Clinical Outcomes After Arthroscopic Pancapsular Shift for the Treatment of Multidirectional Glenohumeral Instability at a Mean Follow-up of 9 Years

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Background: Arthroscopic treatment of multidirectional instability (MDI) of the shoulder is being increasingly performed, but there is a paucity of studies with minimum 5-year follow-up.

Purpose: To report on survivorship and patient-reported outcomes (PROs) after arthroscopic pancapsulorraphy (APC) for MDI with a minimum 5-year follow-up.

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

Methods: Institutional review board approval was obtained before initiation of this retrospective review of prospectively collected data. Patients were included if they had a minimum of follow-up 5 years after APC for MDI. PROs included the 12-Item Short Form Health Survey Physical Component Summary; American Shoulder and Elbow Surgeons; Single Assessment Numeric Evaluation; shortened version of Disabilities of the Arm, Shoulder and Hand; and patient satisfaction. Preoperative, short-term (1-2 years), and final follow-up PROs were compared. Recurrent instability, dislocation, and reoperation were collected, and survivorship analysis was performed.

Results: A total of 49 shoulders in 44 patients (15 male, 29 female) treated between October 2005 and November 2015 were included in the study. MDI onset was atraumatic in 27 shoulders and traumatic in 22. Rotator interval closure was performed in 17 patients. Overall, 14 of 49 (29%) patients reported feelings of instability in the shoulder, of whom 5 (10.2%) underwent revision surgery at a mean of 1.5 years. Kaplan-Meier analysis demonstrated a survivorship rate of 88% at 5 years and 82% at 8 years, with failure defined as requiring revision surgery or postoperative feelings of instability with ASES score <65. Final outcome analysis was performed on 41 shoulders with a mean follow-up of 9.0 years (range, 5.1-14.6 years). All PROs demonstrated significant improvement from preoperative baseline ($P < .05$) and remained significantly improved at both short-term and long-term final follow-up. There was no difference in PROs based on \\ atraumatic versus traumatic onset, or patients treated with a rotator interval closure. There was a significant difference in PROs between patients who had continued instability.

Conclusion: APC for the treatment of MDI provided reasonable, durable long-term PROs that persisted from short-term follow-up. Although 29% of patients experienced feelings of instability at final follow-up, most of these patients still had high postoperative satisfaction and acceptable PROs.

Keywords: shoulder instability; multidirectional instability; capsular shift; patient-reported outcomes; shoulder arthroscopy

Multidirectional instability (MDI) of the shoulder is a challenging diagnosis both for patients with this disorder and for surgeons treating it. The most common definition of MDI is that of symptomatic instability of the shoulder joint that occurs in at least 2 directions, 1 of which is inferior, as manifested by the sulcus sign on physical examination.[9,22] In reality, MDI can occur after an injury[10,22] or atraumatically, as has been classically described in patients with hyperlaxity using the well-known mnemonic "AMBRI" (atraumatic, multidirectional, bilateral, rehabilitation, inferior capsular shift). The first-line treatment for MDI of the shoulder is typically a prolonged physical therapy program of at least 1 year, although this is not effective in all patients, especially in the young, active population.[18]

In those patients with unsuccessful nonoperative treatment, either open capsular shift or arthroscopic capsulorrhaphy has been developed as a possible treatment option. Open capsular shift was first described by Neer and Foster[20] in 1980 and remains a viable treatment option for MDI, with failure rates reported between 5%

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and 45% in the literature, although definitions for surgical failure range from the need for reoperation to postoperative dislocation to subluxation.[2,5,6,11,12,21] Advancements in technology and techniques have led to the development of the arthroscopic pancapsulorraphy (APC), which allows surgeons to address all aspects of the capsule. Using suture anchors on the glenoid rim, surgeons address both sides of the joint simultaneously, and the capsular volume is decreased to a greater degree than with an open shift.[4,8,23] A number of studies have demonstrated promising short-to-midterm results after arthroscopic pancapsular shift for MDI, with failure rates ranging from 5% to 38% and overall good functional and patient-reported outcomes (PROs) with a minimum 1- to 2-year follow-up.[1,3,16,19,22,24,25] Raynor et al[22] demonstrated that 83.3% of patients had stable shoulders at a mean 3.3 years postoperatively, with only 3 of 45 shoulders requiring revision surgery. Importantly, this study noted significant differences between male patients with traumatic MDI and female patients with atraumatic MDI, with female patients with atraumatic MDI more likely to have decreased postoperative outcome scores, a higher incidence of postoperative subluxations, and a lower return to sports rate.[22] Given that most patients with MDI are young and active, understanding the longer-term outcomes of this treatment intervention is important. One concern is the possibility that pathologic capsular tissue may "stretch out" over time, leading to late instability and declining patient function not captured in the current literature focusing on short-term results. Meanwhile, patients with traumatic MDI may expose themselves to higher-risk activities, calling into question whether the arthroscopic repair can withstand repetitive trauma over a longer time course. Unfortunately, to our knowledge, there are no studies looking at longer-term outcomes of APC for MDI.

The purpose of this study was to report on the mid- to long-term failure rates (as defined by recurrent sensation of instability) and PROs for patients with MDI undergoing APC with a minimum 5-year follow-up. Second, this study sought to compare PROs between early postoperative follow-up and final follow-up at ≥5 years postoperatively to better understand the durability of the APC procedure. Finally, we sought to compare the long-term difference in outcomes for atraumatic versus traumatic cases of MDI to determine if differences present at short-term follow-up persisted. We hypothesized that APC in this patient population would have reasonable long-term outcomes, with some deterioration in outcomes over time from the results seen at short-term follow-up, and that the traumatic onset of MDI would be associated with better outcomes compared with atraumatic-onset MDI.

METHODS

This retrospective review of prospectively collected data was conducted with approval from the Vail Health Hospital institutional review board (under study No. VHH-2021-063). Informed consent was obtained. Between October 2005 and November 2015, all patients aged 14 to 45 years at the time of surgery for instability in multiple directions by the senior surgeon (P.J.M.) were reviewed. Patients included in this study had a history of subluxation and/or dislocation. MDI was diagnosed clinically and defined for the purposes of this study as instability in ≥2 directions, of which 1 was inferior. Patients were examined and diagnosed with MDI in the clinical setting, and this diagnosis was confirmed in the operating room before surgery via an examination under anesthesia. Inferior instability was assessed via a sulcus sign, with a positive test being ≥1 cm of inferior humeral head translation at neutral and/or in external rotation.[15] Anterior instability was assessed using the apprehension test and relocation test. The Jerk test was used to determine posterior instability.[17] Examination under anesthesia was also used in assessing the degree of anterior (load and shift), posterior (load and shift), and inferior translation (sulcus >1 cm). The presence of hypermobility in other joints was assessed but not quantified, nor did patients undergo testing for connective tissue disorders. Patients were excluded from this study if they previously refused to participate in research studies or were out of the country and were unable to be contacted. In addition, to avoid additional confounding variables, patients were excluded who had a previous shoulder surgery, had a surgery that did not include APC, or if there was not inferior instability documented in the clinic or operative notes as denoted by a sulcus sign of ≥1 cm. Patients in whom the sulcus sign was not documented were also excluded.

Surgical Technique

The senior author's (P.J.M.) preferred surgical technique for APC has previously been described.[22] An examination

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under anesthesia was performed for each patient to assess preoperative range of motion and laxity. MDI instability was confirmed via a positive sulcus sign with inferior translation >1 cm and grade 2 or higher anterior and/or posterior translation. Patients were then placed in the lateral decubitus position, and diagnostic arthroscopy through a standard posterior portal was performed to assess associated intra-articular injuries, potential glenoid bone loss, and capsular laxity. Two anterior working portals were established in the rotator interval, as well as an accessory posterolateral portal to facilitate anchor placement posteriorly. Repairs were always performed using suture anchors (2.4-mm SutureTak and 2.9-mm PushLock [Arthrex] or 2.9-mm JuggerKnot [Zimmer-Biomet]). The posterior labrum and capsule were addressed first. A shuttling instrument was used to pass sutures through the capsule and around the labrum, and an arthroscopic Weston knot was tied to plicate the capsule and reduce the volume of the patulous inferior capsule. At least 3 anchors were placed posteriorly in the glenoid, starting inferiorly and working cephalad. Subsequently, the anterior labrum and capsule were addressed in a similar manner, with a minimum of 3 suture anchors in the anterior glenoid. If present, Bankart or reverse Bankart lesions were reduced to the glenoid rim concurrently with the capsular shift. Superior labrum anterior and posterior tears were addressed using suture anchors, typically 1 anterior and 1 posterior to the biceps anchor.

Of note, in current practice, although the steps are similar, the senior author has transitioned to beach-chair positioning and knotless, all-suture anchor constructs (FiberTak suture anchors; Arthrex) to reduce the anchor and knot burden on the joint for these procedures.[14]

Upon completion of the capsulorraphy procedure, the shoulder stability was once again assessed via examination by the senior surgeon. If there was evidence of persistent anterior capsular laxity or persistent translation anteriorly or inferiorly, a rotator interval closure (RIC) was performed as previously described.[22]

Postoperative Rehabilitation

Postoperatively, the operative shoulder was immobilized in a padded abduction sling with the arm in neutral rotation with 20° of abduction for 4 to 6 weeks. Distal range of motion exercises were permitted starting immediately after surgery. Passive range of motion was typically initiated 6 weeks after surgery, with the exception of patients with noted hypomobility at the 2- to 3-week follow-up visit, as identified by less than neutral external rotation and <45° of abduction, in which case motion would be started at 4 weeks after surgery. Rotator cuff muscle strengthening typically began at 6 weeks postoperatively, with full return to activity anticipated at 4 to 6 months after surgery.

Patient Characteristics and Operative Data

Patient characteristics, including age, sex, injury mechanism, and operative data, were collected from the institutional database of prospectively collected data. Any missing data or discrepancies found in the data were reconciled via chart review.

Questionnaire Administration

Questionnaires were given to patients to complete at the time of initial presentation and/or before surgery. After surgery, patients were sent questionnaires annually. Patients who did not have minimum 5-year outcomes were contacted regarding their willingness to participate in this study and, if so, were sent a questionnaire.

PRO Assessment

PROs were collected preoperatively and at final follow-up. PROs collected included the following: 12-Item Short Form Health Survey Physical Component Summary (SF-12 PCS; higher scores correspond with better health) score; American Shoulder and Elbow Surgeons (ASES; 100 = best score) score; Single Assessment Numeric Evaluation (SANE; 100 = best score) score; shortened version of Disabilities of the Arm, Shoulder and Hand (QuickDASH; 0 = best score) score; and patient satisfaction (scale, 1-10; 1 = very unsatisfied, 10 = very satisfied).

Subjective assessment of feelings of instability pre- and postoperatively was assessed using the question "How often does your shoulder feel like it will go out?" Answer options included never, rarely, occasionally, and frequently. Pre- and postoperative subjective painless use of the arm was assessed using the question "At what level can you use your arm for painless, reasonably strong activities?" Answer options included overhead, up to top of head, up to neck, up to nipple line, or up to waist. Patients who reported playing sports were asked to grade their level of participation compared with their preinjury level using the following options: equal to or above, slightly below, moderately below, significantly below, cannot compete in my usual sport, or cannot compete in any sports. Subjective assessment of shoulder stability improvement postoperatively was assessed using the question "How stable does your shoulder feel compared with before your injury?" Answer choices included much better, better, same, worse, or much worse.

An analysis of PRO (SF-12 PCS, ASES, SANE, and QuickDASH) progression over time was performed using data from patients who had preoperative, early postoperative (7-31 months), and postoperative data available at a minimum of 5 years.

A subgroup analysis was performed to compare PROs and subjective outcomes for those who had atraumatic or traumatic MDI. Traumatic MDI included those who had instability after a specific injury to the shoulder, such as during a crash while snowboarding or bicycling. Similar subgroup analyses were then performed on shoulders undergoing RIC.

In addition, subjective feelings of instability, recurrent instability or dislocation, and reoperation were reported. Finally, recognizing a group of patients who had recurrent

TABLE 1
Patient Characteristics and Concomitant Pathology and Treatments[a]

Characteristic	Value
Age at the time of surgery, mean (range), y	22 (14-41)
Male/female (44 patients), n	15/29
Atraumatic/traumatic multidirectional instability in shoulders, n	27/22
Hill-Sachs lesion	11/49 (22.4)
Treatment of super labrum, anterior to posterior, tears	18/49 (36.7)
Debridement	3/18 (17.0)
1-anchor repair	7/18 (33.0)
2-anchor repair	8/18 (50.0)
Rotator interval closure	17/49 (34.7)

[a]Values are presented as number (%) unless otherwise indicated.

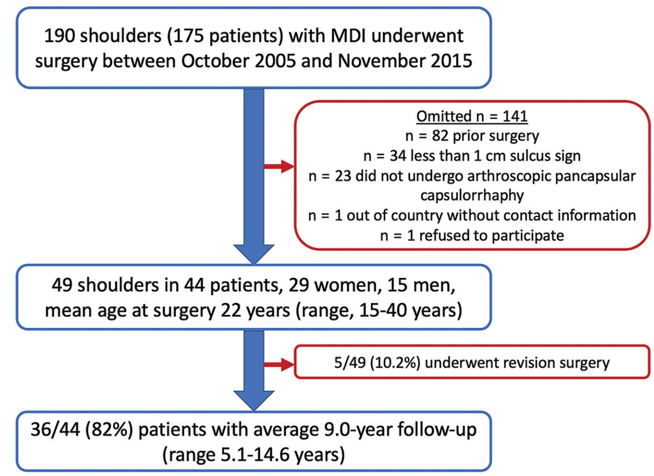

Figure 1. Study flow diagram for determining the final study population. MDI, multidirectional instability.

subjective feelings of instability in the shoulder but did not undergo revision surgery, we sought to delineate them into 4 groups, with groups 3 and 4 constituting having a "surgical failure": group 1, no feelings of instability; group 2, feelings of instability or dislocation with acceptable result (ASES ≥65); group 3, feelings of instability or dislocation with no acceptable results (ASES <65); and group 4, revision surgery. The ASES cutoff was determined via our baseline mean ASES score.

Statistical Analysis

Univariate analyses were performed using an independent *t* test for normally distributed variables. Mann-Whitney or Fisher exact test was performed for data that were not normally distributed or for bivariate comparisons. Data analysis was done with Mann-Whitney U test. Chi-square was used for 2 bivariate variables. Wilcoxon signed rank test was used to detect differences between pre- and postoperative variables. Survivorship analysis was performed using the Kaplan-Meier survival curve for feelings of instability and/or postoperative dislocation and/or revision surgery as an end point. The level of significance was set at $P < .05$. Statistical analyses were performed using SPSS Version 11.0 (SPSS, Inc).

RESULTS

Of a total of 190 shoulders (175 patients) with MDI that underwent surgery between October 2005 and November 2015 by the senior surgeon, 141 shoulders met exclusion criteria. A full breakdown of shoulders that met the exclusion criteria in this study is detailed in the study flow diagram (Figure 1). Overall, 49 shoulders (44 patients) in 15 male and 29 female patients met the inclusion criteria, with a mean age of 22 years (range, 15-40 years) at the time of surgery. There were 5 bilateral shoulders included in the study. Five (10.2%) of these shoulders underwent revision surgery, and thus the final outcome analysis was performed in the remaining 44 shoulders. Minimum 5-year subjective outcomes were collected on 36 of 44 (82%) shoulders, with a mean follow-up length of 9.0 years (range, 5.1-14.6 years). Patient characteristics along with concomitant pathology and treatments are detailed in Table 1.

Postoperative Feelings of Instability, Dislocations, and Revision Surgery

Overall, 14 of 49 (29%) shoulders reported feelings of shoulder instability, of whom 8 of 49 (16.3%) had a postoperative dislocation and 5 (10.2%) progressed to have another surgery at a mean of 1.5 years after the index surgery. Of the 14 patients reporting feelings of shoulder instability, 5 had traumatic MDI, and 9 had atraumatic MDI ($P = .741$).

Defining Surgical Failures

Overall, 9 patients reported shoulder instability or dislocation postoperatively but did not elect to undergo revision surgery. The PROs and satisfaction for this group were compared with those for patients who did not report instability postoperatively, and statistically significant differences were found in SF-12 PCS, ASES, and QuickDASH (all $P < .031$) (Table 2). Finally, surgical successes and failures were identified. There were 27 shoulders in group 1 (stable shoulder postoperatively), 6 shoulders in group 2 (feelings of instability or dislocation with acceptable result; ASES >65), 3 shoulders in group 3 (feelings of instability or dislocation with unacceptable results; ASES <65), and 5 shoulders in group 4 (requiring revision surgery). The survivorship curve, with "surgical success" defined as being in group 1 or 2, was 88% at 5 years postoperatively and 82% at 8 years postoperatively (Figure 2). In terms of revision surgery, 5 patients underwent surgery at a mean 1.5 years (range 5-48 months). 1 patient did well for a year postoperatively but then began having feelings of shoulder

TABLE 2
Postoperative Patient-Reported Outcomes for Surviving Patients[a]

Postoperative PROs	Patient Not Reporting Instability Postoperatively (n = 35)	Instability and/or Dislocation Postoperatively (n = 9)	*P* Value
SF-12 PCS	56.6 ± 3.1	52.9 ± 5.0	**.031**
ASES	93.4 ± 7.7	79.2 ± 19.0	**.012**
SANE	91.4 ± 10.2	84.4 ± 12.7	.154
QuickDASH	6.3 ± 6.8	22.9 ± 17.9	**.006**
Patient satisfaction	10 (3-10)	10 (5-10)	.578

[a]Values are presented at mean ± SD or median (range). ASES, American Shoulder and Elbow Surgeons; PRO, patient-reported outcome; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary. Bold values represent statistical significance (p<0.05).

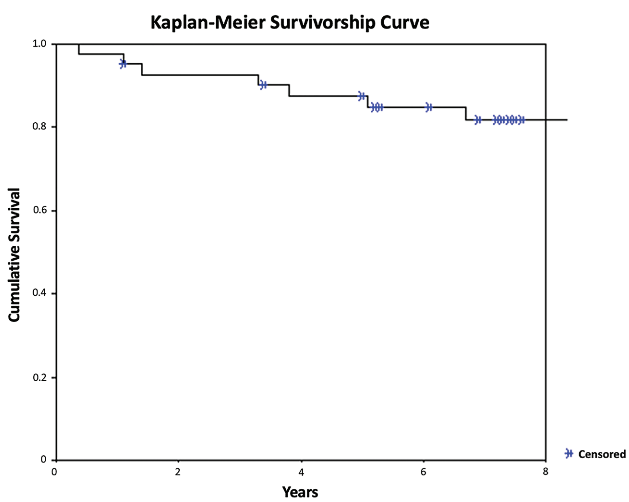

Figure 2. Kaplan-Meier survivorship curve demonstrating survivorship as defined by ''surgical success'' of 88% at 5 years and 82% at 8 years postoperatively.

instability with activities of daily living and progressed to a Latarjet procedure. Another was a professional athlete who reported having a dislocation while stretching approximately 1 year after surgery and progressed to a Latarjet procedure with an open inferior capsular shift. Approximately 5 months postoperatively, another patient had a traumatic subluxation of the operative shoulder in which his arm was forcibly pulled out and later underwent hardware removal and revision anterior and posterior capsulorrhaphy. Another shoulder had recurrent anterior and posterior symptoms of instability 3 years after surgery and later underwent hardware removal and a Latarjet procedure with open anterior capsulorrhaphy. Finally, 1 patient indicated having another surgery on the operative shoulder for instability on the questionnaire 4 years after surgery without additional details on the specific injury or procedure.

PRO Measures

Preoperative and postoperative mean PRO scores, ranges, and *P* values for the entire group are detailed in Table 3. Compared with preoperative baseline, SF-12 PCS, ASES,

TABLE 3
Pre- and Postoperative Outcomes Scores[a]

PROs	Preoperative	Postoperative	*P* Value
SF-12 PCS	42.5 (28.7-57.8)	55.7 (45.5-63.1)	**<.001**
ASES	61.6 (21.6-100)	89.7 (48.3-100)	**<.001**
SANE	59.2 (5-98)	89.7 (59-99)	**<.001**
QuickDASH	40.8 (2.2-79.5)	10.5 (0-50)	**<.001**

[a]Values are presented as mean (range). ASES, American Shoulder and Elbow Surgeons; PRO, patient-reported outcome; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary. Bold values represent statistical significance (p<0.05).

SANE, and QuickDASH scores all significantly improved at the time of final follow-up. Median patient satisfaction was 10 of 10 (range, 1-10; 10 = best). Median subjective painless use of the arm with reasonably strong activity preoperatively was up to nipple line (range, up to waist to overhead) and improved postoperatively to overhead (range, up to nipple line to overhead; $P < .001$). Preoperatively, median subjective feelings of instability occurred occasionally (range, rarely to frequently) and improved postoperatively to rarely (range, never to frequently; $P = .003$). Before surgery, median patient sports participation was reported as significantly below preinjury level (range, equal to or above to cannot compete in any sports), and postoperatively, sports participation improved to equal to or above preinjury level (range, equal to or above to cannot compete in my usual sport; $P = .002$) (Table 4).

PROs Over Time

Overall, 21 of 44 (48%) patients had preoperative, early outcomes (7-31 months) and final follow-up available, which was used to analyze PROs over time (Figure 3). There was a significant improvement from preoperative baseline to early outcomes in SF-12 PCS ($P < .001$), ASES ($P < .001$), SANE ($P = .002$), and QuickDASH ($P < .001$). There was also a significant improvement from preoperative baseline to final follow-up in SF-12 PCS ($P < .001$), ASES ($P < .001$), SANE ($P = .005$), and QuickDASH

TABLE 4
Patient Subjective Results Pre- and Postoperatively as Well as for Traumatic vs Atraumatic MDI[a]

Characteristic	Preoperative (Range)	Postoperative (Range)	P Value
At what level can you use your arm for painless, reasonably strong activities? (Answer choices: overhead, up to top of head, up to neck, up to nipple line, or up to waist)	Up to nipple line (up to nipple line to overhead)	Overhead	<.001
How often does your shoulder feel like it will go out? (Answer choices: never, rarely, occasionally, frequently)	Occasionally (rarely to frequently)	Rarely	.003
How stable does your shoulder feel compared with before your injury? (Answer choices: much better, better, same, worse, or much worse)	Worse (better to much worse)	Much better	.001
Level of sports participation? (Answer choices: equal to or above, slightly below, moderately below, significantly below, cannot compete in my usual sport, or cannot compete in any sports)	Significantly below preinjury level (equal to or above to cannot compete in any sports)	Equal to or above preinjury	.002
	Atraumatic (Range)	Traumatic (Range)	
At what level can you use your arm for painless, reasonably strong activities? (Answer choices: overhead, up to top of head, up to neck, up to nipple line, or up to waist)	Overhead (up to nipple line to overhead)	Overhead (up to nipple line to overhead)	.650
How often does your shoulder feel like it will go out? (Answer choices: never, rarely, occasionally, frequently)	Rarely (never to frequently)	Rarely (never to frequently)	.757
How stable does your shoulder feel compared with before your injury? (Answer choices: much better, better, same, worse, or much worse)	Much better (much better to same)	Much better (much better to better)	.793
Level of sports participation? (Answer choices: equal to or above, slightly below, moderately below, significantly below, cannot compete in my usual sport, or cannot compete in any sports)	Equal to or above preinjury (equal to or above to cannot compete in my usual sport)	Slightly below preinjury level (equal to or above to moderately below)	.944

[a]$P < .05$ is considered statistically significant. MDI, multidirectional instability.

(P = .001). Of note, there were no significant differences in PROs from the early outcomes to final follow-up at a mean of 8.3 years in SF-12 PCS (P = .105), ASES (P = .959), SANE (P = .483), and QuickDASH (P = .271).

Atraumatic Versus Traumatic Multidirectional Instability

PROs of patients with atraumatic MDI were compared with patients who had traumatic MDI (Table 5). There were no significant differences in PROs pre- or postoperatively between the groups. In terms of postoperative painless use of arm with reasonably strong activity, both groups' median reported level was overhead (range, up to nipple line to overhead; P = .650). Regarding postoperative instability, rarely having feelings of instability was the median in both groups (range, never to frequently; P = .757). The median reported shoulder stability compared with before surgery was much better in both the atraumatic (range, much better to same) and traumatic (range, much better to better) MDI groups (P = .793). The median level of sports participation postoperatively in the atraumatic MDI group was equal to or above preinjury level (range, equal to or above to cannot compete in my usual sport). The traumatic MDI group's median level of sports participation postoperatively was slightly below preinjury level (range, equal to or above to moderately below). In addition, there was no significant difference in the reported level of sports participation postoperatively compared with preinjury (P = .944) (Table 4).

Rotator Interval Closure

PROs of patients not undergoing or undergoing a RIC were compared (Table 6). Patients undergoing RIC had a statistically significantly lower ASES score at preoperative baseline as compared with those not undergoing a RIC. Meanwhile, at final follow-up, there were no statistically significant differences in any PROs, satisfaction, or recurrent instability.

DISCUSSION

In the present study, arthroscopic pancapsular shift for the diagnosis of MDI resulted in high patient satisfaction, lasting improvement of function, good survivorship, and low revision rates at a minimum follow-up of 5 years postoperatively. Median patient satisfaction was 10 of 10 postoperatively at a mean of 9 years. Although 29% of patients experienced subjective feelings of instability, only 16.3%

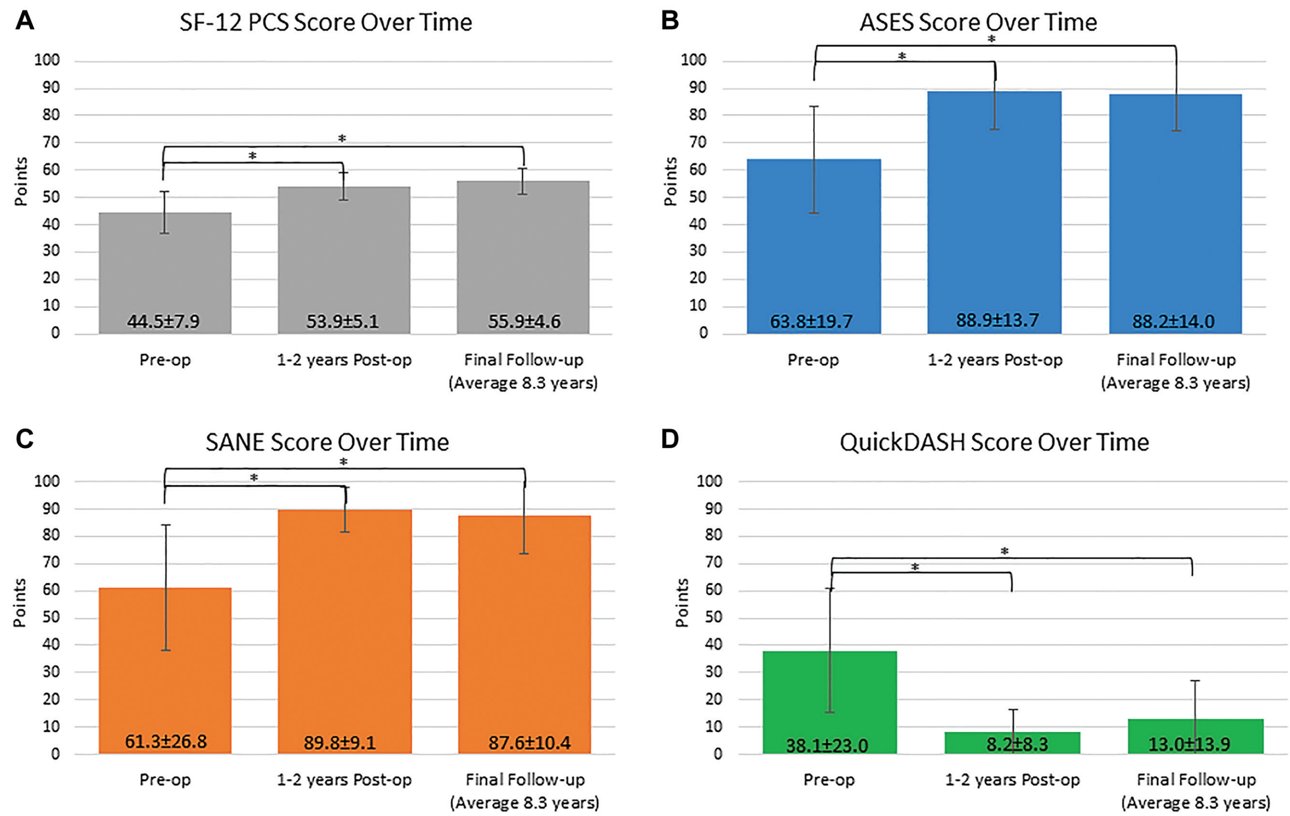

Figure 3. Mean and SD of patient-reported outcomes over time. (A) 12-Item Short Form Health Survey Physical Component Summary (SF-12 PCS) scores preoperatively (Pre-op), 1 to 2 years postoperatively (Post-op), and at final follow-up. (B) American Shoulder and Elbow Surgeons (ASES) scores preoperatively, 1 to 2 years postoperatively, and at final follow-up. (C) Single Assessment Numeric Evaluation (SANE) scores preoperatively, 1 to 2 years postoperatively, and at final follow-up. (D) Shortened version of Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores preoperatively, 1 to 2 years postoperatively, and at final follow-up. *Significant difference ($P < .05$).

TABLE 5
Patient-Reported Outcomes Between Patients With Atraumatic and Traumatic Multidirectional Instability[a]

Outcome Measure	Atraumatic (n = 27)	Traumatic (n = 22)	*P* Value
Preoperative SF-12 PCS	46.1 ± 8.7	41.3 ± 8.6	.236
Postoperative SF-12 PCS	45.5 ± 3.9	45.7 ± 4.2	.885
Preoperative ASES	66.3 ± 18.9	60.9 ± 25.4	.732
Postoperative ASES	87.6 ± 14.1	90.8 ± 14.4	.229
Preoperative SANE	69.8 ± 17.9	55.9 ± 22.9	.104
Postoperative SANE	88.4 ± 11.3	90.6 ± 11.4	.638
Preoperative QuickDASH	31.5 ± 22.7	42.7 ± 22.3	.343
Postoperative QuickDASH	11.9 ± 13.7	7.9 ± 11.5	.390
Postoperative patient satisfaction	10 (3-10)	10 (4-10)	.664

[a]Values are presented as mean + SD or median (range). ASES, American Shoulder and Elbow Surgeons; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary.

experienced a confirmed dislocation, and 10.2% required revision surgery. Survivorship analysis demonstrated surgical success of 88% at 5 years and 82% at 8 years postoperatively. Patients demonstrated statistically significantly improved PROs as compared with preoperatively, as measured using ASES, SANE, QuickDASH, and SF-12 PCS, all of which persisted from the 1- to 2-year follow-up until final follow-up nearly 9 years postoperatively. To the authors' knowledge, the present study has the longest follow-up of any publication on any surgical treatment of

TABLE 6
Patient-Reported Outcomes Between Patients Undergoing RIC and Those Not Undergoing RIC[a]

Outcome Measure	No RIC (n = 24)	RIC (n = 20)	P Value
Preoperative SF-12 PCS	42.2 ± 8.6	40.6 ± 6.3	.685
Postoperative SF-12 PCS	56.3 ± 3.1	54.6 ± 8.0	.382
Preoperative ASES	64.1 ± 21.3	47.3 ± 7.4	**.001**
Postoperative ASES	91.5 ± 9.7	86.4 ± 17.7	.717
Preoperative SANE	58.4 ± 26.1	62.6 ± 14.6	.735
Postoperative SANE	88.9 ± 11.9	91.0 ± 9.9	.537
Preoperative QuickDASH	40.8 ± 22.4	40.9 ± 24.2	.996
Postoperative QuickDASH	9.5 ± 11.3	12.4 ± 15.3	.972
Postoperative patient satisfaction	10 (3-10)	10 (5-10)	.757

[a]Values presented as mean + SD or median (range). Bold indicates statistical significance. ASES, American Shoulder and Elbow Surgeons; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; RIC, rotator interval closure; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary.

MDI. In addition, it is the only study to compare short-term outcomes with long-term outcomes for arthroscopic management of MDI.

Surgical management for patients with MDI has evolved over the years, transitioning from open to arthroscopic surgery as well as from capsular-based suture plication to anchor-based constructs. Neer and Foster[20] first described an open inferior capsular shift in 1980, reporting a failure rate of 6% at a 1- to 2-year follow-up as defined by recurrence of dislocation. Numerous other studies have reported variable midterm outcomes for open capsular shift between 2- and 5-year mean follow-up with failure rates reported between 5% and 45%.[2,5,6,11,12,21] Unfortunately, various outcome measures and differences in the definition of surgical failure make comparison of these studies challenging. Cooper and Brems[6] reported on 43 shoulders with a minimum 2-year follow-up, reporting a failure rate of 9%, as defined by an instability event, and a 24% failure rate, as defined by feelings of apprehension. Hamada et al[11] reported the longest follow-up series with a mean of 8.3 years and a minimum 2-year follow-up, noting a 26% incidence of instability postoperatively, all occurring within the first 3 years.

Numerous studies have reported on short-term postoperative outcomes after arthroscopic treatment of MDI. Treacy et al[24] reported on 25 shoulders with a mean 5-year follow-up, demonstrating a 12% rate of recurrent instability and 88% satisfactory results according to the Neer grading system. Baker et al[3] reported on 43 patients who were evaluated at a mean 2.8 years postoperatively, demonstrating excellent postoperative outcomes, with 93% having excellent or good stability, 86% able to return to sports, and a Western Ontario Shoulder Instability score of 91.1. Voigt et al[25] reported on an overhead athlete population, demonstrating a 38% recurrence rate requiring revision surgery and only 50% satisfaction at a mean 3-year follow-up, concluding that a return to high-performance overhead sports in the setting of MDI cannot be recommended due to low satisfaction and high risk of reinstability. Raynor et al[22] looked at the senior author's patients and demonstrated that 83.3% of patients had stable shoulders at a mean 3.3 years postoperatively, finding that female patients with atraumatic onset of MDI were more likely to have decreased postoperative outcome scores, higher incidence of postoperative subluxations, and lower return to sports rate.

Overall, the present study identified a rate of recurrent instability (as defined by a feeling of subluxation or instability) of 29% at a mean 9-year follow-up. We used the broadest and strictest definition of instability in our population to capture any patients with feelings of instability or subluxation, understanding that many instability events in this population can be subtle and do not necessarily require assisted reduction. Unfortunately, this broad definition makes it difficult to directly compare our study with some previously reported in the literature, where failure was defined as "reoperation" or "dislocation" or not clearly defined. Interestingly, most of the patients in our cohort reporting recurrent instability did not elect to undergo revision surgery and had relatively good PROs. Understanding this subgroup of relatively satisfied patients who nevertheless still experienced feelings of instability, we were able to redefine surgical failure as those patients who required revision surgery or those patients who chose not to undergo revision surgery but had feelings of recurrent instability and an unacceptable ASES score. With this definition, survivorship analysis demonstrated an 87% surgical success rate at 5 years and 82% at 8 years out from the intervention. Meanwhile, only 10.2% of the patients in our study required reoperation. Interestingly, most of the reoperations in this cohort occurred early in the postoperative period at a mean of 1.5 years (range, 5-48 months). These findings indicate that arthroscopic pancapsular shift, when successful, demonstrates prolonged durability, assuaging concerns about the repair "loosening up" over time. Ultimately, our results were similar to those recently presented by Mitchell et al[19] in an adolescent population with MDI, noting a surgical failure rate of 26.0% with a minimum 2-year follow-up, with all reoperations occurring within the first 3 years postoperatively.

Our study demonstrated significantly improved outcome scores in all domains at final follow-up. The mean improvement in the ASES score of 28.1 points from preoperative to final follow-up was likely clinically significant, with a minimal clinically important difference (MCID) for the ASES score as defined for generic shoulder conditions and rotator cuff disease as 6.2 to 26.9 points.[7] Similarly, the MCID was eclipsed for the SF-12 PCS, defined as 6.5 points for generic shoulder disorders.[7] Unfortunately, no MCID has been defined for the used outcomes scores for a population with instability, although the ASES score has been validated for use in shoulder instability despite lacking a specific domain for directly measuring instability.[13] Interestingly, to our knowledge, this is the first study in the literature to report persistent improvement in PROs between short-term and long-term follow-up for arthroscopic treatment of MDI, confirming that even with arthroscopic treatment, the capsular plication does not stretch out over time. Hamada et al[11] reported on 34 shoulders treated for multidirectional instability with an open inferior capsular shift with a mean follow-up of 8.3 years and compared these results with the same cohort, which had been reviewed at 3.5 years after surgery. Their population had 26% of shoulders develop recurrent instability during the first 3 years after the index surgery. Similar to the present study, they found no interval increase in dislocations or changes in PROs in the interim period between 3.5 and 8.3 years postoperatively, concluding that open capsular shift maintained its intended effect and tension over that time period.

In addition, our study sought to compare the results for MDI with an atraumatic onset as compared with MDI caused by trauma. Gerber and Nyffeler[10] recognized that MDI did not always result from pathologic enlargement of the capsule due to underlying hyperlaxity and repetitive microtrauma, and some patients had a specific injury or "microtrauma" to cause their symptoms. Raynor et al[22] classified patients with MDI as having atraumatic or traumatic onset, noting that those with a traumatic onset were more likely to have had labral injury due to the preceding traumatic injuries. Interestingly, the presence of labral injury was associated with significantly higher postoperative ASES and SANE scores. Meanwhile, those patients with a patulous capsule and no labral tear more often required anterior interval closure and had worse postoperative outcomes. Baker et al[3] also noted that postoperative ASES, Western Ontario Shoulder Instability, and patient reporting of stability, function, strength, range of motion, and pain were more favorable in a traumatic-onset cohort at short-term follow-up. Given these short-term results, there was a question of whether this difference would persist in a similar patient population at longer-term follow-up. In the present series, we found that there were no differences in patient satisfaction or PROs between atraumatic and traumatic onset in patients with MDI at long-term follow-up. Patient-perceived ability to return to sports was slightly better in the atraumatic MDI group, but this does not consider that the traumatic MDI group may have been involved in high-level, riskier athletic activities at baseline. Meanwhile, patients with atraumatic onset were more likely to experience feelings of instability, although this difference was not significant, and many of the patients who experienced feelings of instability still had excellent postoperative outcomes.

Finally, we found that PROs, satisfaction, and recurrent instability were similar between groups undergoing RIC and not undergoing RIC, despite significantly lower preoperative ASES scores in the RIC group. RIC was performed by the senior surgeon based on intraoperative assessment after the arthroscopic pancapsular shift and added in cases of perceived continued expanded capsular volume or increased inferior translation. While the ability to make definitive conclusions is limited as this was not a comparative cohort, our results suggest that patients undergoing APC with a RIC did have benefit from the combined procedure.

LIMITATIONS

The main limitation in our study is the retrospective nature relying on email questionnaires for patient outcomes. In addition, there were no long-term radiographic or objective clinical examination data collected in this study. Given the long-term follow-up and the fact that many patients were minors or college aged at the time of index surgery, we were not able to obtain follow-up data for all patients due to a lack of active contact information. As such, outcome analysis was performed with 82% follow-up. Complete PROs used for secondary outcome analysis were available for only 48% of patients. Furthermore, the utilized PROs are not instability-specific questionnaires, and there is no established MCID or Patient Acceptable Symptom State score for MDI. Unfortunately, ligamentous laxity was not quantified or stratified in this study. Finally, this study was performed at a tertiary referral center using a generally healthy population with low comorbidities; thus, our results may not be generalizable to other clinics with different population characteristics. The tertiary nature of our center also meant many patients underwent preoperative rehabilitation at different locations with different underlying protocols.

CONCLUSION

This study demonstrated that APC for patients with MDI can provide significantly improved PROs and low rates of dislocation and reoperation at a minimum 5-year follow-up. Patients and families should be counseled that despite a quarter of patients experiencing feelings of instability postoperatively, most of these patients have acceptable outcomes and do not require progression to revision surgery. Finally, patients undergoing APC for MDI with an atraumatic onset can expect similar outcomes to those undergoing APC for MDI caused by trauma at long-term follow-up.

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