BASIC SCIENCE

Incidence of posterior shoulder instability and trends in surgical reconstruction: a 22-year population-based study

Jarret M. Woodmass, MD, FRCSC, Julia Lee, MD, Isabella T. Wu, BA,
Vishal S. Desai, BS, Christopher L. Camp, MD, Diane L. Dahm, MD,
Aaron J. Krych, MD*

Department of Orthopedic Surgery and Sports Medicine, Mayo Clinic, Rochester, MN, USA

Background: The incidence of posterior shoulder instability (PSI) in the general population is not well defined. This study aimed to define the population-based incidence of PSI and describe trends in incidence and surgery rates.

Methods: The study population included 143 patients (16 females, 127 males) diagnosed with new-onset PSI between January 1, 1994, and December 31, 2015. Medical records were reviewed to extract patient data. Age- and sex-specific incidence rates were calculated and adjusted to the 2010 United States population. Poisson regression was performed to examine trends by timeline, sex, and age.

Results: Age- and sex- adjusted annual incidence of PSI was 4.64 per 100,000 person-years, and posterior dislocation was 1.30 per 100,000 person-years. Peak PSI incidence for males and females was at 14 to 19 years (31.82 and 5.23 per 100,000 person-years). PSI incidence was higher in males than females (8.86 vs. 1.07 per 100,000 person-years, $P < .001$). The 5-year cumulative risk of surgery for patients with PSI was 53.1% between 1996 and 2002, 59.9% between 2003 and 2008, and 87.5% between 2009 and 2015. Patients with PSI between 2009 and 2015 had a significantly increased rate of surgery (hazard ratio, 2.2; 95% confidence interval, 1.4-3.6; $P = .001$) compared with those between 1996 and 2002.

Conclusion: The age- and sex- adjusted incidence of PSI in the general population was 4.64 per 100,000 person-years. There is a significantly greater incidence of PSI in males than females, with both sexes peaking at 14 to 19 years and incidence rates remaining elevated throughout the third and fourth decades of life. The incidence of PSI remained stable over time; however, the rate of surgical intervention increased significantly, from 53.1% of patients between 1996 and 2002 to 87.5% of patients between 2009 and 2015.

Level of evidence: Basic Science Study; Descriptive Epidemiology Study

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Keywords: Posterior shoulder instability; population-based study; incidence; shoulder dislocation; surgical reconstruction; glenohumeral instability

Posterior shoulder instability (PSI) is an uncommon condition representing 2% to 10% of patients with glenohumeral instability.[1,3,13] PSI can result from a traumatic posterior glenohumeral dislocation or more commonly occur secondary to repeated microtrauma from sporting activities.[10] Unlike

anterior instability, patients with PSI primarily complain of pain and weakness rather than a sensation of instability. This atypical presentation can result in a delayed, incorrect, or even missed diagnosis before consultation with an orthopedic surgeon.[8] As a result, the true population-based incidence of PSI has remained unclear.

Posterior shoulder dislocation in the traumatic setting is reported to occur at a rate of 1.1 incidents per 100,000 person-years.[11] The rate of PSI is thought to significantly exceed this estimate. In a high-risk military population, the incidence of PSI is 4.28 per 1000 person-years at risk, with increased frequency among younger male athletes participating in high-level collision sports.[9] In this select population, the rate of surgical intervention for PSI exceeded 80%. These studies provide valuable insight into the diagnosis and management of PSI but do not accurately reflect the injury burden or rate of surgical intervention in the general population.

In this study, we report our findings from a geographically defined population in which we retrospectively reviewed patients diagnosed with PSI over a 22-year period. The purpose of this study was to: (1) define the population-based incidence of PSI, (2) describe the trends of PSI incidence over time, and (3) evaluate changes in the rate of surgical intervention. We hypothesized that the rate of PSI and the rate of surgical intervention would both increase over time.

Materials and methods

This study identified patients with shoulder instability using the Rochester Epidemiology Project (REP). The REP is a medical records linkage system that collects health care data for the entire population of Olmsted County, MN, USA. The database includes all medical records of every individual who has resided in Olmsted County from 1966 until present day, provided that they interacted with a health care provider in the system.[16] The methodology and validation of the REP have previously been reported in detail.[15,16] The REP provides access to demographic information, physician-determined diagnostic codes, and procedural information that is obtained directly from the provider's records.

A search was conducted for all residents of Olmsted County, MN, who had International Classification of Diseases, 9th Clinical Modification, or Current Procedural Terminology (American Medical Association, Chicago, IL, USA) diagnosis codes consistent with shoulder instability occurring between January 1, 1994, and December 31, 2015. The initial search identified 2091 potential cases. Each patient's medical record was manually reviewed to verify the diagnosis of PSI using related clinical notes, imaging studies, and surgical reports. Patients were included if they were clinically diagnosed with PSI during the study period and had imaging supporting the diagnosis. This included a posterior glenohumeral dislocation on an axillary radiograph, a posterior labral tear on magnetic resonance imaging or arthrogram or computed tomography arthrogram, or a surgical procedure for a diagnosis of detached posterior labrum. Individuals with multidirectional shoulder instability and history of seizures were excluded.

Patient demographic information, medical history, physical examination, imaging findings, and treatment details were recorded.

After the final review, there were 143 patients with new-onset PSI between 1994 and 2015 who met all inclusion criteria.

Age- and sex-specific rates of PSI were calculated by use of the number of new-onset PSI occurrences (incident cases) as the numerator. Population estimates were based on decennial census counts as the denominator, with linear interpolation between census years. Only patients who were residents of Olmsted County at the date of the first PSI event were included in the incidence calculations. Incidence rates were adjusted for age and sex to the 2010 Caucasian population of the United States and reported as the rate per 100,000 person-years. We calculated 95% confidence intervals (CIs) for the incidence rates with the assumption that the number of incident cases per year followed a Poisson distribution. Incidence trends for PSI and previous dislocation were examined by use of Poisson regression models with smoothing splines for age and calendar year.

The 5-year cumulative risk of surgical intervention of patients experiencing PSI between 1996 and 2002, 2003 and 2008, and 2009 and 2015 was estimated. Survival free of surgery used the date medical care for PSI was first sought. The association between treatment era and the risk of surgery was assessed using a Cox proportional hazards model. The decision to undergo surgery was based on surgeon and patient preference with indication that changed throughout the study period.

All analysis was performed using JMP 12.0.1 software (SAS Institute Inc., Cary, NC, USA) and R Statistical Software (R Core Team, Foundation for Statistical Computing, Vienna, Austria).

Results

The study population included 143 patients (14 females, 127 males) who were diagnosed with new-onset PSI between 1994 and 2015. Subjects were a mean age of 27.8 years (range, 10.5-65.4 years) at the time of the first instability event. The mean body mass index was 27.1 kg/m^2 (range 12.3-40.6 kg/m^2), 55 of 143 patients (38%) reported prior or current tobacco use, and 5 (3%) had diabetes mellitus. In this population 132 of 143 patients (92%) were right hand-dominant, with 79 (55%) experiencing instability on their dominant side. An acute traumatic event was reported in the clinical note for 91 of 143 patients (64%) with first-time PSI. Of those with an acute traumatic event, 35 of 91 patients (38%) experienced a glenohumeral dislocation and 14 of 35 (40%) of these patients went on to have recurrent dislocations. Of the 143 patients, 131 (92%), reported pain in the shoulder: 105 (73%) mild, 25 (17%) moderate, and 0 (0%) severe. Twelve patients had previously undergone surgery in the affected shoulder, including acromioplasty (n = 3), arthroscopic capsular plication (n = 3), anterior labral repair (n = 1), biceps tenodesis (n = 2), diagnostic arthroscopy (n = 1), and thermal capsulorrhaphy (n = 2). The patient with an anterior labral repair was symptom free for 11 years before posterior glenohumeral dislocation resulting in unidirectional posterior instability. The occupation in 27 of 143 patients (19%) involved manual labor. Previous or current athletic participation in the 143 patients ranged from a recreational to a professional, including 42 (29%) in contact sports (defined as football, wrestling, weightlifting, rugby, etc.) and 38 (27%)

Incidence of Instability by age
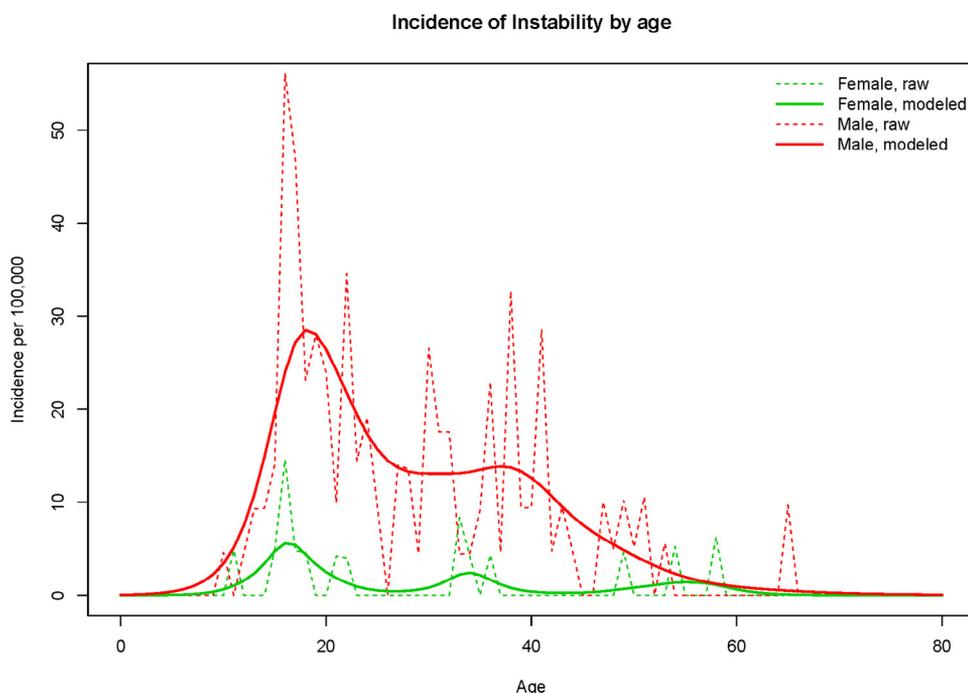
Figure 1 Incidence of instability when stratified by age shows bimodal distribution in both males and females.

who played noncontact sports with overhead motion (volleyball, swimming, rock climbing, etc.).

The overall age- and sex-adjusted annual incidence rate of PSI was 4.64 (95% CI, 3.87-5.40) per 100,000 person-years. When stratified by sex, the age-adjusted incidence rate was 1.05 (95% CI, 0.53-1.56) per 100,000 person-years for females and 8.15 (95% CI, 6.72-9.58) per 100,000 person-years for males. When stratified by age groups, the peak incidence of PSI occurred at the 14 to 19 years age group (18.87 per 100,000 person-years; Table I, *A and B*). When stratified by sex, the distribution remained similar among both males and females (Fig. 1). The greatest incidence occurred in the 14 to 19 years age group, measuring 31.82 per 100,000 person-years in males and 5.28 per 100,000 in females (Table I, *A*). The incidence also remained elevated throughout the third and fourth decades for both men and women (Fig. 1).

When evaluating by time periods, the incidence rates for both sexes peaked from 1999 to 2003, with an age-adjusted rate of 1.51 per 100,000 person-years for females and 11.83 per 100,000 person-years for males. Adjusted for age and sex, the overall incidence rate from 1999 to 2003 was 6.70 (95% CI, 4.71-8.69) per 100,000 person-years. The lowest incidence rates were observed in the most recent period (2010-2015), with an overall age- and sex-adjusted incidence rate of 3.77 (95% CI, 2.48-5.06) per 100,000 person-years. PSI incidence rates for different time intervals during the study period are shown in Table II. The year of diagnosis showed a significant association with PSI incidence when assessed as a continuous variable (linear trend) in the Poisson model ($P = .02$).

Patient sex and age at instability were both significantly associated with the incidence of PSI in the Poisson regression model ($P < .001$). Females had an incident rate ratio (IRR) of 0.13 (95% CI, 0.07-0.21) compared with males. The IRR

Table I Age- and sex-specific (**A**) annual incidence and (**B**) overall incidence of posterior shoulder instability, 1994 to 2015

(A)

Age group (yr)	Patients, No.			Incidence rate*		
	Female	Male	Total	Female	Male	Total
0-13	1	4	5	0.34	1.30	0.83
14-19	6	38	44	5.28	31.82	18.87
20-29	2	30	32	0.97	15.52	8.03
30-39	4	33	37	1.83	14.84	8.38
40-49	1	17	18	0.46	7.96	4.17
≥50	2	5	7	0.45	1.32	0.85
Total	16	127	143	1.07	8.86	4.88

(B)

Summary rates	Incidence rate*	SE	95% CI	
		(Poisson)	Lower	Upper
Age adjusted				
Females	1.05	0.26	0.53	1.56
Males	8.15	0.73	6.72	9.58
Age and sex adjusted, total	4.64	0.39	3.87	5.40

SE, standard error; *CI*, confidence interval.
* Per 100,000 person-years.

Table II   Trends in age- and sex-specific incidence of posterior shoulder instability overtime

Age group (yr)	Time period							
	1994-1998		1999-2003		2004-2009		2010-2015	
	No.	Incidence rate*	No.	Incidence rate	No.	Incidence rate	No.	Incidence rate
Female								
0-13	0	0.00	1	1.57	0	0.00	0	0.00
14-19	1	4.16	1	3.83	1	3.18	3	9.33
20-29	0	0.00	1	2.37	1	1.75	0	0.00
30-39	1	1.99	1	2.00	1	1.70	1	1.67
40-49	0	0.00	0	0.00	1	1.64	0	0.00
≥50	0	0.00	1	1.13	1	0.77	0	0.00
Total	2	0.67	5	1.55	5	1.19	4	0.88
Male								
0-13	1	1.55	2	2.99	1	1.18	0	0.00
14-19	4	16.10	9	32.61	14	42.26	11	32.49
20-29	6	14.73	9	21.93	8	14.93	7	12.09
30-39	12	23.77	9	17.77	6	9.99	6	9.82
40-49	3	6.94	8	16.16	3	5.03	3	4.91
≥50	0	0.00	3	4.03	0	0.00	2	1.55
Total	26	9.07	40	12.90	32	7.94	29	6.69
Adjusted for†								
Age								
Female		0.57 (0-1.37)		1.51 (0.16-2.87)		1.19 (0.14-2.25)		0.93 (0.02-1.85)
Male		7.34 (4.49-10.19)		11.83 (8.09-15.57)		7.37 (4.81-9.92)		6.56 (4.17-8.96)
Age + sex		4.00 (2.50-5.49)		6.70 (4.71-8.69)		4.35 (2.95-5.76)		3.77 (2.48-5.06)

* Incidence rates expressed per 100,000 person-years.
† Incidence rates per 100,000 person-years (95% confidence interval).

Table III   Incident rate ratios for posterior shoulder instability between age groups, 1994 to 2015

Age group (yr)	Relative to	P-value	Incident rate ratio	95% CI
0-13	**14-19**	**<0.001**	**0.04**	**0.02-0.11**
	20-29	**<0.001**	**0.10**	**0.04-0.27**
	30-39	**<0.001**	**0.10**	**0.04-0.26**
	40-49	**<0.002**	**0.21**	**0.08-0.56**
	≥50	0.757	1.20	0.38-3.78
14-19	**20-29**	**<0.001**	**2.47**	**1.57-3.88**
	30-39	**<0.001**	**2.42**	**1.57-3.73**
	40-49	**<0.001**	**4.91**	**2.82-8.55**
	≥50	**<0.001**	**28.36**	**12.80-62.86**
20-29	30-39	0.933	0.98	0.60-1.58
	40-49	**0.023**	**1.99**	**1.10-3.59**
	≥50	**<0.001**	**11.48**	**5.05-26.11**
30-39	**40-49**	**0.017**	**2.03**	**1.14 - 3.61**
	≥50	**<0.001**	**11.72**	**5.20-26.39**
40-49	**≥50**	**<0.001**	**5.78**	**2.39-13.95**

CI, confidence interval.
Bold data are statistically significant.

Table IV   Age- and sex-specific annual incidence of posterior shoulder dislocation, 1994 to 2015

Age group (yr)	Patients, No.			Incidence rate*		
	Female	Male	Total	Female	Male	Total
0-13	0	2	2	0.00	0.65	0.33
14-19	1	11	12	0.88	9.21	5.14
20-29	1	8	9	0.49	4.14	2.26
30-39	0	9	9	0.00	4.05	2.04
40-49	0	5	5	0.00	2.34	1.15
≥50	0	1	1	0.00	0.26	0.12
Total	2	36	38	0.13	2.51	1.30

* Per 100,000 person-years.

12.80-62.86; $P < .001$). The difference between the groups aged 20 to 29 years and 30 to 39 years was nonsignificant ($P = .933$).

Posterior shoulder dislocation

The incidence of posterior shoulder dislocation in this population was also evaluated (Table IV). The overall age- and sex-adjusted incidence rate for posterior shoulder dislocation was 1.22 (95% CI, 0.83-1.62) per 100,000 person-years. For females, the age-adjusted incidence rate of

was significantly increased in the younger age groups compared with patients aged ≥50 years (Table III), with the greatest IRR occurring between the group aged 14 to 19 years and the group aged ≥50 years (IRR, 28.36; 95% CI,

dislocation events was 0.13 (95% CI, 0.00-0.31) per 100,000 person-years. In males, the age-adjusted incidence rate for dislocation was 2.29 (95% CI, 1.53-3.04) per 100,000 person-years. The peak incidence rates for dislocation occurred in the group aged 14 to 19 years among males (9.21 per 100,000 person-years), followed by the group aged 20 to 29 years (2.26 per 100,000 person-years).

Treatment trends

The 5-year cumulative risk of surgical intervention of patients with PSI was 53.1% between 1996 and 2002, 59.9% between 2003 and 2008, and 87.5% between 2009 and 2015. There was a significant association between era that medical attention was sought for instability and the risk of surgery (*P* = .003). Relative to a patient seeking medical care in 1996 to 2002, a patient seen between 2003 and 2006 had a nonsignificant increase risk of surgery (HR, 1.1; 95% CI, 0.7-1.8; *P* = .64), whereas a patient seeking medical care in 2009 to 2015 had a significantly higher risk of surgery (HR, 2.2; 95% CI, 1.4-3.6; *P* = .001). The indications for surgery were based on surgeon and patient preference, with heterogeneity within the study duration.

Discussion

Patients with PSI often present to the orthopedic clinic after considerable delays in diagnosis or having been misdiagnosed. Despite recognition after acute dislocation or in high-risk patient populations, the incidence of PSI in the general population has not been well defined. This population-based study describes the incidence of PSI and reports on trends in the rate of injury and surgical reconstruction in the general population over nearly 2 decades. We describe an overall age- and sex-adjusted incidence rate for PSI of 4.64 per 100,000 person-years.

This study found a significantly higher incidence among males than females, which is consistent with previous reports.[3,9] The peak incidence occurred in both males and females at 14 to 19 years (31.82 per 100,000 person-years in males; 5.28 per 100,000 person-years in females). The distribution amongst both sexes demonstrated a persistently elevated incidence throughout the third and fourth decades of life (Fig. 1). This finding was unexpected, because the peak incidence for other predominantly sport-related pathologies, including anterior glenohumeral instability and anterior cruciate ligament disruption, occurs in patients aged younger than 25 years.[12,13] In these populations, the rate of injury steeply declines after discontinued participation in competitive sports.

The maintenance of elevated incidence rates through the third and fourth generations may be partially explained by a delayed or previously incorrect diagnosis.[8] However, it more likely supports the theory that PSI results from a cumulative burden of repetitive microtrauma rather than the sequela of a single traumatic dislocation. In the current study, only

27% of patients diagnosed with PSI had a history of a traumatic dislocation. Furthermore, Lanzi et al[9] previously demonstrated that the rate of posterior instability was directly related to the number of athletic exposures. Thus, the aggregate influence of continued participation in recreational athletics or the transition into a manual labor career may result in continued exposures that increase the likelihood of developing posterior glenohumeral instability.

During the 22-year study observation period, the incidence of PSI remained relatively stable over time, with a slight elevation between 1999 and 2004. However, a significant increase in the rate at which patients underwent surgical intervention was observed. In the era from 1996 to 2002, the 5-year cumulative risk of undergoing surgery was 53.1%. The increased significantly to 87.5% for patients evaluated between 2009 and 2015 (*P* = .003). Although nonoperative management remains the primary treatment for patients with ligament laxity,[6,7] the indications for nonoperative management and open vs. arthroscopic stabilization of patients with posterior instability have changed considerably over time.

The introduction of suture anchors and advancements in arthroscopic techniques have resulted in a trend from open to arthroscopic capsulolabral repair. In a systematic review of the literature assessing 27 arthroscopic studies and 26 open studies for treatment of PSI, Delong et al[5] reported fewer recurrences with arthroscopic stabilization using suture anchors than with anchorless repairs. Furthermore, arthroscopic stabilization procedures have superior outcomes with respect to stability, recurrence of instability, patient satisfaction, return to sport, and return to previous level of sport compared with patients who undergo open procedures.[5]

Excellent outcomes have been demonstrated with arthroscopic capsulolabral repair.[2,3,6,9] In a study of 200 shoulders, Bradley et al[3] demonstrated that at a mean of 36 months, the American Shoulder and Elbow Surgeons scores after capsulolabral reconstruction went from 45.9 to 85.1. Significant improvements were also reported in instability ratings, pain scores, and return to sport in 89% of athletes.

Although surgical reconstruction has been shown to provide good outcomes, only recently has surgery been compared with nonoperative management for the treatment of PSI.[4] Cruz-Ferreira et al[4] compared 19 nonoperative patients who underwent a standardized rehabilitation protocol to 32 operative patients who underwent surgical intervention. Both groups showed improvements, but the surgical group demonstrated significantly improved Constant and Rowe and Walch-Duplay scores compared with the nonoperative group.[4]

The following limitations should be considered when interpreting the results outlined in this study. First, the reported incidence only reflects patients with clinically diagnosed PSI and does not capture patients who did not seek medical attention or those who were misdiagnosed. Furthermore, given that patients can present with vague symptoms, inclusion in this study required magnetic resonance imaging or arthrogram, computed tomography arthrogram, or surgical confirmation of a posterior labral tear. Thus, the true incidence

of PSI is likely underestimated because patients who had a false-negative advanced imaging study and those who were treated nonoperatively without obtaining advanced imaging were not captured.

Second, the source population is primarily Caucasian,[14] and the activity levels of this population may not be representative of an ethnically diverse population with different geographic demands and activity levels.

Third, although this study captured the diagnosis and treatment from all primary care networks, the orthopedic care was most commonly provided at a tertiary referral center by a relatively small number of surgeons whose treatment patterns may not reflect those in other parts of the United States.

This study also has several important strengths. First, its population-based design with medical record review verification ensured diagnostic accuracy. Second, all medical visits within a geographically defined community—including primary care evaluations, urgent care encounters, emergency department visits and orthopedic consultations—were captured. Third, over 2 decades of data were obtained, allowing for evaluations of trends in the diagnosis and delivery of care. Future studies should evaluate the factors most predictive of successful treatment with nonoperative management vs. those requiring surgical intervention.

Conclusions

The age- and sex-adjusted incidence of PSI in the general population is 4.64 per 100,000 person-years. There is a significantly greater incidence of PSI in males than females, with both sexes peaking at 14 to 19 years and incidence rates remaining elevated throughout the third and fourth decades of life. The incidence of PSI remained stable over time; however, the rate of surgical intervention increased significantly from 53.1% of patients between 1996 and 2002 to 87.5% of patients between 2009 and 2015.

Disclaimer

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