Continuous Loop Double Endobutton Reconstruction for Acromioclavicular Joint Dislocation

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Background: Current anatomic methods for reconstruction of the dislocated acromioclavicular (AC) joint show improved clinical results but continue to be associated with significant rates of fixation loss and complications, limiting more widespread use.

Purpose: To determine the long-term clinical and radiologic outcomes of a novel surgical technique using a closed-loop double Endobutton device to reconstruct both acute and chronic dislocations.

Study Design: Case series; Level of evidence, 4.

Methods: Between 2003 and 2012, a total of 35 patients (31 men, 4 women) at a mean age of 42 years (range, 25-70 years) were surgically treated for a Rockwood type III or greater AC joint dislocation with the described technique (26 chronic, 9 acute). Imbrication of the AC joint capsule and deltotrapezial fascia was performed in all patients. Biological bridging across the coracoclavicular (CC) interval was performed in all patients by use of coracoacromial (CA) ligament transfer in 28 patients and primary repair of the CC ligament in 7 patients. Complete follow-up information was obtained for 31 of 35 patients.

Results: At a mean follow-up of 5.2 years (range, 27-144 months), the construct remained stable in all but 1 patient. The mean CC interval difference was 1.1 mm (range, –2.5 to 4.0 mm) and was <2 mm in 87% of patients. The mean Constant score was 98; the mean University of California, Los Angeles Shoulder Rating Scale score was 34; and the mean American Shoulder and Elbow Surgeons Shoulder Score was 98. Follow-up MRI evaluation in 10 patients consistently demonstrated a wide band of dense scar tissue between the coracoid and clavicle. No infections, fractures, or perioperative complications occurred.

Conclusion: Excellent results were obtained and maintained over long-term follow-up. The continuous loop device eliminated the possibility of knot slippage or breakage. MRI confirmed a robust healing response. The described technique resulted in outcomes that were significantly superior to historical reports of nonsurgical outcomes, and the technique can be recommended both for acute and chronic dislocations.

Keywords: shoulder; acromioclavicular joint

Traumatic injury to the acromioclavicular (AC) joint is a common orthopaedic problem that accounts for 9% of all shoulder injuries.[32] Recent epidemiological studies suggest that the incidence of complete dislocations (Rockwood types III, IV, V, or VI) is nearly 60,000 new cases per year in the United States.[9] Without surgical intervention, the biomechanical and cosmetic consequences of the injury are permanent. This results in unsatisfactory outcomes in 20% of cases, with at least 40% of patients reporting significant residual symptoms.[39,52] Traditional techniques such as the Weaver-Dunn have not consistently demonstrated outcomes that are superior to those of nonoperative treatment.[28] As a result, current surgical indications have been restricted to patients with very high-grade injuries, patients for whom nonsurgical treatment has failed, and high-demand patients.

Numerous biomechanical studies in recent years have led to the development of techniques that stabilize the AC joint complex with fixation that more closely approximates the natural anatomic structure.[15,20,33,45] These anatomic techniques are designed to maintain reduction while allowing normal movement of the joint. The weight of the arm and physiologic forces, however, place significant translation forces in all 3 planes (vertical, anterior-posterior, and axial) that work to disrupt the repair. Long-term stability requires that the initial fixation is strong enough to maintain reduction throughout the biological healing process. Reconstructions using either

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TABLE 1
Patient Demographic Information, Historical Findings, and Surgical Details[a]

	All ACJR (N = 35)	Acute ACJR (n = 9)	Chronic ACJR (n = 26)
Age, mean (range), y	42.4 (25-70)	45.7 (25-55)	41.2 (25-70)
Sex			
Male	31 (88)	8 (89)	23 (88)
Female	4 (12)	1 (11)	3 (12)
Injured side			
Right	18 (51)	5 (56)	13 (50)
Left	17 (49)	4 (44)	13 (50)
Arm dominance			
Right	32 (91)	8 (91)	24 (92)
Left	3 (9)	1 (9)	2 (8)
Interval to surgery, mean (range), d	196 (4-1096)	13 (4-25)	265 (29-1096)
Rockwood grade			
III	19 (54)	5 (56)	14 (54)
IV	2 (6)	1 (11)	1 (4)
V	14 (40)	3 (33)	11 (42)
Payer			
Private insurance	24 (69)	8 (89)	16 (62)
No fault	8 (23)	1 (11)	7 (27)
Workers' compensation	2 (6)	0	2 (7)
Lien	1 (3)	0	1 (4)

[a]Results are reported as n (%) unless otherwise indicated. ACJR, acromioclavicular joint reconstruction.

tendon grafts or suture-button configurations in anatomically placed drill holes have improved clinical results. However, recent studies have reported complication rates of 27% to 52%, including a fracture rate of 20% in one study, limiting more widespread acceptance of surgical management of the acute dislocation.[13,31,40] Tendon grafts may stretch during remodeling, and suture-button devices may fail due to knot slippage, suture breakage, or button migration. One study reported that large or misdirected drill holes contributed to failure rates of up to 29%.[14] Failure to directly address the AC joint capsule may contribute to construct slippage, particularly with arthroscopic techniques that only restore the coracoclavicular (CC) connection.[16-18]

Our hypothesis was that consistent long-term success without construct slippage for both acute and chronic dislocations could be achieved by combining a comprehensive soft tissue repair with a suture-button construct that provided biplanar stabilization with a continuous loop that was not subject to knot slippage or breakage.

METHODS

After approval from our institutional review board, all patients undergoing surgical treatment by the senior author (S.S.) for Rockwood type III, IV, or V AC joint dislocation between April 2003 and October 2012 were identified. There were no Rockwood type VI cases. Revision cases were excluded.

Demographics

During the study period, 35 consecutive AC joint reconstructions were performed in 35 patients. Thirty-one (89%) of the patients were male, while 4 patients (11%) were female. At the time of surgery, the mean age was 42 years (range, 25-70 years). Patient demographics and historical findings are documented in Table 1. The mean time interval from injury to surgery spanned 196 days (range, 4-1096 days). Acute dislocations were defined as those occurring within 4 weeks of surgery, while chronic dislocations occurred more than 4 weeks before the date of surgery. Nine AC joint dislocations (26%) were deemed acute, and 26 (74%) were considered chronic. Nineteen patients injured their dominant arm (54%) and 16 patients (46%) injured their nondominant arm. The mechanism of injury was a fall from a motorcycle or bicycle in 14 patients (40%), a fall on the shoulder in 8 patients (23%), motor vehicle accident in 6 patients (17%), sports injury in 6 patients (17%), and direct trauma in 1 patient (3%).

Surgery

All patients underwent primary AC joint reconstruction via the previously described double Endobutton technique illustrated in Figure 1.[42] Surgical indications included patients with chronic dislocations that had failed nonoperative treatment and patients with acute dislocations with either high-grade dislocations or those with high functional demands preferring a surgical approach. Arthroscopy was not included in the procedure. In all patients, the Endobutton construct was further enhanced by an AC capsule and deltotrapezial imbrication as well as use of local tissue (either the torn CC ligament or a transferred CA ligament) to restore a biological connection across the CC interval. All patients with a chronic dislocation underwent a CA ligament transfer. Two of the 9 patients with an acute dislocation also required a CA ligament transfer due

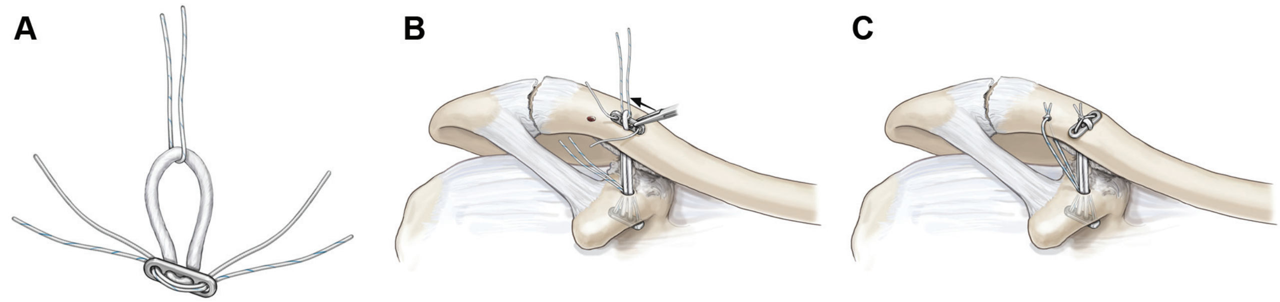

Figure 1. Double Endobutton acromioclavicular joint reconstruction technique. (A) Depiction of the continuous loop and suture limbs threaded through the Endobutton before deployment. (B) The Endobutton is passed through the continuous suture loop that has been pulled up through the prepared holes in the coracoid and clavicle. The free sutures will be passed through the peripheral holes in the button to secure it. (C) Final appearance of construct with an auxiliary stitch replicating the course of the trapezoid ligament.

to the lack of an adequate residual CC ligament for repair. The other 7 patients with an acute dislocation underwent repair of the CC ligament as described below.

A deltoid-splitting incision was used to expose the coracoid surface and provide access to the AC joint. The AC capsule was incised in line with the fibers to include the deltotrapezial fascia, and the AC joint was reduced. The distal clavicle could be excised to facilitate the reduction. A 2.4-mm drill hole was made in the top of the clavicle midway between the anterior and posterior border and directly in line with the base of the coracoid. After the hole had been drilled through the coracoid, it was reamed over with a 4.5-mm Endobutton reamer (Smith & Nephew). A second 2.5-mm drill hole was placed in the clavicle 1 cm lateral to the central drill hole. Loop length was determined with the joint reduced by measuring the channel length from the superior surface of the clavicle to the inferior surface of the coracoid with a depth gauge. The continuous loop is available in 5-mm increments. If the measured distance was within 1 mm of the standard loop size, a regular Endobutton was used on the cortical surface of the clavicle (Figure 2A). If the measured length was more than 1 mm longer than a standard loop size, the next larger continuous loop size was chosen and the excess loop was filled with a thicker button (Xtendobutton, Smith & Nephew) to ensure reduction to within 1 mm of the measured channel (Figure 2B). Two No. 5 Ethibond sutures (Ethicon) were placed into the Endobutton, and 1 suture was placed into the loop (Figure 1A). The Endobutton was pushed through the drill holes and deployed. With the joint held reduced, the loop stitch was pulled up until only the tip protruded from the clavicular hole, and a free Endobutton (Smith & Nephew) or Xtendobutton was then slid into the loop and stabilized by passing the 2 free suture limbs into the holes of the implant on either side of the loop and tied, securing the button (Figure 1B). The “trapezoid” stitch was then placed by passing 1 limb from the other No. 5 Ethibond suture into the second drill hole and tying, completing the repair (Figure 1C). The CC ligament, if available, was sewn to the periosteum on the anterior clavicle. If insufficient, the CA ligament was transferred and sewn to the anterior clavicular cortex by passing the uncut suture limbs from the trapezoid stitch into the substance of the transferred CA ligament and tying, fixing the CA ligament to the anterior cortex of the clavicle.

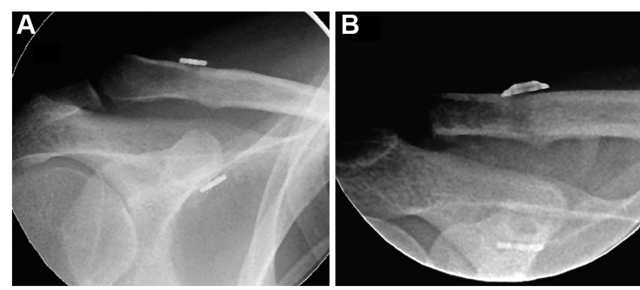

Figure 2. Fluoroscopic images demonstrating different variations of clavicular buttons used to achieve reduction. (A) Endobutton and (B) Xtendobutton.

Postoperative Treatment

Patients used a sling for 6 weeks. Passive external rotation with the arm at the side was encouraged, and pendulum exercises began at 2 weeks. At 6 weeks, the sling was discontinued and active movement of the shoulder was encouraged. Full return to activity and/or sports was allowed after 4 to 6 months depending on progress.

Clinical Follow-up

A comprehensive clinical evaluation, including a detailed patient interview and physical examination, was performed by the same clinician, who was not the surgeon. Range of motion was measured with a goniometer. Multiple validated outcome measures were collected, including the modified University of California, Los Angeles (UCLA) Shoulder Rating Scale, American Shoulder and Elbow Surgeons (ASES) Shoulder Score, Simple Shoulder

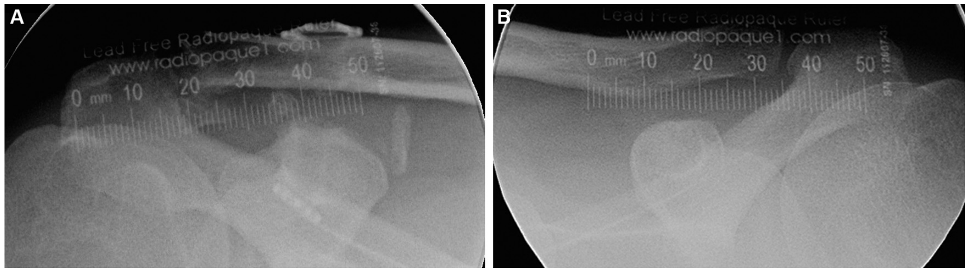

Figure 3. Zanca views of an (A) injured and (B) uninjured shoulder in the plane of the acromioclavicular joint with a radiopaque ruler placed directly over the coracoid process to scale measurements.

Test (SST), and Constant score. Objective strength was measured for the Constant score with a digital spring scale as originally described by Constant and Murley[11] and in accordance with the updated guidelines by Constant et al.[12] The final Constant score was normalized by age and sex.[25]

Radiographic Follow-up

Postoperative radiographs were obtained with a conventional Zanca view of the shoulder. Radiographs of the injured and contralateral shoulder were obtained with a radiopaque ruler placed directly over the coracoid process and in the plane of the CC ligament to scale measurements (Figure 3). All patients were asked to undergo magnetic resonance imaging (MRI) at the time of final follow-up, and 10 patients (32%) agreed to do so. MRI was conducted at a mean follow-up of 4.2 years (range, 2-8 years) to investigate the soft tissue repair at varying time points.

Statistical Analysis

The unpaired independent t test was used to compare the mean with variances among continuous study outcome parameters. The Pearson chi-square test and Fisher exact test were used to compare categorical outcomes. The Pearson correlation coefficient (r) was used to assess data trends. The level of statistical significance was set at $P <$ .05. All data were analyzed with the use of SPSS software (version 20, IBM Corp). Results are expressed as the mean $\pm$ SD unless otherwise specified.

RESULTS

Clinical Outcomes

Follow-up was obtained on 31 of the 35 patients (89%) at mean follow-up of 5.2 years (range, 27-144 months) with a minimum of 2 years. Four patients were lost to follow-up. Mean functional outcomes scores are reported in Table 2. The distal clavicle was excised in 11 of the 35 patients, all of whom had chronic dislocation. No significant difference in mean functional scores was noted between patients undergoing acute versus chronic reconstruction, CC ligament repair versus CA ligament transfer, or distal clavicle excision versus retention. Age, side dominance, sex, body mass index, Rockwood grade, payer, time interval between injury and surgery, and follow-up time elapsed did not significantly correlate with functional outcomes.

Radiographic Outcomes

Radiographic findings are summarized in Table 3. Comparison of the CC interval of the injured to the uninjured side revealed that 27 patients (87%) were reduced to within 2 mm of the contralateral side. The remaining 4 patients were underreduced by a mean distance of 3.4 mm (range, 2.5-4.0 mm). One to 2 millimeters of indentation of the button into the superior clavicular cortical surface was noted in 20 patients (65%), and intraosseous migration was noted in 1 patient. Calcification of the CC interval was noted in 11 patients (36%). No significant correlation was noted between time elapsed after surgery and radiographic outcomes. Button selection, timing of surgery (acute vs chronic), soft tissue procedure (CC ligament repair vs CA ligament transfer), and distal clavicle intervention (resection vs retention) did not significantly affect radiographic outcomes. No significant association between radiographic outcomes and functional scores was detected.

In all 10 patients who underwent MRI, a thickened soft tissue complex with a mean width of 9.2 mm within the CC interval was identified. MRI results of the reconstruction in 2 patients at 2 years and at 4 years postoperatively are displayed in Figure 4.

Complications

No surgical site infections or perioperative fractures were observed. No complications were noted from the use of the CA ligament transfer. On final follow-up, 1 patient was incidentally noted to have an asymptomatic nondisplaced fracture of the distal clavicle that communicated with the primary clavicular drill hole. Two patients complained of shoulder pain at final follow-up that was associated with AC joint arthrosis and responded to a steroid injection. One patient redislocated 10 weeks postoperatively as a result of a motor vehicle accident and required revision. Revision surgery was successfully done with the same procedure (outcome scores from this patient were excluded from analysis).

TABLE 2
Functional Outcome Scores After Double Endobutton Acromioclavicular Joint Reconstruction[a]

	All ACJR	Acute ACJR	Chronic ACJR	CC Ligament Repair	CA Ligament Transfer	Distal Clavicle Excision	Distal Clavicle Retention
UCLA	33.5 ± 2.2	34.1 ± 1.6	33.3 ± 2.4	34.4 ± 1.0	33.3 ± 2.4	33.5 ± 1.4	33.5 ± 2.4
ASES	97.8 ± 3.3	98.6 ± 1.5	97.5 ± 3.7	98.3 ± 1.7	97.7 ± 3.7	96.9 ± 4.7	98.2 ± 2.7
SST	11.4 ± 1.4	12 ± 0	11.3 ± 1.5	11.7 ± 0.5	11.4 ± 1.5	11.8 ± 0.5	11.3 ± 1.6
Constant score							
Raw	97.6 ± 3.2	98.8 ± 1.1	97.3 ± 3.1	98.4 ± 2.1	97.4 ± 3.4	97.7 ± 2.3	97.7 ± 3.4
Normalized[25]	99.6 ± 1.0	100 ± 0	99.4 ± 1.1	99.7 ± 0.8	99.5 ± 1.1	99.7 ± 0.5	99.5 ± 1.2

[a]Results are reported as mean ± SD. ACJR, acromioclavicular joint reconstruction; ASES, American Shoulder and Elbow Surgeons Shoulder Score; CC, coracoclavicular; CA, coracoacromial; SST, Simple Shoulder Test; UCLA, University of California, Los Angeles Shoulder Rating Scale.

TABLE 3
Radiographic Findings After Double Endobutton Acromioclavicular Joint Reconstruction[a]

	All ACJR	Acute ACJR	Chronic ACJR
CC interval, mm			
Injured side	8.3 ± 2.5	7.7 ± 2.9	8.5 ± 2.4
Uninjured side	7.5 ± 1.9	6.4 ± 2.2	7.8 ± 1.8
Difference (absolute)	1.1 ± 1.2	1.1 ± 1.0	1.1 ± 1.2

[a]Results are reported as mean ± SD. ACJR, acromioclavicular joint reconstruction; CC, coracoclavicular.

DISCUSSION

Early surgical intervention for acute AC joint dislocations remains controversial. Several studies and meta-analyses comparing early surgical treatment with nonsurgical management have failed to show a significant difference.[6,28,36,43] These conclusions, however, were limited by the inclusion of older, nonanatomic surgical techniques that are largely not in current use. This problem was underscored by a recent Cochrane review by Tamaoki et al.[44] Only 3 studies qualified for inclusion—all were published before 1990 and all used techniques with rigid hardware fixation. None of the studies distinguished among Rockwood subtypes or included validated outcome measures. Comparative studies examining newer methods of fixation such as tendon grafts and suture-button constructs currently do not exist. Residual symptoms after nonoperative treatment remain a significant problem. Studies that have examined the outcome of nonoperative treatment using modern validated scoring systems have consistently shown mean Constant scores lower than 90, confirming the presence of ongoing symptoms in the typical patient.[21,22] While nonoperative management is often recommended for less severe (type III) dislocations and surgical management for higher grades (types IV, V, and VI), these studies did not document an outcome difference between subtypes. Scapular dyskinesis has been documented in 70% of patients treated nonoperatively, with 45% showing evidence of SICK scapula syndrome (a pneumonic that stands for scapular malposition, inferior medial scapular winging, coracoid tenderness, and scapular dyskinesis).[22] Unsatisfactory outcomes are seen in 20% to 40% of patients treated nonoperatively.[26,39,52]

The potential advantage of early surgery for AC joint dislocations is the ability to harness the healing response of the acute injury. Late surgery is more extensive, requires the use of a graft to bridge the CC space, and may necessitate excision of the distal clavicle. A recent meta-analysis by Song et al[41] suggested that early surgical treatment may enhance functional outcomes and minimize recurrent subluxations. Successful results from use of the Bosworth screw and other rigid fixation techniques highlight the robust healing response after acute injury. If initial fixation is sufficiently stable, excellent long-term biological stability can be achieved in a matter of weeks.[46,48,49,51] However, the need for a second operation and the high rate of hardware complications have made these techniques less desirable.

The results of the present study demonstrate that successful long-term outcomes for the treatment of both acute and chronic AC joint dislocations can be achieved by use of a novel fixation device in conjunction with a soft tissue repair that addresses both the AC and CC ligaments. We observed no infections and no complications related to hardware or suture material, and we noted no complications related to CA ligament transfer. Biomechanical testing suggests that the CA ligament plays a role in glenohumeral stability and that CA ligament transfer may potentially contribute to glenohumeral laxity.[29] However, this theoretical risk has not been borne out by clinical studies, and current published series fail to report complications directly related to CA transfer. In the current study, 1 patient redislocated 10 weeks postoperatively secondary to trauma. Drill holes were minimized in both size and number, which likely contributed to the absence of complications. Other techniques for anatomic reconstructions call for larger coracoid drill holes (up to 7 mm) and the use of 2 large drill holes in the clavicle,[15,33] thereby increasing fracture risk.[27] The open approach ensured accurate placement of drill holes in the center of the coracoid and facilitated imbrication of the AC capsule and deltotrapezial fascia as well as direct repair of the CC ligaments in acute cases or the CA ligament transfer in chronic cases, obviating the need for free tendon grafts.

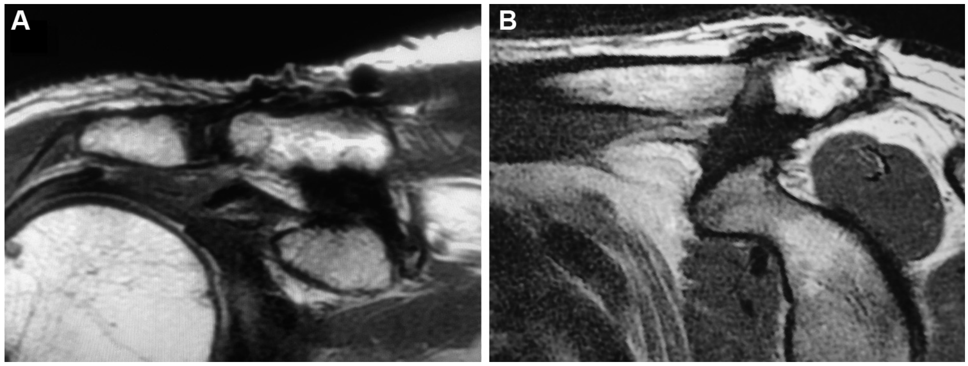

Figure 4. Coronal magnetic resonance images of 2 patients showing the coracoclavicular interval at (A) 2 years and (B) 4 years postoperatively. Note the increase in width and density of the soft tissue complex within the coracoclavicular interval with time.

The use of a continuous loop design in this study demonstrated significantly improved outcomes over standard suture-button configurations. All previous studies use various configurations of sutures, all requiring a knot. The suture-button configuration, introduced in 2006, has been validated on biomechanical testing.[7,50] Clinical results, however, have been inconsistent, with loss of reduction (subluxation or dislocation) seen in 34% to 94% of cases.[10,30,37,38] A closed loop eliminates the problem of knot slippage or breakage that is inherent to a standard suture-button device. The loop has similar stiffness (142 N) and more than double the strength (1063 N) of the native ligament.[23] The construct is further enhanced by the second trapezoid stitch to control posterior stability.[19] Perhaps more important, the loop is particularly resistant to creep under cyclical load, demonstrating only a 1.3-mm change in length with cyclic loading of up to 250 N at 4500 cycles.[5,35] In a study by Barrow et al,[5] both the knotted constructs and the self-locking loops used for ACL reconstruction had clinical failure (defined as 3 mm elongation) well before 5000 cycles (1349 and 1680, respectively). Final elongations for a suture-button construct were 13 mm (knotted) and 42 mm (unknotted). In a study by Abbi et al,[1] constructs with knots also demonstrated the potential to either slip or fail when subjected to cyclical loads. Ultra-high-molecular-weight polyethylene (UHMPE) braided sutures, in particular, have frictional properties that lead to slippage at loads significantly below their failure threshold.[4] Ihali et al[23] demonstrated that No. 2 Fiberwire (Arthrex) tied with 5 square knots exhibited 3 mm of slippage at only 60% of the ultimate failure load. Lim et al[30] suggested that knot slippage was a factor in the reported 50% slippage rate with the use of a suture-button fixation device. The sizing problem posed by using a loop of fixed length that comes in 5-mm increments was easily handled by choosing either a thin or thick Endobutton for clavicular fixation, resulting in a reduction to within 1 mm of the measured channel in all cases.

In keeping with multiple biomechanical studies that underscore the importance of the AC capsule in preventing posterior instability, the AC capsule and deltotrapezial fascia were imbricated in all cases.[16-18] Fukuda et al[18] showed that the AC capsule plays a primary role in resisting posterior subluxation forces. Debski et al[17] shed further light on the role of the AC capsule by demonstrating that transection of the AC capsule resulted in a 200% increase of in situ forces on the conoid ligament. Dawson et al[16] confirmed these findings, concluding that residual anteroposterior instability after isolated CC ligament reconstruction may lead to higher rates of failure. The authors of both of these studies concluded that in the absence of an AC capsule repair, these higher forces might contribute to early failure of suture and graft materials. In the current study, we further enhanced the posterior stability by adding the trapezoid stitch. Recent biomechanical testing of the double Endobutton construct has demonstrated that this additional stitch significantly reduces posterior translation.[19] Although arthroscopic techniques reduce morbidity and have shown improved clinical outcomes over older techniques, fixation failure rates (subluxation or dislocation) have ranged from 28% to 43%,[37,38,47] and fixation slippage, as measured by changes in CC interval, has averaged 4.5 mm.[38] In 2010, Salzmann et al[37] hypothesized that failure to reconstruct the deltotrapezial fascia may have contributed to failures.

The use of an anatomically placed tendon graft, introduced by Bunnell[8] in 1928, was recently repopularized after biomechanical studies showed the potential for better stability relative to standard nonanatomic procedures. Clinical outcome studies of these anatomic constructs, however, have yielded inconsistent results, with subluxation rates from 17% to 38%.[13,14,24,34] While tendon grafts have adequate initial strength, the tissue is avascular at the time of surgery, and the fate of the graft during the healing process, both biologically and mechanically, is unknown and has not been studied.

In addition to using the double Endobutton fixation, we reestablished a biological connection between the coracoid and the clavicle in all cases, with either repair of the torn CC ligament or a CA ligament transfer. Although these tissues have the advantage of being vascularized, they are inherently weak structurally and contribute marginally to initial stability as they are shielded from load by the Endobutton implant. However, recreating this biological CC link may contribute to the healing response and long-term stability. Indeed, all postoperative MRIs showed evidence of a very robust healing response with a thick band of scar tissue filling the CC interval. This initial repair tissue may have served as a scaffold or nidus around which scar forms. Other studies showed excellent results when a CA ligament transfer was sufficiently shielded from initial postoperative loads.[2,3] More important, placement of a device alone in the CC interval without any biological tissue bridging the span has been cited as a source of failure in other studies.[38,40]

The mean follow-up period of 5.3 years is the second longest follow-up for a suture-button configuration. This is also the first study of its kind to correlate clinical outcomes with MRI findings. However, the present study had several limitations. First, this was a level 4 study, and no control group was created to directly compare outcomes to alternative treatment options, including nonoperative therapy. Second, no preoperative clinical functional scores or radiographs were collected for baseline comparison. Third, radiographic results were only measured in the vertical direction and did not account for displacement in the anteroposterior direction.

CONCLUSION

The presented method for the repair of both acute and chronic AC joint dislocations was successful in restoring stability in a large patient group followed for up to 11 years. Excellent outcomes were achieved for both clinical scores and radiologic parameters. The double Endobutton construct as described is a low-profile, durable fixation device that maintains a stable AC joint, allowing enough time for strong soft tissue healing to develop. This is the first study to validate the method by examining postoperative MRIs at various points after surgery to evaluate biological changes.

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