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Outcomes After Arthroscopic Pancapsular Capsulorrhaphy With Suture Anchors for the Treatment of Multidirectional Glenohumeral Instability in Athletes

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Background: Outcomes after arthroscopic pancapsular capsulorrhaphy (APC) with suture anchors for multidirectional instability (MDI) of the shoulder are not widely reported.

Purpose: To compare intraoperative findings and midterm outcomes of APC with suture anchors for MDI between female and male athletes and between a classic, atraumatic onset versus clinical onset of MDI after a traumatic event.

Study Design: Cohort study; Level of evidence, 3.

Methods: Patients who underwent APC with suture anchors for MDI and were at least 2 years out from surgery were included. Data were prospectively collected and retrospectively reviewed and included the onset of MDI, intraoperative pathoanatomic findings, level of sports participation, and patient satisfaction as well as the American Shoulder and Elbow Surgeons (ASES), Single Assessment Numeric Evaluation (SANE), Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), and Short Form–12 Physical Component Summary (SF-12 PCS) scores. Information regarding shoulder instability and return to sport was collected, and Kaplan-Meier survivorship analysis was performed.

Results: Forty-one patients (45 shoulders; 25 male, 20 female), consecutively treated between October 2006 and January 2013, were included. The onset of MDI was atraumatic in 22 shoulders and traumatic in 23 shoulders. At surgery, 29 of 45 (64.4%) had labral detachment. Seven shoulders (16.7%) experienced instability episodes postoperatively, and 3 of these underwent revision surgery. The mean follow-up was 3.3 years (range, 2.0-6.6 years). All subjective outcome scores improved significantly from preoperative levels ($P < .005$). At final follow-up, the mean ASES score was 92.0, and 76.7% (23/30) indicated that they had returned to sports participation equal to or slightly below their preinjury level. Kaplan-Meier analysis showed a survivorship rate of 87% at 3 years. Male patients were 2.3 times more likely to have a traumatic onset of instability (68% vs 30%, respectively; $P = .017$) and were 2.1 times more likely to have concomitant lesions (84% vs 40%, respectively; $P = .004$) than female patients. Furthermore, male patients demonstrated a higher mean postoperative ASES score than female patients (97.0 $\pm$ 4.7 vs 85.5 $\pm$ 16.4, respectively; $P = .023$). Female patients were 6.9 times more likely to undergo an additional rotator interval closure (RIC) procedure (58% vs 4.7%, respectively; $P < .001$) and to experience postoperative subluxations (40% vs 22%, respectively; $P = .035$) than male patients. A traumatic onset of MDI was associated with a higher mean postoperative ASES score (96.4 $\pm$ 6.9 vs 87.0 $\pm$ 15.7, respectively; $P = .048$), higher median satisfaction score (10 vs 9, respectively; $P = .029$), and higher return-to-sport rate (83% vs 44%, respectively; $P = .030$) than an atraumatic onset.

Conclusion: APC with suture anchors can be an effective and safe treatment for patients with MDI. Labral tears were commonly found, even in patients with a classic, atraumatic onset. Male patients and patients with a traumatic onset of MDI had more favorable outcomes. Female patients may be more challenging to treat as they were more likely to undergo an additional RIC procedure and experience postoperative subluxations.

Keywords: multidirectional instability; traumatic; labral tear; shoulder instability; athletes; outcomes

Multidirectional instability (MDI) of the shoulder is a clinical diagnosis that can be difficult to both diagnose and treat. There are many proposed classification systems for shoulder instability, such as the AMBRI (atraumatic, multidirectional, bilateral, rehabilitation, inferior capsular shift) and TUBS (traumatic, unilateral, Bankart, surgery) system and the FEDS (frequency, etiology [cause], direction, severity) system.[4,14,15,21] Currently, the most universal definition of MDI is symptomatic instability of the

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shoulder joint in more than one direction, one of which is inferior.[8] The hallmark of MDI is an inferior sulcus sign on a physical examination. The "classic" onset of MDI has been defined as atraumatic or trivial; however, MDI has also been observed in the context of traumatic injuries, especially in patients without hyperlaxity.[2,9,22] Regarding the role of sex with MDI, more severe cases of MDI have previously been reported in female patients.[9]

Historically, the treatment for MDI has been nonoperative with a supervised exercise program, but results have sometimes been suboptimal.[4,19] The refinement of open capsular shift surgery and the development of arthroscopic techniques for restoring stability to the glenohumeral joint have allowed for surgical treatment in those who have failed nonoperative treatment. Most arthroscopic techniques have now evolved to include capsulorrhaphy with suture anchors, which effectively reduces the capsular joint volume to magnitudes equal to or better than that with open capsular shift, with the ability to also address both sides of the joint simultaneously.[5,10,20,25] Initial outcome studies have shown promising results with arthroscopic capsulorrhaphy for the treatment of MDI.[1,3,6,12,28] However, little is known about if and how sex and the onset of MDI affect intraoperative findings and midterm outcomes of arthroscopic pancapsular capsulorrhaphy (APC).

The purpose of this study was to compare intraoperative findings and midterm outcomes of APC with suture anchors for MDI between female and male athletes and between an atraumatic versus traumatic onset of MDI. We hypothesized that a traumatic onset of MDI would be associated with more concomitant glenohumeral injuries and better outcomes whereas outcomes would be less favorable for female than male patients.

METHODS

This study had prior institutional review board approval. Between October 2006 and January 2013, all patients who underwent APC with suture anchors for MDI and were at least 2 years out from surgery were assessed for eligibility. MDI was strictly defined as symptomatic glenohumeral instability in $\geq$2 directions, one of which was inferior. The diagnosis of MDI was clinical. All shoulders had a positive sulcus sign with symptomatic inferior translation of $>$1 cm in neutral position and in external rotation.[17] In addition, all shoulders had a history of dislocations or subluxations as well as clinical apprehension signs in the anterior and/or posterior direction. Anterior instability was clinically tested with the apprehension sign and the relocation test, and posterior instability was tested with the jerk test.[18] Anteroinferior and posteroinferior instability without symptomatic inferior translation of $>$1 cm was not defined as MDI. During the clinical examination, general signs of joint hypermobility (ie, hyperextension of the elbows, knees, and thumbs) were assessed but not quantified with a specific hypermobility score. Patients were questioned regarding known connective tissue diseases; however, there was no systematic diagnostic screening. Patients were additionally questioned if they could voluntarily dislocate their shoulders.

All patients with an atraumatic onset of MDI and patients with a traumatic onset of MDI without evidence of a labral tear on magnetic resonance imaging initially failed a minimum 6-month course of nonoperative management that included the avoidance of painful activities, nonsteroidal anti-inflammatory medication, and a physical therapy program designed to improve shoulder strength.[18] All patients had persistent shoulder instability causing pain that interfered with their daily life and/or athletic endeavors. Patients were excluded if they were under the age of 16 years, underwent open stabilization surgery, had undergone a previous stabilization procedure on the index shoulder, had a known connective tissue disease such as Ehlers-Danlos syndrome, or had relevant confounding events that occurred postoperatively and interfered with the MDI surgery outcome.

Demographic Data

All patient data were prospectively collected and retrospectively analyzed. These included demographic information (age, sex, dominant shoulder, mode of injury, treatment history).

The nature of the onset of instability (traumatic or atraumatic) was recorded. The onset of MDI was classified as either (1) traumatic with a distinct traumatic event such as a ski accident, football injury, or skateboarding fall that resulted in instability (dislocation or subluxation) of the shoulder with the patient seeking treatment or (2) atraumatic without any specific trauma. Patients indicated the sports that they participated in and their level of sports participation as a professional athlete, collegiate athlete, high school athlete, or recreational athlete.

Concomitant injuries found at the time of the index surgery, such as glenolabral articular disruption (GLAD) lesions, labral disruption (Bankart lesions, reverse

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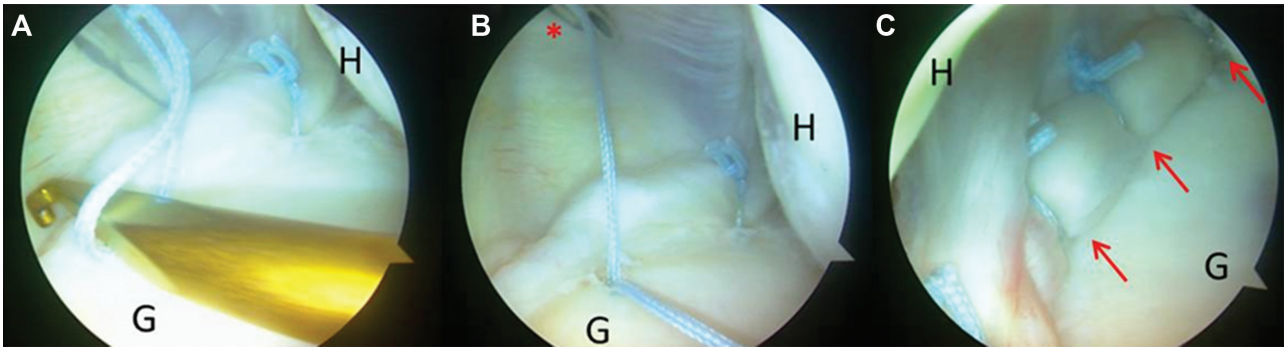

Figure 1. Arthroscopic pancapsular capsulorrhaphy surgical technique. Right shoulder, lateral decubitus position, posterior viewing portal. (A) Retrieving the suture from the suture anchor. (B) Before passing the suture through the capsule and around the labrum with the shuttling instrument (*). (C) Final anterior repair with 3 suture anchors (arrows). G, glenoid; H, humeral head.

Bankart lesions), superior labrum anterior to posterior (SLAP) tears, or Hill-Sachs lesions, were noted. Adjuvant treatments (such as rotator interval closure [RIC]) and postoperative complications were also noted.

Surgical Technique

Each patient underwent an examination under anesthesia to help identify the preoperative range of motion as well as the degree and severity of laxity. All patients had a positive sulcus sign with inferior translation of >1 cm and translation of the humeral head of grade 2 or higher in the anterior and/or posterior direction. Patients were placed in the lateral decubitus position. Diagnostic arthroscopic surgery was performed through a standard posterior portal to identify associated intra-articular injuries and verify the degree of laxity. An anterior working portal was made high in the rotator interval, and a second anteroinferior working portal was created lower in the rotator interval. The arthroscope was then introduced into the anterosuperior portal to better view the posterior labrum. Next, an accessory posterolateral portal was created, through which to insert the posterior anchors, to repair the posterior labrum and perform posterior capsulorrhaphy.

All repairs were performed with suture anchors. First, the capsule was abraded to help in healing of the synovium. The posterior labrum and capsule were repaired and plicated by placing 2.4-mm biocomposite anchors (Bio-SutureTak suture anchors; Arthrex) on the glenoid rim. A shuttling instrument (SutureLasso; Arthrex) was used to pass the sutures through the capsule and around the labrum. The sutures were secured using No. 2 permanent sutures (FiberWire; Arthrex) with an arthroscopic Weston knot to reduce the capsular volume. A minimum of 3 anchors was placed posteriorly on the glenoid, starting inferior and working cephalad, to produce a volume reduction of the patulous inferior capsule as well (Figure 1). After the posterior labrum and capsule were addressed, a switching stick was placed into the posterior portal under direct vision so that the scope could be once again placed posteriorly, safely without disrupting the repair. Subsequently, the anterior labrum and capsule were addressed, effectively performing pancapsular capsulorrhaphy. The anterior structures were secured using a minimum of 3 suture anchors. When present, Bankart lesions and reverse Bankart lesions were reduced to the glenoid rim with the suture anchors at the same time as the capsular shift. If a SLAP tear was encountered superiorly, it was also repaired with suture anchors: one anterior and one posterior to the biceps anchor.

After anchor placement and the completion of capsulorrhaphy, the stability of the joint was once again assessed subjectively by the senior surgeon. If the anterior joint volume still appeared patulous and laxity remained unsatisfactory (>1 cm of translation in the anterior or inferior direction), the rotator interval capsule was closed.[7,8,20,23] For this, a crescent lasso loaded with a No. 1 PDS suture was passed through the leading edge of the superior glenohumeral ligament. A penetrating device (BirdBeak; Arthrex) was then used to pierce the middle glenohumeral ligament and retrieve the free end of the suture. An arthroscopic Weston knot was then tied external to the joint to complete RIC.

Postoperative Rehabilitation

Patients were strictly immobilized for 4 to 6 weeks using a sling and a small abduction pillow. Hand, wrist, and elbow range of motion exercises were permitted from surgery. Passive range of motion (PROM) was initiated at 6 weeks, unless there was severe joint hypomobility (<45° of glenohumeral abduction or external rotation less than neutral) noted during routine clinical follow-up examinations in the first 3 weeks, in which case PROM was started at 4 weeks. Strengthening of the rotator cuff muscles was initiated at the 6-week mark, and full return to activities was permitted at 4 to 6 months postoperatively.

Data Collection

Patient-centered outcome scores were collected preoperatively and postoperatively and included the American Shoulder and Elbow Surgeons (ASES) score, Quick

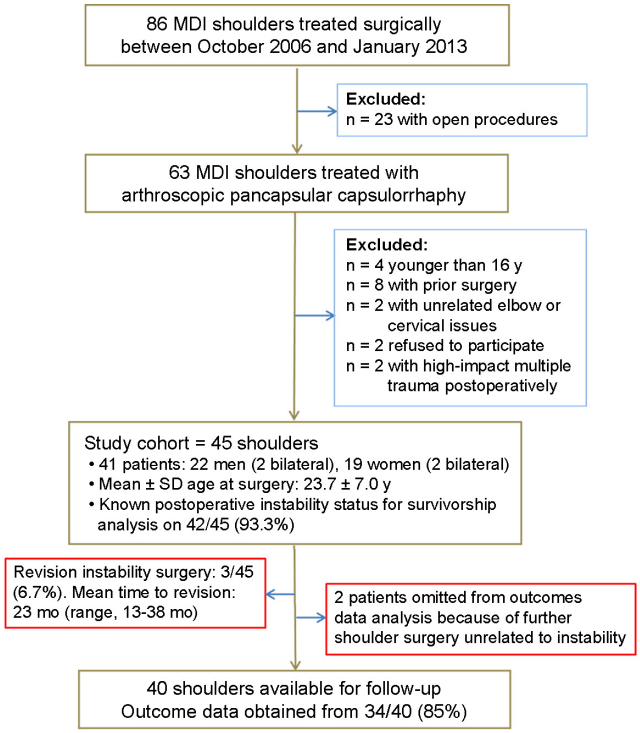

Figure 2. Patient flow diagram. MDI, multidirectional instability (defined as symptomatic glenohumeral instability in ≥2 directions, including symptomatic inferior translation >1 cm).

Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, Short Form–12 Physical Component Summary (SF-12 PCS) score, and Single Assessment Numeric Evaluation (SANE) score along with subjective questions about instability symptoms. The ASES score has previously been validated for use in patients with instability.[13] Patients were also asked specific questions regarding their ability to return to sporting activities and intensity of participation as well as if they were able to return to their original fitness program. At final follow-up, patient satisfaction with outcomes was noted in addition to the outcome scores. Treatment failure was defined as a patient undergoing revision surgery for instability, any postoperative dislocation event, or the subjective feeling of glenohumeral instability.

Statistical Analysis

Statistical analyses were performed using statistical software SPSS (version 11.0; IBM Corp). For statistical analysis of outcome scores, only patients that had not progressed to another shoulder surgery were included. Univariate analysis was performed using an independent t test, Mann-Whitney U test, or Wilcoxon signed-rank test depending on data normality, along with a paired t test to detect the change in the outcome score from preoperatively to postoperatively. Bivariate analysis was performed by chi-square (χ^2) analysis. The Fisher exact test was used to test for the association between the onset of instability and labral injuries. Kaplan-Meier survivorship analysis was performed with self-reported postoperative dislocations or any subjective instability symptoms to define an unstable shoulder. All reported P values are 2-tailed, with $<.05$ indicating a statistically significant difference.

RESULTS

Between October 2006 and January 2013, 86 consecutive patients with MDI of the shoulder underwent surgical intervention. Twenty-three patients treated with open procedures (eg, for large bony defects or dysplasia of the glenoid) were excluded. Sixty-three patients were treated with APC with suture anchors. After inclusion and exclusion criteria were applied to the cohort treated with APC with suture anchors, 45 shoulders (41 patients) were analyzed (Figure 2). Two patients were excluded for other unrelated confounding health issues: one with unresolved ulnar nerve pain and another undergoing several cervical and lumbar surgeries. Two patients were also excluded from the study analysis because they suffered injuries to their index shoulder after high-energy collisions (motor vehicle accident and high-speed longboard crash). These 2 patients sustained secondary injuries that were likely to confound the follow-up from MDI surgery.

There were 22 men and 19 women with a mean age at the time of surgery of 23.7 years (range, 16-44 years). Several demographic and surgical parameters were significantly different between male and female patients (Table 1). None of the patients had a known connective tissue disease, and no patient could voluntarily dislocate his or her shoulder. All shoulders had an inferior sulcus sign with symptomatic inferior translation of >1 cm. Thirty-three shoulders had additional anterior and posterior translation of grade 2 or higher. The remaining 12 shoulders had either anterior translation (n = 9) or posterior translation (n = 3) of grade 2 or higher with some extent of translation in the other direction. The mean duration of symptoms finally leading to APC with suture anchors was 478 days (range, 2-4547 days).

Eighteen patients (21 shoulders) were classified as actively competing athletes, while 23 patients (24 shoulders) were recreational athletes (Table 2). The mean duration of sports participation was 13 years (range, 3-30 years).

Twenty-three shoulders had a traumatic onset of instability, while 22 shoulders were atraumatic (Table 3). Eight shoulders with an atraumatic onset (36.4%) had distinct signs of general joint hyperlaxity. Three shoulders with traumatic instability (13.0%) had 1 or more dislocations that required reduction by another person. The remaining 20 shoulders with traumatic instability had dislocations with spontaneous reduction or subluxations during a traumatic event. Four shoulders with an atraumatic onset (18.2% each anterior + inferior) and 8 shoulders with a traumatic onset (34.8%, n = 5 anterior + inferior and n = 3 posterior + inferior) had 2 main directions of instability, whereas all other patients had instability in all 3 main directions (P = .36).

TABLE 1
Demographic and Surgical Data by Sex[a]

	Male Patients (n = 25 Shoulders)	Female Patients (n = 20 Shoulders)	*P* Value
Age at surgery, y, mean ± SD	25.9 ± 7.4	20.9 ± 5.4	.017[b]
Dominant shoulder	48 (12)	65 (13)	.367
Competitive athlete	32 (8)	65 (13)	.038[b]
Atraumatic instability	32 (8)	70 (14)	.017[b]
Hill-Sachs lesion	36 (9)	0 (0)	.002[b]
SLAP tear, types 2-4	64 (16)	20 (4)	.006[b]
Bankart lesion	80 (20)	35 (7)	.005[b]
RIC	8 (2)	55 (11)	.001[b]

[a]Data are presented as % (n) unless otherwise specified. RIC, rotator interval closure; SLAP, superior labrum anterior to posterior.
[b]Statistically significant difference ($P < .05$).

TABLE 2
Summary of Patients' Sports Participation

Sporting Activity	Competitive/ Recreational, n	Total, n
Alpine skiing/snowboarding	2/12	14
Swimming/volleyball/golf	7/2	9
Baseball/softball	3/0	3
Kayaking	0/3	3
Football/hockey/rugby	4/3	7
Other (martial arts/extreme fitness/ hiking/skateboarding/soccer)	2/3	5

TABLE 3
Demographic and Surgical Data Associated With Onset of MDI[a]

	Traumatic (n = 23 Shoulders)	Atraumatic (n = 22 Shoulders)	*P* Value
Age at surgery, y, mean ± SD	25.2 ± 7.3	22.1 ± 6.4	.149
Dominant shoulder	43 (10)	68 (15)	.136
Competitive athlete	35 (8)	59 (13)	.139
Female sex	26 (6)	64 (14)	.017[b]
Hill-Sachs lesion	30 (7)	9 (2)	.135
SLAP tear, types 2-4	61 (14)	27 (6)	.036[b]
Bankart lesion	91 (21)	27 (6)	<.001[b]
RIC	13 (3)	45 (10)	.023[b]

[a]Data are presented as % (n) unless otherwise specified. MDI, multidirectional instability; RIC, rotator interval closure; SLAP, superior labrum anterior to posterior.
[b]Statistically significant difference ($P < .05$).

Overall, 29 of 45 shoulders (64.4%) had labral detachment, and 9 of 45 (20.0%) had chondral Hill-Sachs lesions without bone involvement (Table 4). Twenty of 45 shoulders (44.4%) had SLAP lesions (types 2-4), of which 19 were repaired, while 1 underwent debridement, biceps tenotomy, and subpectoral biceps tenodesis. Thirteen of 45 shoulders (28.9%) had remaining laxity after pancapsular capsulorrhaphy and therefore underwent an additional RIC procedure.

TABLE 4
Surgical Findings (N = 45 Shoulders)[a]

	Pathoanatomic Findings, n (%)
No discrete labral tear	16 (35.6)
SLAP tear	20 (44.4)
Type 2	15 (33.3)
Type 3	4 (8.9)
Type 4	1 (2.2)
Labral tear	29 (64.4)
Isolated SLAP tear (types 2-4)	2 (4.4)
Bankart lesion	3 (6.7)
Reverse Bankart lesion	2 (4.4)
Bankart lesion + reverse Bankart lesion	6 (13.3)
360° lesion (Bankart lesion + reverse Bankart lesion + SLAP tear)	16 (35.6)
ALPSA lesion	2 (4.4)
GLAD lesion	9 (20.0)
Loose bodies	5 (11.1)
Synovitis	17 (37.8)
Chondral Hill-Sachs lesion	9 (20.0)

[a]ALPSA, anterior labroligamentous periosteal sleeve avulsion; GLAD, glenolabral articular disruption; SLAP, superior labrum anterior to posterior.

At the time of the latest follow-up, the stability status was known for 42 of 45 (93.3%) shoulders. Thirty-five of 42 (83.3%) shoulders were stable, while 7 shoulders (16.7%) were unstable and had either redislocated or had recurrent subluxation symptoms. Of these 7 unstable shoulders, 3 went on to undergo another stabilization surgery at a mean of 23 months (range, 13-38 months). These revision surgeries included 2 Latarjet procedures and 1 revision arthroscopic procedure. For the entire cohort, Kaplan-Meier survivorship analysis demonstrated that shoulder stability was 100% at 1 year and 87% at 3 years (Figure 3).

Outcome Analysis

For outcome analysis, only patients who had not progressed to another shoulder surgery were included. Given

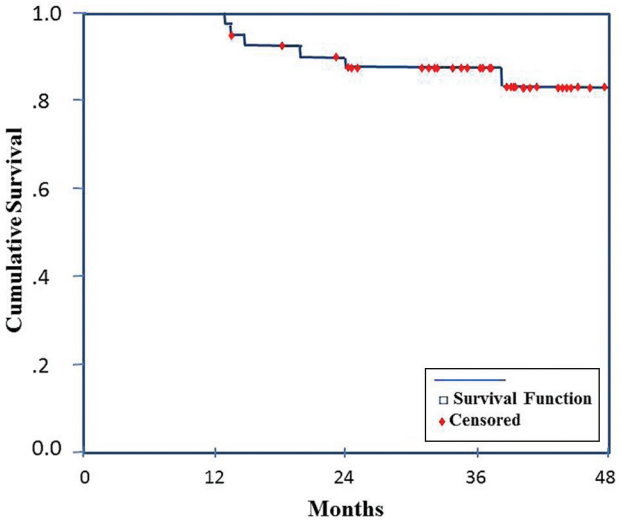

Figure 3. Overall survivorship was 100% at 1 year after surgery and 87% at 3 years.

that the postoperative outcome scores of the 3 shoulders that proceeded to secondary stabilization surgeries would reflect the secondary procedure rather than the index APC procedure at their latest follow-up, their scores were excluded from outcome data analysis. One patient who developed severe polyarticular inflammatory arthritis 8 months postoperatively and then developed an unstable shoulder and another patient who underwent the arthroscopic treatment of acromioclavicular arthritis 5 months after the index surgery but whose shoulder remained stable were included in the survivorship analysis but excluded from the outcome analysis. The minimum 2-year subjective outcome data were available on 34 of 40 shoulders (85.0%). The mean follow-up was 3.3 years (range, 2.0-6.6 years).

Overall, all patient-derived subjective outcome scores improved significantly from preoperative levels ($P < .005$) (Table 5). At final follow-up, 76.7% (23/30) indicated that they had returned to sports participation equal to or slightly below their preinjury level.

Shoulders with a labral tear (n = 29) had a significantly higher mean postoperative ASES score (97.5 vs 83.1, respectively; $P = .003$) and SANE score (93.2 vs 82.2, respectively; $P = .040$) than those without a discrete labral tear (n = 16) but had no differences between the SF-12 PCS ($P = .859$), QuickDASH ($P = .065$), or patient satisfaction ($P = .064$) scores.

Outcomes by Sex

Sex was significantly associated with many of the surgical findings and treatments (Table 1). Female patients were significantly associated with an atraumatic onset ($P = .017$). Female patients were 6.9 times more likely to undergo an additional RIC procedure (55% vs 8%, respectively; $P < .001$) at surgery and to experience postoperative subluxations (40% vs 22%, respectively; $P = .035$) than male patients. Male patients were 2.3 times more likely to have a traumatic onset of instability (68% vs 30%, respectively; $P = .017$) and 2.1 times more likely to have concomitant lesions (84% vs 40%, respectively; $P = .004$) than female patients. Male patients were significantly older

TABLE 5
Preoperative and Postoperative Outcome Measures[a]

	Preoperative (Mean, 24 d; Range, 0-191 d)	Postoperative (Mean, 3.3 y; Range, 2-6.6 y)	*P* Value
SF-12 PCS score	40.0 ± 10.2	55.3 ± 5.7	<.001[b]
ASES score (0-100)	60.7 ± 22.0	92.0 ± 12.6	<.001[b]
SANE score (0-100)	52.5 ± 27.8	88.9 ± 12.1	.002[b]
QuickDASH score (100-0)	43.6 ± 24.4	8.7 ± 15.4	.001[b]
Subluxations (never, rare, occasionally, frequently)	Occasionally	Rare	<.001[b]
Stability of shoulder compared with before onset of symptoms (preoperative) and compared with preoperatively (postoperative) (1-5)	5; much worse	1; much better	.003[b]
Painless use of arm (to waist, to chest, to neck, to head, overhead; 1-5)	2; chest	5; overhead	<.001[b]
Level of sports participation (1-6)	5; cannot compete in usual sport	1; equal or above preinjury level	<.001[b]
Strength with competition (1-6)	4; severe weakness prevents competition	2; mild weakness or fatigue	<.001[b]
Competition intensity (1-6)	4; 25%-49% of preinjury level	1; same or better than preinjury level	<.001[b]
Able to return to fitness program, % (n)	N/A	64.7 (22/34)	
Patient satisfaction with outcomes (1-10; 10 = best), median (range)	N/A	9.5 (2-10)	

[a]Data are presented as mean ± SD unless otherwise specified. ASES, American Shoulder and Elbow Surgeons; N/A, not applicable; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form–12 Physical Component Summary.

[b]Statistically significant difference ($P < .05$).

TABLE 6
Comparison of Preoperative and Postoperative Outcome Measures by Sex[a]

Outcomes	Male Patients	Female Patients	*P* Value
Preoperative ASES score	67.6 ± 21.2	50.0 ± 23.9	.037[b]
Preoperative pain component of ASES score (0-50; 50 = best)	37.0 ± 12.1	24.2 ± 13.2	.015[b]
Postoperative ASES score	97.0 ± 4.7	85.5 ± 16.4	.023[b]
Postoperative pain component of ASES score (0-50; 50 = best)	49.1 ± 2.7	41.7 ± 11.1	.016[b]
Delta in ASES score	29.2 ± 22.9	34.6 ± 25.2	.669
Subluxations (never, rarely occasionally, frequently)	Never (range, never-occasionally)	Rarely (range, never-frequently)	.035[b]
Able to return to fitness program, % (n)	88.9 (16/18)	40.0 (6/15)	.013[b]
Patient satisfaction with outcomes (1-10; 10 = best), median (range)	10 (5-10)	9 (2-10)	.003[b]
Modified activities postoperatively because of pain, % (n)	5.6 (1/18)	33.3 (5/15)	.072
Modified activities postoperatively because of feeling of instability, % (n)	11.1 (2/18)	46.7 (7/15)	.012[b]
Modified activities postoperatively because of fear of reinjury or further surgery, % (n)	11.1 (2/18)	46.7 (7/15)	.046[b]

[a]Data are presented as mean ± SD unless otherwise specified. ASES, American Shoulder and Elbow Surgeons.
[b]Statistically significant difference ($P < .05$).

than female patients at the time of surgery (26 vs 21 years, respectively; $P = .017$) and had more associated intra-articular injuries, such as anterior and posterior labral tears ($P = .005$), chondral Hill-Sachs lesions ($P = .002$), and SLAP tears ($P = .006$). Of interest, male patients had a higher mean ASES score preoperatively (67.6 vs 50.0, respectively; $P = .037$) and had a significantly higher mean postoperative ASES score (97.0 vs 85.5, respectively; $P = .023$) than female patients, but both had similar improvements in their ASES scores (Table 6). Significant differences in the pain component of the ASES score were found across sexes, with female patients reporting higher levels of pain than male patients. Male patients were slightly more satisfied with their surgical outcomes than female patients (10 vs 9, respectively; $P = .003$).

Traumatic Versus Atraumatic Onset

The outcome scores of patients with either a traumatic or atraumatic onset of instability all improved significantly from preoperative levels ($P < .05$), except for the SANE score in patients with an atraumatic onset ($P = .128$). There was a significant association between a traumatic onset and labral injuries ($P < .001$). At final follow-up, patients with a traumatic onset of MDI had higher ASES scores, had fewer subluxations, and were significantly more satisfied with surgical outcomes (10 vs 9, respectively; $P = .029$) than those with an atraumatic onset (Table 7).

Outcomes of Patients With and Without RIC

Thirteen shoulders (11 female, 2 male) had remaining anterior or inferior translation of >1 cm during intraoperative examinations after APC with suture anchors and therefore underwent an additional RIC procedure. The onset of MDI was rated as atraumatic in 10 shoulders and traumatic in 3 shoulders. Shoulders with RIC (n = 13; 19.6 ± 4.7 years) were significantly younger than shoulders without an additional RIC procedure (n = 32; 25.3 ± 7.2 years). No significant differences in outcome scores were observed between these 2 groups, except for a higher mean ASES score in shoulders without RIC (Table 8).

DISCUSSION

In this study, APC with suture anchors for the treatment of MDI resulted in improved function, high survivorship, low complications, and low revision rates. The mean improvement in the ASES score of 31 points from preoperative to final follow-up was clinically significant, given that the minimal clinically important difference for the ASES score is 12 to 17 points.[13,24,26] Male patients were older than female patients in this study and had significantly better preoperative and postoperative ASES scores, although the amount of improvement was not significantly different. Labral tears were common, even in the atraumatic group. Overall, outcomes were favorable in male patients and in patients with a traumatic onset of MDI. At final follow-up, 76.7% indicated that they had returned to sports participation equal to or slightly below their preinjury level. Kaplan-Meier survivorship analysis demonstrated that shoulder stability was 100% at 1 year and 87% at 3 years.

The initial treatment of MDI had traditionally been strictly nonoperative with a supervised physical therapy program. However, published results of this treatment have, in some series, been suboptimal.[4,19] While Burkhead and Rockwood[4] reported 80% good-to-excellent results in

TABLE 7
Comparison of Outcome Measures by Onset of MDI[a]

Outcomes	Traumatic	Atraumatic	*P* Value
Preoperative ASES score	56.4 ± 23.5	56.1 ± 21.5	.395
Preoperative pain component of ASES score (0-50; 50 = best)	34.7 ± 14.0	27.3 ± 12.7	.152
Postoperative ASES score	96.4 ± 6.9	87.0 ± 15.7	.048[b]
Postoperative pain component of ASES score (0-50; 50 = best)	48.6 ± 4.1	42.8 ± 10.8	.031[b]
Subluxations (never, rarely occasionally, frequently)	Never (range, never-rarely)	Rarely (range, never-occasionally)	.011[b]
Able to return to fitness program, % (n)	83.3 (15/18)	43.8 (7/16)	.030[b]
Patient satisfaction with outcomes (1-10; 10 = best), median (range)	10 (8-10)	9 (2-10)	.029[b]
Modified activities postoperatively because of pain, % (n)	16.7 (3/18)	18.8 (3/16)	>.999
Modified activities postoperatively because of feeling of instability, % (n)	22.2 (4/18)	37.5 (6/16)	.250
Modified activities postoperatively because of fear of reinjury or further surgery, % (n)	22.2 (4/18)	31.3 (5/16)	.703

[a]Data are presented as mean ± SD unless otherwise specified. ASES, American Shoulder and Elbow Surgeons; MDI, multidirectional instability.
[b]Statistically significant difference ($P < .05$).

TABLE 8
Subjective Outcomes of Shoulders Treated With and Without an Additional RIC Procedure[a]

Postoperative Scores	Shoulders With Additional RIC (Mean, 3.4 y; Range, 2-4.8 y)	Shoulders Without RIC (Mean, 3.2 y; Range, 2-6.6 y)	*P* Value
ASES	85.6 (57-100)	94.6 (62-100)	.025[b]
SANE	83.4 (49-99)	90.9 (59-99)	.401
QuickDASH	14.3 (0-56.8)	6.3 (0-50.0)	.233
SF-12 PCS	53.0 (32-60.5)	56.2 (48.3-59.0)	.383

[a]Data are presented as mean (range). ASES, American Shoulder and Elbow Surgeons; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; RIC, rotator interval closure; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form–12 Physical Component Summary.
[b]Statistically significant difference ($P < .05$).

66 patients treated nonoperatively, Misamore et al[19] followed 36 young patients treated nonoperatively for a minimum of 8 years and found only 35% with good-to-excellent results and 52% reporting poor results. Consequently, there has been an increase in the surgical management of patients with MDI in case of failed nonoperative treatment.

Neer and Foster[21] described the open capsular shift procedure in 1980, which has shown promising results with up to a 95% success rate for reducing recurrent instability, although the outcome measures were less strict than used in the present study. As arthroscopic skills and equipment have advanced, there has been an increased use of the arthroscopic management of MDI.[12,21,22] One of the major advantages of arthroscopic treatment is the ability to address both the anterior and posterior aspects of the shoulder capsule with one surgical technique. One of the first arthroscopic techniques was thermal capsulorrhaphy, which was appealing for its ease of use and immediate visual feedback of capsular volume reduction. However, complications such as thermal chondrolysis and thermal nerve damage occurred, and the failure rates of up to 60% were unacceptably high.[9] Arthroscopic shoulder stabilization procedures with capsular shift and suture anchors have become the standard for the treatment of MDI in past years.[17,25] For example, Sekiya et al[25] demonstrated that multiple-pleated arthroscopic capsular plication provided even greater capsular volume reduction than open inferior capsular shift in a cadaveric model. This suggests that arthroscopic capsular plication can be as or even more effective than open shift to reduce the capsular volume. A recent study by Martetschlager et al[17] has shown that suture anchor repair performs well biomechanically in the anterior and posterior shoulder capsule. These results have translated clinically for patients with MDI, as in the present study, which has shown that APC with suture anchors results in good stability and function with low complication and revision rates.

Gartsman et al,[6] in 2001, published results on 47 patients who underwent arthroscopic capsular plication, with 94% good or excellent results. They found that the ASES, Constant, and University of California, Los Angeles (UCLA) scores all significantly improved from preoperatively to final follow-up. They also reported that 85%

returned to their previous level of sporting activities. Similarly, Baker et al,[3] in 2009, reviewed the 2- to 5-year clinical outcomes of 43 shoulders with MDI treated with arthroscopic capsular plication. ASES scores and Western Ontario Shoulder Instability Index (WOSI) scores both significantly improved, and they reported an 86% return-to-sport rate. Treacy et al[28] retrospectively reviewed 25 patients at an average of 60 months postoperatively. Eighty-eight percent had a satisfactory result, while 3 of 25 had episodes of recurrent instability. In the present study, patients had significantly improved outcome scores, and 76.7% (23/30) of the athletes returned to their prior level of sports participation at equal to or slightly below their preinjury level. Both Gartsman et al[6] and Baker et al[3] suggest that return to play may be superior in properly selected patients. Certainly, participation is easier for some sports than others. Unfortunately, despite the wide range of sporting activities in our cohort, the limited numbers in each sport make subgroup analysis difficult, and counseling patients regarding return to play still relies on clinical judgment. However, the present study does highlight the fact that patients with a traumatic onset of MDI are more likely to return to sports participation than those whose MDI had an atraumatic onset (83% vs 44%, respectively). Looking specifically at overhead athletes, a recent publication by Ma et al[16] evaluated pancapsular plication for MDI in 25 overhead athletes with a mean age of 23 years (range, 19-33 years) in 17 men and 8 women. All patients reported good-to-excellent results based on ASES, Constant, and Rowe scores. However, only 5 of 25 (20%) were able to return to the same level of sport. The remainder were able to return but at a limited level.

Hewitt et al[11] examined 30 shoulders with purely atraumatic MDI without associated labral tears in 2003. The patients underwent arthroscopic pancapsular plication without suture anchor fixation. Good-to-excellent results were reported in 83% of patients, and they had 97% return to sport, 20% of whom returned at a lower level from preoperatively.[11] In contrast, Alpert et al[1] published their results of pancapsular shift for MDI in 13 patients, all of whom had labral tears of at least 270°. In their series, 15% (2/13) had recurrent instability, but none were revised. Also, 69% (9/13) of patients were completely satisfied, 15% (2/13) were mostly satisfied, and 15% (2/13) were completely unsatisfied.[1]

Several newer studies have shown that the origin of MDI lies on a diverse continuum. Patients can have a completely atraumatic onset of MDI or suffer it after traumatic injuries that create panlabral lesions around the entire glenoid.[1,27] This also highlights the challenges in defining MDI. Gerber and Nyffeler[9] in 2002 subclassified MDI into MDI with and without hyperlaxity. Thereafter, the latter is associated with injuries causing instability.[9] MDI is a clinical diagnosis but likely represents a variety of pathoanatomic findings from hyperlaxity and a patulous capsule without labral tears to panlabral tears. With a clear clinical definition of MDI as symptomatic instability in more than one direction, one of which was inferior, we surprisingly found a variety of different pathoanatomic findings. We were surprised by the prevalence of labral tears present. The pathoanatomy was also associated with the outcome scores. For example, patients with labral tears had a significantly higher mean postoperative ASES score (97.5 vs 83.1, respectively; $P = .003$) and SANE score (93.2 vs 82.2, respectively; $P = .040$) than those without a discrete labral tear, demonstrating that patients with a labral lesion can expect better outcomes. When no discrete labral tear was present, only the typical patulous capsule was found, RIC was frequently added, and the outcomes were less favorable. These patients likely have atypical collagen with pathological hyperlaxity and a greater tendency to "stretch out" their repairs.

Only a subset of patients had distinct clinical signs of hyperlaxity. However, because no assessment of a specific hypermobility score was conducted, the "true" percentage of relevant hyperlaxity may remain unclear. The definition of traumatic versus atraumatic MDI was not necessarily linked to the cause of MDI but to the onset of MDI. Patients were rated as having a traumatic onset of MDI if a distinct traumatic event led to the development of instability symptoms for which the patient was seeking medical advice and treatment. Patients with atraumatic MDI, on the other hand, had symptoms of instability without an association to a traumatic event. Because dislocations and subluxations may occur in both groups and a patulous capsule was pathognomonic in all patients, both groups of patients could contain persons with concomitant lesions such as labral tears or with known hyperlaxity. With this clinical subclassification of MDI, the variety of pathoanatomic findings remains unchanged, however, and a prediction of concomitant findings, the likelihood for concomitant procedures and outcomes, and more specified patient counseling become possible.

The rationale for performing an additional RIC procedure was linked to the subjective assessment of the senior surgeon. Although the effect of RIC on glenohumeral translation has been shown to be biomechanically limited, recent work suggests a significant reduction in the capsular volume by RIC.[7,8,20,23] The senior surgeon had the intraoperative clinical impression that the capsular volume was still significantly increased after APC, and patients had accompanying increased translation in these cases. Patients with RIC had similar subjective outcomes as patients without RIC with regard to the SF-12 PCS, SANE, and QuickDASH scores, which suggests that these patients may have had a benefit from the additional procedure. However, the lower ASES scores for patients with RIC may be an indicator of a more severe injury.

The results from our study are consistent with those from the other case series outlined above. One of the most promising findings of the present study was an 87% survivorship rate at 3 years postoperatively for patients with MDI treated with APC with suture anchors. In this study, survivorship was strictly defined as no further dislocations or feelings of frequent subluxation. In addition to high survivorship rates, there were also significant increases in outcome scores from preoperative levels. Those patients with a traumatic onset of instability had better results than those with an atraumatic onset, although outcome scores improved in both groups. Baker et al[3] also found that postoperative scores, including the ASES, the WOSI, and subjective reporting on stability, pain, function, range of motion, and strength, were higher in the group with a traumatic onset of instability. In the

present series, all patients were highly satisfied, although patients with a traumatic onset were significantly more satisfied with outcomes.

Limitations

This is a retrospective cohort study with outcomes based on mail questionnaires. The patients were not examined clinically after 6 months postoperatively, which limited an objective assessment of instability. The follow-up questionnaire included an assessment of several subjective outcome tools and the commonly used ASES score, which has been validated for use in shoulder stability, even though it does not contain a domain measuring instability directly.[13] Because no specific hyperlaxity screening was conducted, the "true" rate of hyperlaxity and its effect on outcomes remain unclear in the present cohort. As a further limitation, there was no control group for comparison of the treatment modality (eg, open pancapsular capsulorrhaphy). We were able to determine survivorship based on a 93.3% follow-up of the study group, although the outcome analysis was performed with an 85% follow-up. Despite multiple emails, mailed questionnaires, registered letters, and telephone conversations to patients, we were not able to obtain follow-up questionnaires for outcome score analysis, thus limiting the data analysis. While our patient population was active and relatively young, there was no way to account for those patients who stopped competing because of a lifestyle change such as graduating from high school or college.

CONCLUSION

APC with suture anchors can be an effective and safe treatment for patients with MDI. A labral injury was commonly found, even in patients with a classic, atraumatic onset. Male patients and patients with a traumatic onset of MDI had more favorable outcomes. Female patients may be more challenging to treat as they were more likely to undergo an additional RIC procedure and experience postoperative subluxations.

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