Original Article

Significant Changes in the Diagnosis, Injury Severity and Treatment for Anterior Shoulder Instability Over Time in a U.S. Population

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Purpose: To report the annual incidence of anterior shoulder instability (ASI) diagnosis, injury severity, and surgical stabilization in a U.S. population. **Methods:** An established U.S. geographic database was used to identify patients < 40 years old with diagnoses of ASI from 1994-2016. Medical records were reviewed to obtain patient demographics, histories, imaging results, and surgical details. Age- and sex-specific incidence rates were calculated and adjusted to the 2010 U.S. population. Poisson regression was performed to examine trends by timeline, sex and age. **Results:** The study population consisted of 652 patients with ASI and a mean age of 21.5 years (range, 3.6-39.5). Comparing 2015-2016 to 1994-1999, we found an increase in the number of dislocations (from 1.0-1.9; $P = 0.016$) and total instability events (from 2.3-3.4; $P = 0.041$) per patient prior to presentation to a physician. There was a trend in increased diagnosis of bony Bankart and/or Hill-Sachs on MRI over time, with these lesions documented in 96% of patients undergoing MRI in 2015-2018 compared to 52.9% in 1994-1999 ($P < .001$). The use of arthroscopic procedures increased and peaked in 2005-2009 (90% of surgical cases performed). The proportion of open Latarjet procedures increased from 2010-2014 (14%) and 2015-2018 (31%). **Conclusions:** The age- and sex- adjusted incidence of ASI diagnosis in a U.S. population from 1994-2016 is comparable to that demonstrated in Canadian and European populations. This study demonstrates an increasing number of instability events prior to surgical evaluation, which may correlate with patients' more commonly presenting with bone loss and requiring more aggressive surgical treatment or that ASI is being more frequently cared for and documented by present-day orthopedic surgeons. **Level of Evidence:** Level III, cross-sectional study.

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Glenohumeral instability is a common problem affecting the general population, especially young males, military personnel and athletes involved in contact sports.[1-6] Anterior shoulder instability (ASI) is the most common direction of instability, with a prevalence estimated to be as high as 1.7% in the general population.[7,8] Annual incidence rates of ASI have previously been reported to range from 8 to 24 per 100,000 person-years.[9-11] Although the incidence of ASI has been well described in certain high-risk populations such as military personnel,[1-6,8] current knowledge regarding the annual incidence rate in the general U.S. population is limited to few studies.[11,12] With much of the understanding of ASI epidemiology coming from studies based in Denmark,[13] Canada,[9] Sweden,[7] the United Kingdom,[10] and Norway,[14] there is a void of knowledge regarding the trends in annual incidence rates of ASI over time in various U.S. populations.

In patients < 25 years of age with ASI, up to 50% have been reported to undergo shoulder-stabilization procedures; both open and arthroscopic techniques are frequently used.[7,15] Trends in surgical management of ASI have demonstrated a consistent annual increase in the use of arthroscopic techniques, especially by newly trained orthopaedic surgeons.[16-18] Arthroscopic techniques offer the potential advantage of decreased morbidity, with several studies demonstrating faster return to preoperative function and return to sport.[19-22] However, many studies have generated concern about arthroscopic stabilization techniques in certain patient populations due to reported higher rates of recurrent instability and decreased time to recurrence when compared to open techniques.[23-28]

More specifically, increased failure of arthroscopic techniques has been demonstrated in the presence of large glenohumeral bony defects. A 2017 study by Shin et al.[29] reported anterior glenoid bone loss of 17.3% or more as the “critical” amount of bone loss that may result in recurrent glenohumeral instability following arthroscopic Bankart repair. These findings suggest that an amount of critical glenoid bone loss should be strongly considered because this threshold may result in recurrent glenohumeral instability after arthroscopic Bankart repair; and open techniques, such as Latarjet-Bristow and bone block augmentation procedures, have been recommended in these clinical situations.[30-32]

As the treatment landscape continues to evolve due to increased understanding of the role of glenoid bone loss and failure of arthroscopic surgery, there is need for large epidemiologic studies to better understand the trends in the diagnosis and treatment of ASI over time. This effort will provide the data necessary to work toward the development of a standardized treatment algorithm for patients with ASI. Furthermore, it is important to evaluate broader U.S. populations, in addition to high-risk groups, to provide data generalizable to various civilian practices. Therefore, the purposes of this study were to report the annual incidence of ASI diagnosis, injury severity and surgical stabilization in a U.S. population. We hypothesized that there will be an increase in the rate of ASI diagnosis and the use of arthroscopic Bankart procedures over time.

Table 1. Patient Demographics

Male, n (%)	506 (77.6%)
Female, n (%)	146 (22.4%)
Mean age, years (range)	21.5 (3.6-39.5)
Mean body mass index, kg/m^2 (SD)	25.5 (5.5)
Dominant arm involvement	53.1%
Acute traumatic inciting event	88.2%
Current/former smoker	20.9%
Hyperlaxity	8.1%
Athlete	66.6%
Seizure disorder	2.5%
Laborer occupation	8.6%

Materials and Methods

Study Population and Design

Following institutional review board approval of both Mayo Clinic and Olmsted Medical Center (16-007084 and 042-OMC-16), patients who presented for consultation following an episode of ASI between January 1, 1994, and July 31, 2016, were identified by using the Rochester Epidemiology Project (REP). The REP is an established geographic database of more than 500,000 patients in Olmsted County, Minnesota, and neighboring counties in southeast Minnesota and western Wisconsin. The REP has been used from 1966 to the present day and contains complete medical records of included residents, independent of treating institution, given that those residents interacted with a health care provider in the system.[33-35] In a previous study evaluating the generalizability of the REP, age, sex and ethnic characteristics of the REP catchment were similar to those of the state of Minnesota and the upper Midwest.[36] However, the REP was less ethnically diverse than the entire U.S. population (a higher percentage of Caucasian ethnicity), more highly educated and wealthier. Patients with ASI were identified from the REP database by using International Classification of Disease-9 diagnosis codes for ASI. Patients' charts were individually reviewed in detail to confirm the diagnosis of ASI. Inclusion criteria consisted of (1) patients with 1 or more ASI events, (2) patients < 40 years of age at the time of initial instability and (3) an initial instability event occurring within the time frame of 1994-2016. Exclusion criteria consisted of patients with (1) multidirectional instability, (2) posterior shoulder instability or (3) an unknown date of initial instability event.

Table 2. Overall Incidence Rates of Anterior Shoulder Instability From 1994-2016 (per 100,000 Person-Years)

Age Group	M (#)	F (#)	Male	Female	Total
0-15	103	45	28.1	12.8	20.6
16-20	199	35	203.3	37.5	122.5
21-25	83	21	90.1	20.8	53.9
26-30	50	22	41.8	17.7	29.5
31-40	71	23	30.8	10.1	20.5
			Age-adjusted, male (95% CI)	Age-adjusted, female (95% CI)	Age- and sex-adjusted (95% CI)
Total	506	146	61.1 (55.7-66.5)	17.0 (14.2-19.8)	39.5 (36.4-42.5)

CI, confidence interval.

Patients were considered to have confirmed ASI if there was a documented clinical diagnosis of either dislocation or subluxation by a consulting physician. Individual medical records were reviewed through December 31, 2018, to record details regarding patients' demographics (age, sex, body mass index, etc.), histories, imaging findings (Hill-Sachs, bony Bankart, labral pathology, etc.), surgical details (arthroscopic vs open, labral repair, rotator cuff repair, etc.), and recurrent instability. Imaging findings of primary focus included anterior glenohumeral dislocation on radiograph; Hill-Sachs and bony-Bankart lesions on radiograph or magnetic resonance imaging (MRI); and anterior/inferior labral tear on MRI.

Statistical Analysis

The data are summarized using standard summary statistics, including mean and standard deviation for continuous variables and count and percentage for categorical variables. The age-, sex-, and calendar year-specific incidence rates of ASI were calculated using the number of cases of ASI in Olmsted County, MN, in each age/sex/calendar-year group as the numerators and the corresponding U.S. decennial census population counts for Olmsted County, MN, as the denominators. Age-, sex- and age- and-sex-adjusted incidence rates were calculated by direct standardization to the 2010 United States population. The incidence rates are reported with 95% confidence intervals, which were calculated assuming the data followed a Poisson distribution. Associations of age, sex and calendar year with the incidence rates were evaluated using Poisson regression; age and calendar year were modeled using smoothing splines. Among the incident cases, the association of calendar year and imaging results as well as type of surgical treatment were examined by using logistic regression. All statistical tests were 2-sided, and *P* values less than 0.05 were considered significant. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC) and R version 3.4.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

We identified 758 patients with confirmed ASI. Of these, 106 patients were excluded because the initial

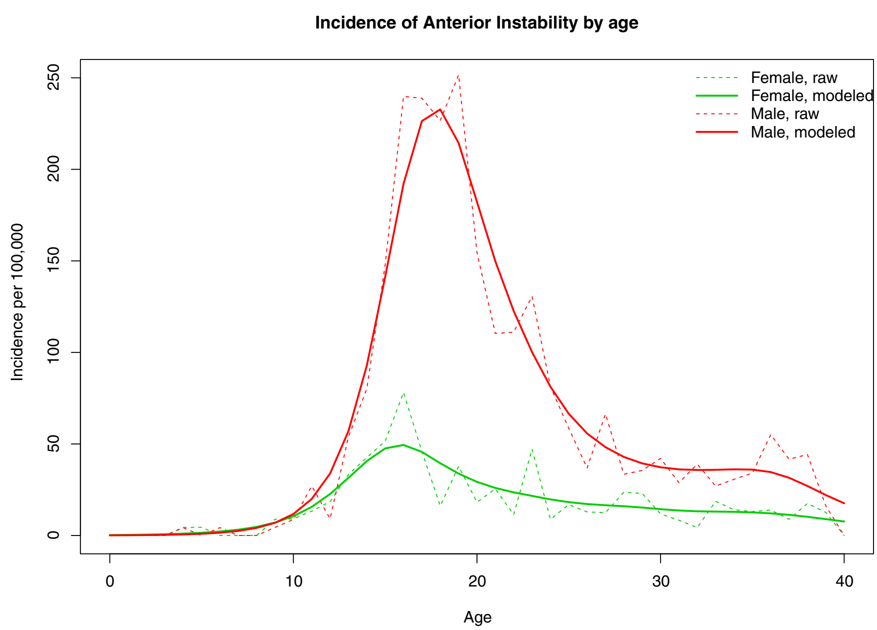

Fig 1. Incidence of anterior shoulder instability diagnosis by age at initial instability. The red (male) and green (female) dotted lines represent raw incidence rates by age. The red (male) and green (female) solid lines represent the modeled incidence rates based on a smoothed function of age in a Poisson regression.

Table 3. Overall Age- and Sex-Adjusted Anterior Shoulder Instability Incidence Rates by Calendar Year (per 100,000 Person-Years)

Calendar years	Age-adjusted, Male (95% CI)	Age-adjusted, Female (95% CI)	Age- and Sex-adjusted (95% CI)
1994-1998	66.8 (54.3-79.3)	18.4 (12.0-24.9)	43.0 (35.9-50.2)
1999-2003	78.8 (65.6-91.9)	28.0 (20.2-35.8)	53.9 (46.2-61.6)
2004-2009	61.3 (50.8-71.8)	14.5 (9.5-19.5)	38.4 (32.5-44.3)
2010-2016	45.6 (37.4-53.9)	11.2 (7.2-15.2)	28.7 (24.1-33.4)

CI, confidence interval.

dates of their instabilities were unavailable or out of the time frame of 1994-2016. Ultimately, 652 (86%) patients met the inclusion criteria. The study population consisted of 506 males (78%) and 146 females (22%), and their mean age was 21.5 years (range, 3.6-39.5) (Table 1). The overall age- and sex-adjusted incidence of ASI diagnosis in patients < 40 years old was 39.5 (95% confidence interval (CI), 36.4-42.5) per 100,000 person-years (Table 2). The overall age-adjusted rate in males and females was 61.1 (95% CI, 55.7-66.5) and 17.0 (95% CI, 14.2-19.8) per 100,000 person-years, respectively, with an incidence rate ratio (IRR) of males relative to females of 3.4 to 1 (95% CI, 2.9-4.1; $P < .001$). Peak incidence of ASI was observed in patients 16-20 years of age at initial instability in both males and females, with rates of 203.3 and 37.5 per 100,000, respectively (Table 2) (Fig 1). Patients 16-20 years of age demonstrated an incidence of 122.5 per 100,000 person-years, which was significantly greater than patients 0-15 (IRR 5.8, 95% CI 4.7-7.1; $P < .001$), 21-25 (2.2, 1.7-2.7; $P < .001$), 26-30 (3.9, 3.0-5.1; $P < .001$), and 31-40 years old (IRR 5.9, 4.6-7.5; $P < 0.001$). Additionally, patients 21-25 years of age also demonstrated a greater incidence rate compared to patients 0-15 (2.7, 2.1-3.4; $P < .001$), 26-30 (1.8, 1.3-2.4; $P < .001$) and 31-40 years of age (2.7, 2.1-3.6; $P < .001$).

Overall age- and sex-adjusted incidence was highest between 1999-2003, with a peak of 53.9 (95% CI, 46.2-61.6) per 100,000 person-years (Table 3) (Fig 2). This incidence rate was significantly higher compared to the calendar years of 1994-1998 (IRR 1.3,1.0-1.6; $P = 0.036$), 2004-2009 (1.8, 1.3-2.4; $P < .001$), and 2010-2016 (1.9, 1.5-2.3; $P < .001$). Additionally, calendar years 1994-1999 demonstrated significantly higher incidence compared to 2004-2009 (1.3, 1.1-1.7; $P = .009$) and 2010-2016 (1.5, 1.2-1.9; $P < .001$). There was no statistical difference the overall age- and sex-adjusted incidence rates between calendar years 2004-2009 and 2010-2016 ($P = 0.322$).

Between calendar years 1994-1999, patients pursued physician consultation after a mean of 0.99 (± 1.09) dislocations and 2.25 (± 1.77) total instability events (Table 4). There was an increase in both the number of dislocations and the total instability events prior to physician presentation over time, with a peak of 1.85 (1.79, $P = 0.016$) and 3.38 (2.29, $P = 0.041$) from

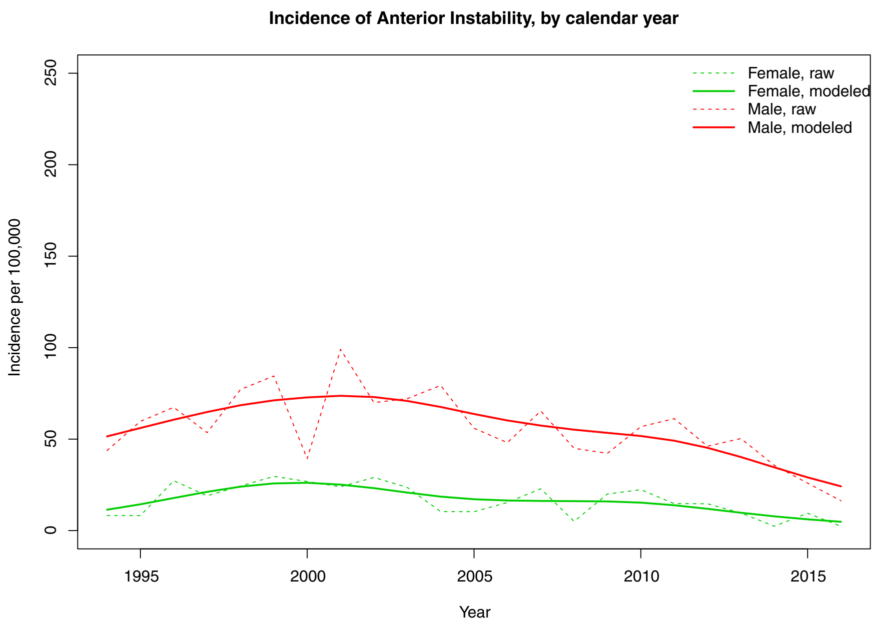

Fig 2. Incidence of anterior shoulder instability diagnosis by calendar year. The red (male) and green (female) dotted lines represent raw incidence rates by age. The red (male) and green (female) solid lines represent the modeled incidence rates based on a smoothed function of year in a Poisson regression.

Table 4. Trends in the Number of Dislocations and Total Instability Events Prior to Consultation and Surgery

Year of Physician Visit	Mean # Dislocations Prior to Consult (SD)	P Value	Mean # Instability Events Prior to Consult	P Value	Calendar Years	Mean # Instability Events Prior to Surgery†	P Value
1994-1999	0.99 (1.09)*	0.016	2.25 (1.77)*	0.041	1994-1999	4.69 (2.77)	0.180
2000-2004	1.35 (1.49)		2.52 (2.27)		2000-2004	4.39 (3.18)	
2005-2009	1.38 (1.33)		2.57 (1.99)		2005-2009	5.87 (3.61)	
2010-2014	1.44 (1.56)		2.82 (2.34)		2010-2014	5.23 (2.81)	
2015-2016	1.85 (1.79)*		3.38 (2.29)*		2015-2018	5.69 (3.17)	

SD, standard deviation.
*Significant differences shown between these groups.
†Subset of patients who underwent surgery.

2015-2018. There was no statistically significant difference between calendar years regarding total number of instability events prior to surgical intervention ($P = 0.180$); the mean number of instability events after presentation but prior to surgery was 2.4 between 1994-1999 and 2.3 between 2015-2018. There was also a trend over time regarding increased rate of diagnosis of bony Bankart and/or Hill-Sachs on MRI, with 96% of patients who underwent MRI demonstrating these lesions in 2015-2018 compared to 53% in 1994-1999 ($P <0$ .01)(Table 5) (Fig 3). Similarly, there was a trend in the proportion of patients who underwent surgical intervention, with significantly higher rates in 2010-2014 and 2015-2018 ($P < .01$) compared to calendar years 1994-1999. Use of arthroscopic surgery peaked between calendar years 2005-2009 (90% of surgical cases) (Fig 4); a trend was observed in the increase of open Latarjet procedures in both 2010-2014 (14%; 95% CI 5.7%-26.3%) and 2015-2018 (31%; 95% CI 16.1%-50.0%) (Table 5).

Discussion

The major findings of this study include an age- and sex-adjusted annual incidence of ASI diagnosis of 39.5 per 100,000 person-years from 1994-2016 in a U.S. geographic population. Peak ASI incidence for both males and females occurred between 16-20 years of age (203.3 and 37.5 per 100,000 person-years, respectively). The incidence rate ratio of males to females was 3.4 to 1 ($P < 0.001$). There were a number of significant trends over time that warrant attention and discussion, including a steadily increasing number of dislocations/instability events prior to physician presentation, increasing diagnosis of bony Bankart and/or Hill-Sachs defect on MRI, increasing number of patients progressing to surgery, decreased use of arthroscopic surgery in recent years, and recently increasing use of the Latarjet procedure.

The overall age- and sex-adjusted incidence of ASI diagnosis was 39.5 (95% CI, 36.4-42.5) per 100,000 person-years in this study. In current literature, population incidence rates for shoulder dislocation have been reported as 12.3 per 100,000 person-years in Denmark,[13] 23.1 per 100,000 in Canada,[9] 23.9 per 100,000 in U.S. emergency departments,[12] 28.0 per 100,000 in the U.K.,[10] and 56.3 per 100,000 in Norway.[14] Although the incidence rate in the present study falls within the range of current studies, it remains higher than in the majority. This is likely explained by inclusion of both glenohumeral subluxation and dislocation events. We believe this methodology offers novel value because glenohumeral subluxation accounts for more than three-fourths of all glenohumeral instability events, with the potential of resulting in structural damage similar to that of dislocation.[2,37,38] Additionally, the age-adjusted ASI instability rate was 61.1 (95% CI, 55.7-66.5) per 100,000 person-years in males and 17.0 (95% CI, 14.2-19.8) in females, with males demonstrating an IRR of 3.4 to 1 (95% CI, 2.9-4.1) relative to females. These findings are also well aligned with current literature, which shows that reported incidence rates of dislocation range from 34.3-82.2 per 100,000 person-years in males and 11.8-30.9 in females (IRR 2.6-2.8).[9,10,12,14]

Over time, patients demonstrated a steadily increasing number of dislocations or instability events

Table 5. Trends Over Time in the Rate of BB or HS on MRI, Surgery, Arthroscopic Surgery, and Latarjet Procedures

Calendar Years	BB or HS on MRI (n)	P Value	Progressed to Surgery (n)	Odds Ratio	P Value	Arthroscopic Surgery (n)	Odds Ratio	P Value	Latarjet Procedure (n)	95% CI (for rates)
1994-1999	53% (9/17)	*	20% (30/154)	1.0	*	47% (14/30)	1.0	*	0% (0/25)	N/A
2000-2004	56% (38/68)	0.827	25% (44/178)	1.36	0.254	72% (31/43)	2.95	0.030	0% (0/43)	N/A
2005-2009	81% (55/68)	0.021	29% (39/134)	1.70	0.058	90% (35/39)	10.0	<.001	0% (0/36)	N/A
2010-2014	82% (69/84)	0.012	38% (53/140)	2.52	<.001	83% (44/53)	5.59	<.001	14% (7/51)	(5.7%-26.3%)
2015-2018	96% (27/28)	0.005	70% (32/46)	9.45	<.001	66% (21/32)	2.18	0.135	31% (10/32)	(16.1%-50.0%)

BB, bony Bankart lesion; CI, confidence interval; HS, Hill-Sachs lesion; MRI, magnetic resonance imaging; N/A, not applicable.
*Reference for P value comparisons.

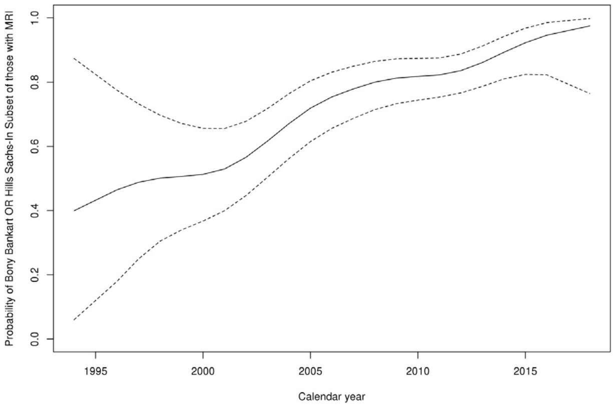

Fig 3. Rate of diagnosis of Hill-Sachs or Bony Bankart on MRI by calendar year. The solid line represents the modeled probability, and the dashed lines represent the 95% confidence interval.

prior to physician presentation as well as a significantly increased rate of diagnosis of bony Bankart and/or Hill-Sachs defects in patients who underwent MRI. Although the present data do not provide answers about why these trends are observed, there are several possibilities. This trend in more severe pathology and structural damage may be related to the increased number of instability events reported prior to presentation and imaging. Additionally, it may be associated with improved MRI modalities, increased focus on identifying bony Bankart and/or Hill-Sachs lesions and increasing concern about glenoid bone loss. Alternatively, perhaps the increasing number of reported instability events at the time of physician consultation is due to an increased awareness of ASI diagnosis by athletes and the general public, resulting in an increasing number of reported events over time.

Additionally, overall age- and sex-adjusted incidence peaked between 1999-2003 and decreased thereafter. Theoretical explanations for an increasing avoidance of prompt medical evaluation by a treating physician include increasing normalization of ASI among athletes and the general public, changes in health care copays or other socioeconomic factors over time, increasing prevalence of initial nonoperative ASI management by athletic trainers or physical therapists until multiple instability events have occurred, or growing pressure on coaches and young athletes to remain active and competitive, thereby playing through injury. A 2012 youth sports survey study reported that roughly half of all coaches have received pressure from either parents or kids themselves to let an injured child play during a game.[39] Whatman et al., in 2018,[40] similarly reported that approximately 50% of players and coaches have seen players put under pressure to play when injured; a lack of knowledge and the desire to win and not let the team down are key reasons given for this behavior. Regardless, the observed trends in the present study are alarming. An initial ASI event may be perceived as a minor or temporary injury by some, but recent orthopedic literature makes a strong case for the importance of early orthopedic consultation.

A 2019 study by Dickens et al.[41] demonstrated measurable glenoid bone loss after a single instability event (6.8% of glenoid width), which increased up to nearly one-fourth (22.8%) of glenoid width in the setting of recurrent instability. McNeil et al.[42] reported increased total time of ASI to be a significant factor in greater attritional glenoid bone loss, and increasingly severe glenoid bone injury has been associated with both recurrent instability and inferior outcomes following arthroscopic Bankart repair.[31,32,43-46] Furthermore, the Multicenter Orthopaedic Outcomes Network Shoulder Group has demonstrated increasing glenoid bone loss and increasing number of instability events before surgery to be associated with increased need for revision stabilization surgery.[47] The amount of bone loss considered critical to warranting conversion to an open stabilization procedure is unclear, but it has been reported to range from 13.5-25%.[31,43,45] As such, the trends demonstrated in this

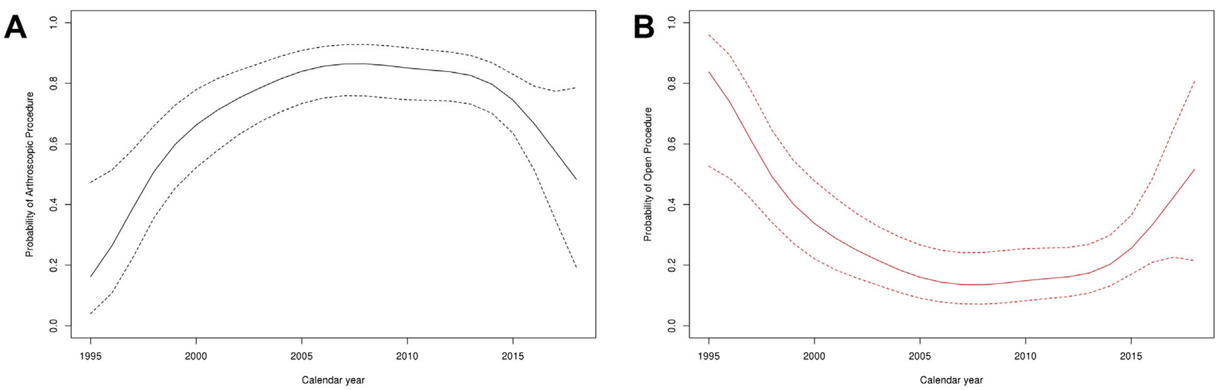

Fig 4. Trends in the percentage of (A) arthroscopic surgery and (B) open Latarjet procedures in patients who underwent surgical stabilization, by calendar year. The solid line represents the modeled probability; the dashed lines represent the 95% confidence interval.

study are of utmost importance. Although recent literature may indicate the need for early surgical intervention in young patients so as to prevent attritional glenoid bone loss,[41] there remains a challenging disconnect in the results of the current study. Education of the general public, young athletes and coaches regarding the significance of ASI and the potential long-term effects is imperative. Additionally, the number of dislocations prior to presentation has increased over time, but the mean number of instability events after presentation but prior to surgery has remained steady. Perhaps this is a potential area for medial provider education; some of these patients should be considered for earlier surgery.

In regard to treatment trends observed over time, the present study did demonstrate an increase in the proportion of patients undergoing surgical intervention. Additionally, the use of arthroscopic surgery peaked between calendar years 2005-2009 (90% of surgical cases); a trend was observed in the increase of open Latarjet procedures from both 2010-2014 (14% of surgical cases; 95% CI 5.7%-26.3%) and 2015-2018 (31%; 95% CI 16.1%-50.0%). Because of the small sample size and large confidence intervals, this study was unable to conclude whether there was a significant change in the proportion of patients undergoing Latarjet procedures betwen 2010-2014 and 2015-2018.

Degen et al.[48] reported a similar trend when evaluating cases from the American Board of Orthopaedic Surgery database. From 2004-2013, the overall annual incidence of both arthroscopic stabilization and bone-block procedures increased; however, the proportion of stabilization cases using bone-block augmentation increased significantly, while the proportion of arthroscopic stabilizations decreased significantly. In a recent study of the military population, Galvin et al.[49] reported that although arthroscopic Bankart repair remained relatively stable as the dominant surgical procedure for ASI, there was a significant increase in the use of the Latarjet procedure, probably because of the recognition of bone loss through use of preoperative advanced imaging and 3-dimensional reconstructions.

These surgical trends are likely to be multifactorial; current literature has demonstrated that risk factors for recurrence following arthroscopic Bankart repair include patient functional status, high-risk sport participation, longer symptom duration, increasing numbers of dislocations, and greater glenoid bone loss.[31,45,50,51] In these patients, Latarjet procedures have demonstrated superior functional outcomes and lower rates of recurrent instability.[45,50,51] A 2019 multicenter prospective study by the Multicenter Orthopaedic Outcomes Network shoulder group reported the significant predictors of surgical decision making and use of the Latarjet procedure to include longer symptom duration, increasing number of dislocations, greater humeral and glenoid bone loss, and past shoulder surgery.[52] More specifically, patients with a Hill-Sachs lesion measuring 11%-20%, glenoid bone loss of 11%-20% and glenoid bone loss of 21%-30% were 10, 64 and 136 times, respectively, more likely to undergo a Latarjet procedure. In the context of the present study, the proportion of open Latarjet procedures is increasing, and the proportion of arthroscopic Bankart surgical repair is decreasing. This observation may be explained by a greater incidence of glenohumeral bone lesions in patients with increasing severity of pathology at the time of initial presentation and/or increasing understanding of glenohumeral bone loss with improved measurement by MRI and CT, and/or the majority of these procedures' being performed in a referral type of practice and/or an increasing familiarity with the Latarjet procedure by orthopedic surgeons.

Limitations

The present study is not without limitations. The results provided are based on a retrospective review of ASI, such that the results and conclusions may be susceptible to the inherent bias of the retrospective process. This includes dependence upon accurate and complete documentation in patients' medical records, which may also be susceptible to subjectivity. However, using an established geographic database capturing all medical records for involved patients partially alleviates some of these limitations. Second, the treatment modalities and techniques described are based on surgeon preference because there was no standardized study protocol, which may also influence the reported outcomes. However, using a standardized treatment protocol would have been detrimental to the overall purpose of the study, which involved reporting the trends in treatment over time. Third, the use and availability of advanced imaging was probably variable across the geographic database, and it certainly changed with patient care over time. Furthermore, the diagnoses of bony Bankart and/or Hill-Sachs defects in patients who underwent MRI were reported by a radiologist and surgeon at the time of evaluation rather than a review of images, as in the current study. Fourth, objective data involving severity of humeral or glenoid bone loss was not calculated on advanced imaging and, thus, cannot be quantified in our study. Last, the geographic group used was a U.S. population of patients < 40 years of age. This may result in cultural or regional bias regarding clinical and surgical decision making. Additionally, the trends observed in this patient population may not be generalizable to other geographic populations due to the regional bias of this study, the relatively low number of patients treated surgically within each year and the referral-type of practice setting where many of these patients may have been seen initially by outside providers.

Conclusions

The age- and sex-adjusted incidence of ASI diagnosis in a U.S. population from 1994-2016 is comparable to that demonstrated in Canadian and European populations. This study demonstrates an increasing number of instability events prior to surgical evaluation, which may correlate with patients' more commonly presenting with bone loss and requiring more aggressive surgical treatment or with ASI being more frequently cared for and documented by present-day orthopedic surgeons.

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