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Descriptive Epidemiology of the MOON Shoulder Instability Cohort

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Background: Shoulder instability is a common diagnosis among patients undergoing shoulder surgery.

Purpose: To perform a descriptive analysis of patients undergoing surgery for shoulder instability through a large multicenter consortium.

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

Methods: All patients undergoing surgery for shoulder instability who were enrolled in the MOON Shoulder Instability Study were included. Baseline demographics included age, sex, body mass index, and race. Baseline patient-reported outcomes (PROs) included the American Shoulder and Elbow Surgeons (ASES) score, Shoulder Activity Score, Western Ontario Shoulder Instability Index (WOSI), 36-Item Health Survey (RAND-36), and Single Assessment Numeric Evaluation (SANE). The preoperative physician examination included active range of motion (ROM) and strength testing. Preoperative imaging assessments with plain radiography, magnetic resonance imaging (MRI), and computed tomography were also included and analyzed.

Results: Twenty-six surgeons had enrolled 863 patients (709 male, 154 female) across 10 clinical sites. The mean age for the cohort was 24 years (range, 12-63 years). Male patients represented 82% of the cohort. The primary direction of instability was anterior for both male (74%) and female (73%) patients. Football (24%) and basketball (13%) were the most common sports in which the primary shoulder injury occurred. No clinically significant differences were found in preoperative ROM between the affected and unaffected sides for any measurement taken. Preoperative MRI scans were obtained in 798 patients (92%). An anterior labral tear was the most common injury found on preoperative MRI, seen in 66% of patients, followed by a Hill-Sachs lesion in 41%. Poor PRO scores were recorded preoperatively (mean: ASES, 72.4; WOSI, 43.3; SANE, 46.6).

Conclusion: The MOON Shoulder Instability Study has enrolled the largest cohort of patients undergoing shoulder stabilization to date. Anterior instability is most common among shoulder instability patients, and most patients undergoing shoulder stabilization are in their early 20s or younger. The results of this study provide important epidemiological information for patients undergoing shoulder stabilization surgery.

Keywords: shoulder instability; shoulder stabilization; epidemiology; MOON Shoulder Instability Group

Shoulder instability is a common diagnosis especially among young athletes.[11,14,21,22] Glenohumeral instability occurs most often in the anterior direction,[23] with approximately three-fourths of anterior dislocations occurring in male patients.[16,17] Recently, shoulder dislocations have been shown to occur at a higher rate among collegiate athletes compared with their high school counterparts.[14] Furthermore, shoulder dislocations require surgical intervention more frequently than other shoulder injuries.[14] Previous studies have described the epidemiology of patients with shoulder instability at the United States Military Academy[23] and within various sports including men's lacrosse,[8] rugby,[4,10] and high school[12] and collegiate athletics[22] in general. However, there have been no prior studies that have provided a general descriptive analysis of all patients undergoing surgery for shoulder instability. The purpose of this study was to describe the epidemiology of patients undergoing shoulder stabilization within a large multicenter consortium.

METHODS

Study Design

The Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Instability Study is a prospective multicenter trial that has been previously described.[6] This study was approved by the institutional review board at each institution of 26 sports medicine or shoulder fellowship-trained

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surgeons from 10 academic and private groups throughout the United States. The study is supported by National Institutes of Health Clinical and Translational Science Awards grant U54TR001356. This prospective study enrolled patients undergoing surgical treatment for shoulder instability. Baseline demographics, patient-reported outcome (PRO) scores, physical examination data, and preoperative imaging data were collected. Participants provided written informed consent using institutional review board–approved consent forms and procedures. Most preoperative data were collected at a single intake at the first evaluation, with additional data such as preoperative imaging collected as they were completed and evaluated. A MOON Shoulder Instability Group investigator performed the physical examination. Patients completed the questionnaires either via a paper form or online.

Participants

Patients were enrolled at 1 of 10 participating institutions. Patients were eligible to enroll if they were between the ages of 12 and 99 years and had a history and physical examination consistent with shoulder instability. Primary and revision surgery, as well as open and arthroscopic procedures, were included in this study. Exclusion criteria included patients undergoing concomitant rotator cuff surgery and those with workers' compensation claims.

Data Collection

Baseline data collected included demographic characteristics, medical comorbidities, and historical information regarding previous surgeries or treatments and PROs including the American Shoulder and Elbow Surgeons (ASES) score, Shoulder Activity Score,[5] Western Ontario Shoulder Instability Index (WOSI), 36-Item Health Survey (RAND-36), and Single Assessment Numeric Evaluation (SANE). Shoulder instability was categorized according to the FEDS (frequency, etiology, direction, severity) classification system.[15] Patients who had both shoulders enrolled answered all questions and PROs twice, once for each shoulder. Patients recorded all sports in which they were involved before the injury from a list of 21 sports. Patients were asked, "Have you ever had a shoulder dislocation that required assistance in putting it back in place?" This required a "yes" or "no" response. On the basis of this, patients recorded the total number of shoulder dislocations in the past year before their evaluation on an ordinal scale of 0, 1, 2-5, and >5 dislocations.

Plain radiographs were obtained and reviewed at the time of enrollment. If additional imaging was available, such as magnetic resonance imaging (MRI) or computed tomography (CT), these were also reviewed but were not required as part of the standard protocol.

A detailed physical examination was performed on each patient and documented by the operating surgeon. At the baseline visit, participants were evaluated for active range of motion (ROM) in forward elevation, abduction, external rotation at the side, external rotation in 90° of abduction, internal rotation at the side, and internal rotation in 90° of abduction. The anterior and posterior apprehension tests were performed and graded as pain, fear, both, or neither for each test.[18] The Beighton Hypermobility Score[2] (BHS) was also assessed.

Statistical Analysis

Continuous variables were reported as means, SDs, and ranges. Descriptive variables were reported with counts and frequencies. Matched-pair *t* tests were used to compare ROM between the affected and unaffected sides.

RESULTS

Demographics

As of April 24, 2017, 26 surgeons had enrolled 863 patients across 10 sites. Enrollment began on October 30, 2012. The mean age for the cohort was 24 years (range, 12-63 years). Male patients represented 82% of the cohort (Figure 1). The primary direction of instability was in the anterior direction for both male and female patients at 74% (527/709) and 73% (113/154), respectively, with 23% (202/863) of all patients experiencing posterior shoulder instability. Seven patients were included with both shoulders enrolled. The dominant shoulder was affected in 445 patients overall (52%). The primary direction of instability between male and female patients was significantly different ($P = .016$), although this is mostly a result of the large sample size included as the proportions were similar between male and female patients (Figure 2). The most common race reported was white (87%), followed by black (8%) (Table 1). The mean height, weight, and body mass index among all patients were 178 cm, 82 kg, and 26 kg/m^2, respectively. A primary procedure was performed on 753 patients (87%), with a reoperation performed in the remaining 110 patients (13%). The injury occurred while playing sports in 644 patients (75%), of which the most common sport was football, followed by basketball (Table 2). Overall, 363 patients (42%) responded "yes" to the question "Have you ever had a shoulder dislocation that required assistance in putting it back in place?" Patients most commonly

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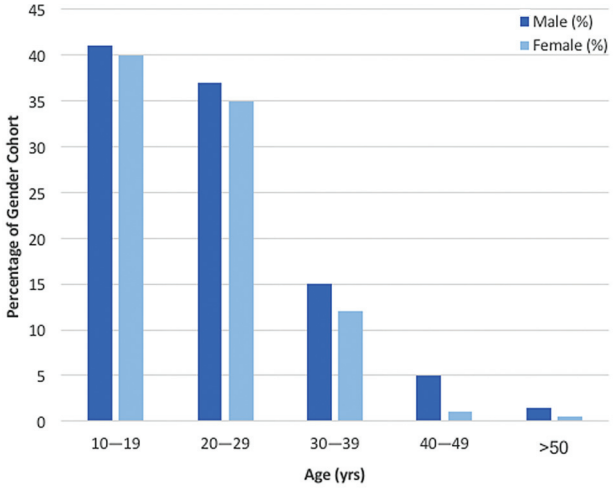

Figure 1. Age at the time of enrollment.

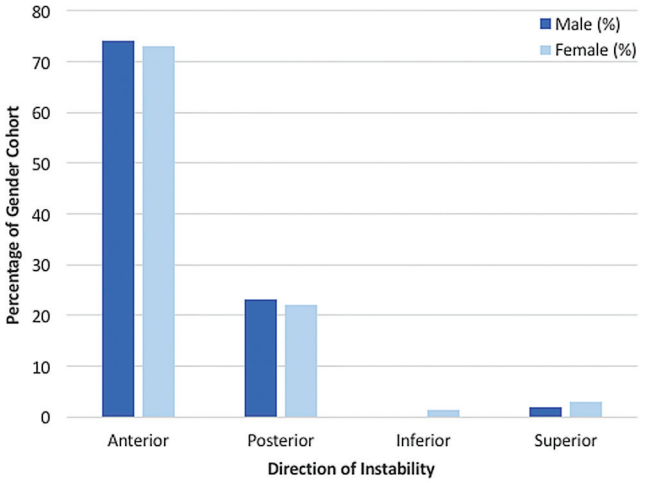

Figure 2. Direction of instability.

TABLE 1
Reported Race of Enrolled Patients[a]

	No. of Patients (%)
White	748 (87)
Black or African American	65 (8)
Asian	37 (4)
Prefer not to answer	18 (2)
American Indian/Alaska Native	10 (1)
Native Hawaiian or other Pacific Islander	3 (0.4)

[a]Some patients selected multiple race options.

reported experiencing 2 to 5 shoulder dislocations in the year before the evaluation (Table 3).

Baseline PRO Scores

Baseline PRO scores are shown in Tables 4 and 5. Poor PRO scores were recorded preoperatively for multiple assessments (mean: ASES, 72.4; WOSI, 43.3; SANE, 46.6; RAND-36 [role limitations due to physical health], 44.0), indicating a generally inferior impression of shoulder function specifically and upper extremity function overall, with limitations due to pain or instability symptoms.

Physical Examination

The anterior apprehension test elicited fear in 140 patients, pain in 44 patients, and both pain and fear in 393 patients. The posterior apprehension test elicited fear in 2 patients, pain in 62 patients, and both pain and fear in 88 patients. Baseline ROM is shown in Table 6. Statistically significant differences between the affected and unaffected sides were found for all measurements, although none was considered clinically significant. The BHS was reported in 842 patients (98%), with a mean score of 1.0. A score of $\geq$4 (indicative of generalized joint hypermobility[9,13]) was reported in 108 of the 842 patients (13%).

TABLE 2
Sports in Which the Primary Injury Occurred[a]

	No. of Patients
Football	204
Basketball	108
Other	85
Wrestling	51
Baseball	46
Skiing	38
Softball	35
Volleyball	31
Weight training	31
Soccer	30
Hockey	28
Extreme sports	25
Swimming	18
Lacrosse	12
Rock climbing	12
Golf	8
Tennis	7
Diving	6
Rodeo	2
Field hockey	0
Other racquet sports	0
Injury did not occur during sports	210

[a]Information missing for 9 patients. Some patients selected multiple sports.

TABLE 3
Number of Shoulder Dislocations in the Year Before the Evaluation[a]

	No. of Patients (%)
0	212 (25)
1	157 (18)
2-5	279 (32)
>5	211 (24)

[a]Information missing for 4 patients.

TABLE 4
Baseline Patient-Reported Outcome Scores[a]

Patient-Reported Outcome	Mean ± SD
ASES	72.4 ± 20.6
Shoulder Activity Score	13.2 ± 4.5
WOSI	43.3 ± 19.9
SANE	46.6 ± 24.2

[a]ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation; WOSI, Western Ontario Shoulder Instability Index.

TABLE 5
Baseline RAND-36 Scores[a]

RAND-36 Subscales	Mean ± SD
Physical functioning	82.0 ± 16.4
Role limitations due to physical health	44.0 ± 42.7
Role limitations due to emotional problems	81.7 ± 35.0
Energy/fatigue	60.5 ± 23.7
Emotional well-being	75.2 ± 18.0
Social functioning	77.5 ± 24.1
Pain	60.2 ± 24.1
General health	77.5 ± 15.6

[a]RAND-36, 36-Item Health Survey.

TABLE 6
Baseline Range of Motion[a]

Range of Motion	Affected Side, deg	Unaffected Side, deg	*P* Value
Forward elevation	169.4 ± 19.3	174.4 ± 8.6	<.0001
Abduction	163.1 ± 24.5	168.2 ± 17.6	<.0001
External rotation at side	67.3 ± 18.4	70.7 ± 16.7	<.0001
External rotation in 90° of abduction	87.3 ± 15.0	92.3 ± 11.5	<.0001
Internal rotation at side	–57.8 ± 6.3	–58.3 ± 5.6	.02
Internal rotation in 90° of abduction	59.1 ± 19.1	63.6 ± 16.8	<.001

[a]Data are presented as mean ± SD. Scores between the affected and unaffected sides were all significant ($P < .05$).

Imaging

Plain radiographs were obtained in 807 patients (94%), of whom 224 of the 807 patients (28%) demonstrated bony deficiency (Table 7). CT scans were obtained in 106 patients (12%), of whom 55 of the 106 patients (52%) were revisions and 98 of the 106 patients (92%) demonstrated bony deficiency. MRI scans were obtained in 798 patients (92%). On MRI, an anterior labral tear was found in 528 patients, with a Hill-Sachs lesion evident in 326 patients (Table 8). Among the 581 patients with anterior instability and a preoperative MRI scan, 294 (51%) were found to have a Hill-Sachs lesion on MRI. In contrast, only 5% of patients with posterior instability were found to have a reverse Hill-Sachs lesion.

TABLE 7
Radiographic and CT Findings[a]

Abnormality	Radiography (n = 807)	CT (n = 106)
Bony deficiency	224 (28)	98 (92)
Humeral deficiency		
Anterior	21 (3)	11 (10)
Posterior	157 (19)	74 (70)
None	33 (4)	11 (10)
Glenoid deficiency		
Anterior	82 (10)	82 (77)
Posterior	11 (1)	4 (4)
None	107 (13)	13 (12)

[a]Data are presented as n (%). CT, computed tomography.

DISCUSSION

This study provides a descriptive epidemiological analysis of all patients undergoing surgical intervention for shoulder instability. The most common direction of instability found in this study was anterior, confirming previous studies.[23,26] Male patients represented 82% of the MOON shoulder instability cohort, which reflects similar findings of 2 Canadian studies that found that approximately three-fourths of anterior dislocations occur in male patients.[16,17] In one of these studies, Leroux et al[17] found that the median age of all patients in Ontario, Canada, undergoing primary closed reduction of an anterior shoulder dislocation was 35 years but that the highest incidence density rate (number of primary anterior shoulder dislocations requiring closed reduction per 100,000 person-years) was among male patients ≤20 years of age, similar to the results of the current study.

Football was the most common sport in which patients reported that their primary shoulder injury took place. Again, this confirms recent findings by Kraeutler et al,[14] who used the High School Reporting Information Online and National Collegiate Athletic Association Injury Surveillance Program over a 10-year period and found that football accounted for the highest number of shoulder dislocations among 20 sports studied.

Although statistically significant differences were found between the affected and unaffected shoulders for each ROM test performed, none of these differences was

TABLE 8
MRI Findings[a]

Abnormality	Overall (n = 798)	Anterior Instability (n = 581)	Posterior Instability (n = 291)
Anterior labral tear	528 (66)	488 (84)	32 (11)
Hill-Sachs lesion	326 (41)	294 (51)	10 (3)
Posterior labral tear	242 (30)	67 (12)	9 (3)
SLAP tear	146 (18)	99 (17)	31 (10)
Anterior glenoid bone loss	122 (15)	122 (21)	0 (0)
ALPSA	49 (6)	49 (8)	0 (0)
GLAD	26 (3)	23 (4)	3 (1)
HAGL	20 (3)	13 (2)	0 (0)
Reverse Hill-Sachs lesion	15 (2)	0 (0)	15 (5)
Posterior glenoid bone loss	11 (1)	2 (0.3)	9 (3)
Biceps lesion	9 (1)	6 (1)	2 (0.7)
Effusion	7 (0.9)	6 (1)	1 (0.3)
Spinoglenoid cyst	5 (0.6)	0 (0)	4 (1)
Supraspinatus tear	5 (0.6)	4 (0.7)	0 (0)
Infraspinatus tear	2 (0.3)	2 (0.3)	0 (0)
Subscapularis tear	2 (0.3)	1 (0.2)	0 (0)

[a]Data are presented as n (%). Percentages are based on the entire cohort of patients who had an MRI scan or those patients diagnosed with anterior or posterior instability, respectively. ALPSA, anterior labroligamentous periosteal sleeve avulsion; GLAD, glenolabral articular disruption; HAGL, humeral avulsion of the glenohumeral ligament; MRI, magnetic resonance imaging; SLAP, superior labrum from anterior to posterior.

considered clinically significant. Interestingly, only 13% of patients in this study were found to have a BHS of $\geq$4, which is indicative of generalized joint hypermobility.[9,13] Cameron et al[7] performed a cross-sectional cohort study of 1050 students entering their freshman year at the United States Military Academy and found a significant correlation between a history of glenohumeral joint instability and a BHS of $\geq$2 (P = .023). However, only 11 students in this study had a BHS of $\geq$4,[7] and therefore, the association between generalized joint hypermobility and glenohumeral instability may be overstated.

Despite recent concerns throughout the orthopaedic community regarding the appropriate utilization of health care dollars and the cost-effectiveness of different tests and procedures, the authors found that 798 of 863 patients enrolled in this study (92%) had a preoperative MRI scan for review. In cases of questionable bone loss, CT has demonstrated superior sensitivity to MRI in the detection of significant glenoid bone defects, although CT exposes a patient to ionizing radiation.[3,20,24,25] Given the high prevalence of MRI use in the present study, future studies should investigate the relative values of a preoperative MRI versus CT scan on shoulder instability treatment decision making.

Among patients with a preoperative MRI scan, the most common injury seen was an anterior labral tear (66%), followed by a Hill-Sachs lesion (41%). Atef et al[1] used ultrasound and MRI to evaluate associated injuries in a series of 240 patients (average age, 35 years) after a traumatic anterior shoulder dislocation. Imaging was performed within 1 week of the shoulder dislocation in all patients. The authors found that a rotator cuff tear was the most common associated injury, found in 67 patients (28%). In our study, patients undergoing concomitant rotator cuff repair surgery were excluded. Interestingly, Atef et al[1] found a Bankart lesion in only 50 patients (21%). This is much lower than the prevalence within our cohort, although this may be related to the older age of patients in Atef et al's[1] study as older patients have been found to have a lower prevalence of Bankart lesions after anterior shoulder dislocations.[19]

The strengths of this study include the first descriptive analysis of the largest cohort of patients undergoing surgical intervention for shoulder instability. The limitations of this study should also be noted. In particular, patients were required to consent for enrollment in this prospective study, and therefore, this cohort does not represent an all-inclusive or consecutive series of patients. In addition, ROM and strength testing and preoperative imaging assessments were performed by the operating surgeon and therefore were not performed by the same clinician in all cases. Given the large sample size of patients included in this study, many findings were statistically significant but would not be considered clinically significant given the minimal clinically important differences reported for various outcomes. Finally, this particular study did not describe or compare the clinical outcomes of patients based on any demographic or pathological characteristics but simply serves as a descriptive epidemiological study of the MOON shoulder instability cohort.

CONCLUSION

The MOON Shoulder Instability Study has enrolled the largest cohort of patients undergoing shoulder stabilization to date. Anterior instability is most common among shoulder instability patients, and most patients undergoing shoulder stabilization are in their early 20s or younger. The results of this study provide important epidemiological information for patients undergoing shoulder stabilization surgery.

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