445.
20. Bhattacharya R, Goodchild L, Rangan A. Acromioclavicular joint reconstruction using the Nottingham Surgilig: a preliminary report. *Acta Orthop Belg.* 2008; 74(2):167-172.
21. Jeon IH, Dewnany G, Hartley R, Neumann L, Wallace WA. Chronic acromioclavicular separation: the medium term results of coracoclavicular ligament reconstruction using braided polyester prosthetic ligament. *In-*

jury. 2007; 38(11):1247-1253.

22. Dimakopoulos P, Panagopoulos A, Syggelos SA, Panagiotopoulos E, Lambiris E. Double-loop suture repair for acute acromioclavicular joint disruption. *Am J Sports Med.* 2006; 34(7):1112-1119.

23. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. *Am J Sports Med.* 2010; 38(6):1179-1187.

24. Kumar V, Garg S, Elzein I, Lawrence T, Manning P, Wallace WA. Modified Weaver-Dunn procedure versus the use of a synthetic ligament for acromioclavicular joint reconstruction. *J Orthop Surg (Hong Kong).* 2014; 22(2):199-203.

25. Kocsis G, McCulloch TA, Thyagarajan D, Wallace WA. The biological response to a failed extra-articular polyester ligament used for AC joint reconstruction at the shoulder girdle: a retrieval analysis of five cases. *Bone Joint J.* 2015; 97-B(1):83-88.