Predictors for Surgery in Shoulder Instability

A Retrospective Cohort Study Using the FEDS System

George F. Lebus V,*† MD, Martin B. Raynor,† MD, Samuel K. Nwosu,† MS, Emily Wagstrom,‡ MD, Sunil S. Jani,§ MD, MS, James L. Carey,§ MD, MPH, Carolyn M. Hettrich,‡ MD, MPH, Charles L. Cox,† MD, MPH, and John E. Kuhn,† MS, MD, for the MOON Shoulder Group

Investigation performed at Vanderbilt Orthopaedic Institute, Sports Medicine, Nashville, Tennessee, USA

Background: Shoulder instability is a common cause of pain and dysfunction in young, active patients. While studies have analyzed risk factors for recurrent instability and failure after instability surgery, few have examined which variables are associated with initial surgery in this patient population.

Purpose: To identify variables that may be associated with surgical intervention in patients with shoulder instability in the context of the FEDS (frequency, etiology, direction, severity) classification, a system that may be useful in the surgical treatment of shoulder instability patients.

Study Design: Cohort study (prognosis); Level of evidence, 2.

Methods: A database of patients treated for shoulder instability from 3 separate institutions from 2005 to 2010 was generated using International Classification of Diseases–9th Revision data. Data were collected via retrospective review. Injury data were categorized according to the FEDS system. Data were analyzed for significance, with the primary outcome of surgical intervention. Summary statistics were used to assess which variables were associated with eventual surgery. To test the unadjusted bivariate associations between shoulder surgery and each data point, Pearson chi-square tests were used for categorical variables and Wilcoxon tests were used for continuous variables.

Results: Over the study time period, 377 patients were treated for shoulder instability. Patients who had surgery were more likely younger, had recurrent instability, and had their initial injury while playing a sport. Most patients had anterior instability; however, there was a greater proportion of posterior instability patients in the operative group. Severity of dislocation, measured by whether the patient required help to relocate the shoulder, was not significantly associated with eventual surgery. While imaging was not available for all patients, surgical patients were more likely to have magnetic resonance imaging findings of anterior labral injury and less likely to have a supraspinatus or subscapularis tear.

Conclusion: Patients who underwent surgery for shoulder instability were younger, more likely to have experienced recurrent instability, and more likely to have sustained their original injury while playing sports. The FEDS classification, particularly the frequency and etiology of the patient's shoulder instability, may be helpful in identifying patients with a higher likelihood of undergoing surgical treatment.

Keywords: shoulder instability; shoulder instability surgery; FEDS classification

*Address correspondence to George F. Lebus, MD, Vanderbilt Orthopaedic Institute, 1215 21st Avenue South, Medical Center East, South Tower, Suite 4200, Nashville, TN 37232, USA (email: geoflebus@gmail.com).

†Vanderbilt Orthopaedic Institute, Sports Medicine, Nashville, Tennessee, USA.

‡University of Iowa, Iowa City, Iowa, USA.

§Penn Sports Medicine Center, Philadelphia, Pennsylvania, USA.

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Shoulder instability has long been recognized as a common ailment for individuals of all demographics. Prevalence of primary anterior shoulder dislocation has been reported to be as high as 1.7%.[4,6,9,16] Recent epidemiologic studies have confirmed the high prevalence and deleterious effects of shoulder instability in young, athletic patient populations.[5,10,13,14] This pathology accounts for a great deal of missed performance and training time, as well as long-term health detriment and lifestyle modification. Although some patients who experience shoulder instability can return to the preinjury activity levels without surgical treatment, others have persistent dysfunction that impairs

their quality of life and performance and requires surgical intervention. Predicting which patients will require surgical intervention for their shoulder instability is difficult. Although reports have analyzed risk factors for recurrent instability[2,8,15] and failure after instability surgery,[1] there is a paucity of data about what factors are associated with initial surgery in this patient population.

Furthermore, the literature to this point regarding shoulder instability has been heterogeneous in its terminology, and patient selection and has led to difficulty in meaningfully defining shoulder instability, comparing treatment strategies, and predicting outcomes. More recently, a new classification system known as the FEDS (frequency, etiology, direction, severity) system was proposed in an effort to simplify and standardize discussion about shoulder instability.[7] This classification was developed by incorporating the most common elements from existing instability classification schemes in the literature, including frequency of dislocation/subluxation, etiology of instability (traumatic or atraumatic), primary direction of instability (anterior, posterior, or inferior), and severity of instability events, measured by whether the patient had to have assistance to relocate the shoulder joint (dislocation vs subluxation). The FEDS system relies on information that can be gleaned from patient history and physical examination and has been shown to have high intraobserver and interobserver agreement.[7] Although the FEDS classification system was not specifically defined to be predictive of surgical outcome in patients with shoulder instability, one important measure of classifications in general is whether they are useful in identifying natural history and informing treatment options. We therefore hypothesized that the FEDS parameters would be different between patients who undergo surgery for shoulder instability versus those who are treated nonoperatively. The FEDS system may then be useful in predicting which shoulder instability patients go on to surgical intervention.

METHODS

A patient database was created using the International Classification of Diseases–9th Revision (ICD-9) coding data of all patients evaluated by the 3 separate institutions for shoulder instability from 2005 to 2010. The research team then interrogated the database retrospectively. Data were extracted from patient records and entered into the Redcap database. Information collected included demographics as well as injury characteristics in the organization of the FEDS classification. Demographic data consisted of age at first presentation, age at first episode of instability, sex, dominant arm, presence of generalized ligamentous laxity on examination, and medical setting to which the patient first presented. This information was gleaned from chart review. Signs of ligamentous laxity were not graded but were instead categorized as present or absent based on the evaluation of the treating physician. Injury characteristics were collected based on the FEDS classification system, including frequency of instability episodes in 1 year (categorized as solitary, 2-5, or >5 episodes), etiology of initial episode (atraumatic vs traumatic and, if traumatic, whether injury occurred while playing a sport), primary direction of instability (anterior, posterior, or inferior), and severity (whether the patient needed assistance to reduce the shoulder).

Although imaging information is not included in the FEDS classification scheme and was not available for all patients, imaging data were also reviewed and compared between the surgical and nonsurgical groups. Data were specifically collected on types of radiographic studies performed, whether a bony defect was present on plain films or computed tomography (CT), and what other lesions were present on magnetic resonance imaging (MRI), if any. Of the study group of 377 patients, 283 (75%) had radiographs, 45 (12%) had CT scans, and 194 (51%) had MRIs available for review. An analysis was performed that excluded those patients who did not have imaging studies available. Finally, for those patients who did undergo surgery, information was collected on surgical approach and procedure performed but was not analyzed as part of this investigation.

Data were then analyzed descriptively, with occurrence of surgery as the primary outcome. For this analysis, our patient population was split into 2 groups: those who eventually underwent surgery and those who did not. All data points were considered possible associated variables and were compared between these 2 groups. In our comparison, means and SDs were calculated for continuous variables, and categorical variables were expressed as frequencies and percentages. To test the unadjusted bivariate associations of each data point, Pearson chi-square tests were used for categorical variables and Wilcoxon tests were used for continuous variables. Statistical significance was set at $P < .05$.

RESULTS

We identified 377 patients who were evaluated and treated for shoulder instability and who had complete data that could be extracted from the chart during the study time period of 2005 to 2010. With regard to overall demographic data, the majority of patients (72%) were male, ranging in age from 10 to 79 years. Mean age at first episode of instability was 26 years (median, 21 years), and mean age at first presentation to medical attention was 29 years (median, 22 years). The majority of patients (68%) initially presented to a specialty orthopaedic clinic, whereas the remainder presented to either the emergency department or another general clinic. Overall demographic information is presented in Table 1.

Patients were divided into 2 groups for statistical comparison depending on whether they eventually underwent surgery for shoulder instability. Of the total patient cohort, 234 (62%) underwent a surgical procedure for shoulder instability whereas 143 (38%) did not. With regard to demographic data and patient characteristics, patients in the surgical group were younger, experiencing initial instability symptoms at a mean age of 22 years (median, 18 years) compared with a mean age of 31 years (median, 24 years) in

TABLE 1
Demographic Data of the Study Population (N = 377)[a]

Sex	
Female	28 (106)
Male	72 (271)
Age, y, mean ± SD (lower quartile/median/upper quartile)	
First instability episode	26 ± 19 (15/20/32)
Initial presentation	29 ± 17 (17/22/37)
Dominant arm	
Left	9 (34)
Not stated	33 (126)
Right	58 (217)
Where patient presented	
Emergency department	21 (78)
General orthopaedic clinic	6 (23)
Specialty orthopaedic clinic	69 (259)
Other clinic	5 (17)

[a]Results are reported as % (n) unless noted otherwise.

TABLE 2
Demographic Data of Nonsurgical Versus Surgical Groups[a]

	Nonsurgical Group (n = 143)	Surgical Group (n = 234)	*P* Value
Age, y, mean ± SD (lower quartile/median/upper quartile)			
First instability episode	31 ± 22 (17/24/46)	22 ± 15 (15/18/25)	<.001[b]
Initial presentation	35 ± 20 (19/29/46)	26 ± 14 (17/21/32)	<.001[b]
Sex			.11[c]
Female	33 (47)	25 (59)	
Male	67 (96)	75 (175)	
Dominant arm			.11[c]
Left	8 (11)	10 (23)	
Not stated	40 (57)	29 (69)	
Right	52 (75)	61 (142)	
Signs of ligamentous laxity			.34[c]
No	57 (57)	51 (106)	
Yes	43 (43)	49 (101)	

[a]Results are reported as % (n) unless noted otherwise.
[b]Wilcoxon test.
[c]Pearson chi-square test.

the nonsurgical group ($P < .001$). Patients in the surgical group presented to medical attention earlier as well at a mean age of 26 years (median, 21 years) compared with a mean age of 35 years (median, 29 years) in the nonsurgical group ($P < .001$). As demonstrated in Table 2, there was no significant difference in sex, hand dominance, or presence of signs of ligamentous laxity between the 2 groups.

In the analysis of injury characteristics collected in the framework of the FEDS classification system, frequency of instability and whether injury occurred while playing sports were found to be significantly different between the surgical and nonsurgical groups ($P < .001$). Statistical significance was also found in comparing direction of dislocation between groups, although anterior instability was predominant in both surgical and nonsurgical populations. Severity, or whether the patient required assistance to reduce their shoulder, was not different between surgical and nonsurgical groups.

With regard to frequency, approximately two-thirds of patients in the surgical group experienced more than 1 episode of instability in the prior year compared with only one-third of patients in the nonsurgical group. Specifically, 81 patients (35%) in the surgical group experienced >5 episodes of instability, and 78 (33%) had 2 to 5 episodes of instability. Only 16 patients (11%) in the nonsurgical group had more than 5 episodes of instability, and only 30 (21%) had 2 to 5 episodes. Among those patients who underwent surgery, relatively fewer (32%) had a solitary episode of instability, whereas most in the nonsurgical group (68%) had a solitary episode of instability ($P < .001$). With regard to etiology, most patients in the cohort overall (86%) reported a traumatic event that initiated their symptoms of instability; however, type of traumatic injury was different between the nonsurgical and surgical groups. In all, 128 individuals in the surgical group (58%) sustained an injury while playing sports while only 54 (38%) in the nonsurgical group related their original injury to athletics ($P < .001$). In the analysis of direction of dislocation, instability was described as anterior in 187 (80%), posterior in 45 (19%), and inferior in 2 patients (1%) in the surgical group. In the nonsurgical group, instability was anterior in 119 (83%), posterior in 18 (13%), and inferior in 6 (4%). There was a statistically significant difference in these figures between the 2 groups ($P = .028$), with a higher proportion of patients in the surgical group experiencing posterior instability and a lower proportion experiencing anterior and inferior instability compared with the nonsurgical group; however, notably, the majority of patients in both groups experienced anterior instability. Additionally, there were 3 times more patients with inferior shoulder instability treated nonoperatively. Finally, with regard to severity, there was no statistically significant difference between the 2 groups. A total of 140 (60%) patients in the surgical group required assistance to reduce their shoulder after injury compared with 87 (61%) in the nonsurgical group ($P = .85$). Demographic data and injury characteristics/FEDS data comparing the surgical and nonsurgical groups are demonstrated in Tables 2 and 3, respectively.

With respect to imaging, data were not available for all patients. Overall, 283 (75%) had radiographs, 45 (12%) had CT scans, and 194 (51%) had MRIs available for review. Of the 234 surgical patients, 163 (70%) had radiographs, 36 (15%) had CT scans, and 148 (63%) had MRIs. Of the 143 nonsurgical patients, 120 (84%) had radiographs, 9 (6%) had CT scans, and 46 (32%) had MRIs. Despite the lack of complete data, analyzing the presence of lesions identified on imaging studies between the surgical and nonsurgical groups revealed that patients in the surgical group were more likely to have an MRI revealing an anterior labral tear ($P = .012$) and less likely to have a supraspinatus tear ($P = .006$) or subscapularis tear ($P = .017$). A greater

TABLE 3
Injury Characteristics Organized by the FEDS Classification System: Nonsurgical Versus Surgical Groups[a]

	Nonsurgical Group (n = 143)	Surgical Group (n = 234)	Combined (N = 377)	*P* Value
Frequency: ipsilateral shoulder				<.001[b]
1 (solitary)	68 (97)	32 (75)	46 (172)	
2-5	21 (30)	33 (78)	29 (108)	
>5	11 (16)	35 (81)	26 (97)	
Etiology: injury started problem				.56[b]
No	15 (22)	13 (31)	14 (53)	
Yes	85 (121)	87 (203)	86 (324)	
Injury occurred while playing sport				<.001[b]
No	62 (87)	42 (94)	50 (181)	
Yes	38 (54)	58 (128)	50 (182)	
Direction of dislocation/subluxation				.028[b]
Anterior	83 (119)	80 (187)	81 (306)	
Inferior	4 (6)	1 (2)	2 (8)	
Posterior	13 (18)	19 (45)	17 (63)	
Severity: assistance to reduce shoulder				.85[b]
No	39 (56)	40 (94)	40 (150)	
Yes	61 (87)	60 (140)	60 (227)	

[a]Results are reported as % (n). FEDS, frequency, etiology, direction, severity.
[b]Pearson chi-square test.

percentage of patients in the surgical group had anterior glenoid bone loss than in the nonsurgical group, but the results were not statistically significant ($P = .055$). These data are presented in Table 4.

DISCUSSION

Shoulder instability is a common cause of pain and dysfunction in young, active patients, particularly in athletes. There is still debate regarding the precise role of surgical treatment in this condition. While previous authors have analyzed risk factors for recurrent instability[2,8,15] and failure after shoulder stabilization surgery in this population,[1] there has been a lack of investigation regarding which variables are associated with surgery for shoulder instability in the first place. This study is novel in that it seeks to address this question in the framework of the FEDS classification system. Based on this retrospective analysis, patients requiring surgery for shoulder instability are not surprisingly similar to those who are at risk for recurrent instability. They are more likely to have symptoms and present at a younger age, have multiple episodes of instability, and to relate the origin of their instability to an injury sustained while playing sports. The FEDS classification system may be a useful way to approach evaluation and treatment of this challenging patient population.

The findings in this report are congruent with those of several other studies that have addressed risk factors for recurrent shoulder instability as well as failure after shoulder instability surgery. In 2006, Robinson et al[15] found that younger, active male patients were most at risk for recurrent instability, and that 86.7% of patients known to have recurrent instability developed recurrent symptoms within the first 2 years. Leroux et al[8] reported in their series that young age, male sex, and higher income quintile were predictive of recurrent shoulder instability. They found medical comorbidities, dislocation associated with humeral tuberosity fracture, and reduction performed by an orthopaedic surgeon to be protective for recurrent instability.[8] History of prior injury was a risk factor for future instability in a review of a young military population by Cameron et al.[2] Specifically, patients with a self-reported history of glenohumeral instability were noted to be 5 times more likely to experience another instability event during the study time period.[2] Individuals who continue to have symptoms, recurrent injury, and prolonged dysfunction may be more likely to seek surgical treatment for their condition. The Instability Severity Index Score developed by Balg and Boileau[1] was established to identify which patients treated with arthroscopic stabilization of shoulder instability may go on to develop recurrent instability. Risk factors identified in their study are quite similar to the variables identified in our patient sample; they found that patient age less than 20 years at the time of surgery, involvement in competitive or contact sports, hyperlaxity, or Hill-Sachs lesion or loss of inferior glenoid sclerotic edge were all risk factors for recurrent instability after arthroscopic stabilization.[1]

Shoulder instability has commonly been associated with the athletic shoulder. Similarly, in this study, patients whose instability symptoms started after an injury during sports were more likely to undergo shoulder surgery. Despite the prevalence of instability among athletes, optimal treatment and return-to-play guidelines are still unclear. The morbidity sustained by athletes due to instability, however, has been demonstrated consistently. In a recent prospective multicenter study, Dickens et al[3] showed that only 27% of contact intercollegiate athletes

TABLE 4
Imaging Data: Radiograph, CT, and MRI Findings of the Nonsurgical Versus Surgical Groups (Available Data)[a]

	Nonsurgical Group	Surgical Group	Combined	*P* Value
Radiographs	n = 120	n = 163	n = 283	
Bony defect				.2[b]
No	68 (81)	60 (98)	63 (179)	
Yes	32 (39)	40 (65)	37 (104)	
CT	n = 9	n = 36	n = 45	
Bony defect				.54[b]
No	22 (2)	14 (5)	16 (7)	
Yes	78 (7)	86 (31)	84 (38)	
MRI	n = 46	n = 148	n = 194	
Anterior glenoid bone loss				.055[b]
No	93 (43)	82 (121)	85 (164)	
Yes	7 (3)	18 (27)	15 (30)	
Posterior glenoid bone loss				.21[b]
No	100 (46)	97 (143)	97 (189)	
Yes	0 (0)	2 (5)	3 (5)	
Hill-Sachs lesion				.17[b]
No	67 (31)	56 (83)	59 (114)	
Yes	33 (15)	44 (65)	41 (80)	
Reverse Hill-Sachs lesion				.08[b]
No	87 (40)	95 (140)	93 (180)	
Yes	13 (6)	5 (8)	7 (14)	
Anterior labral tear				.012[b]
No	65 (30)	44 (65)	49 (95)	
Yes	35 (16)	56 (83)	51 (99)	
Posterior labral tear				.74[b]
No	76 (35)	74 (109)	74 (144)	
Yes	24 (11)	26 (39)	26 (50)	
HAGL				.33[b]
No	100 (46)	98 (145)	98 (191)	
Yes	0 (0)	2 (3)	2 (3)	
Supraspinatus tear				.006[b]
No	78 (36)	93 (137)	89 (173)	
Yes	22 (10)	7 (11)	11 (21)	
Infraspinatus tear				.081[b]
No	89 (41)	96 (142)	94 (183)	
Yes	11 (5)	4 (6)	6 (11)	
Subscapularis tear				.017[b]
No	89 (41)	99 (146)	96 (187)	
Yes	11 (5)	1 (2)	4 (7)	

[a]Results are reported as % (n). CT, computed tomography; HAGL, humeral avulsion of glenohumeral ligament; MRI, magnetic resonance imaging.
[b]Pearson chi-square test.

who had an initial instability event returned to their sport and completed their season without subsequent instability. Athletes may be more likely to undergo shoulder surgery due to the high rate of recurrent symptoms they experience during athletic competition.

Direction of instability also deserves special mention. Anterior instability was the most common in both surgical and nonsurgical groups, but posterior was more common and inferior less common in patients who eventually underwent surgery in this cohort. Interestingly, differences between the surgical and nonsurgical groups were statistically significant despite that the overwhelming majority of instability events in both groups were anterior. Specifically, posterior instability was slightly more common in the surgically treated group than the nonsurgical group (19% compared with 13%). This finding correlates with a recent report by Song et al,[17] who found that 40% of their arthroscopic surgery–treated shoulder instabilities were for posterior or combined instability. Posterior shoulder instability may represent a more common surgical problem in young, active individuals than previously recognized.

With regard to the imaging findings in this study, no definitive conclusions can be drawn as data are incomplete.

Nevertheless, analysis of available information reveals some interesting points that may be the target of future study. Patients who underwent surgery were more likely to have an anterior labral injury identified on MRI and less likely to have a rotator cuff tear. These data corroborate that structural injury to the anterior shoulder may be predictive of need for surgery. That rotator cuff tears were less commonly identified in patients treated surgically may be a product of the more probable discovery of rotator cuff tears in the older patients in our cohort who were treated nonoperatively. Certainly, the rotator cuff as a dynamic stabilizer of the glenohumeral joint would presumably benefit from surgical intervention apart from other confounding variables. These factors need further study as not all patients in this group, particularly nonoperatively treated patients, underwent advanced imaging or had imaging available for review. Reasons for patients not having imaging data likely include that advanced imaging may have not been obtained in cases of isolated instability events with a nonoperative treatment plan and that outside institution imaging information may have not been available at the time of chart review. The role of imaging in predicting shoulder instability has been explored to a degree in the literature. Owens et al[11,12] demonstrated a correlation with anatomic variation in shoulder girdle anatomy, specifically related to glenoid version and shape and coracohumeral distance. As many patients in our study did not have 3-dimensional imaging available for review at the time of data collection, analysis of these particular data points was not possible; however, future studies could examine these features in patients who go on to shoulder instability surgery to determine whether there is an association between certain imaging findings and need for operative intervention and surgical outcomes.

This analysis has several important limitations. Our study was a retrospective, descriptive analysis, and as such, is vulnerable to the confounding and bias inherent in this study design. Additionally, the primary outcome of our study was occurrence of surgical treatment in this population. There are certainly multiple variables that factor into the decision-making process for surgery that were not controlled, including individual patient and surgeon preference and general indications for surgery. Ultimately, this study cannot determine precisely why patients in our cohort went on to have surgery. Likewise, it cannot provide insight into why some patients were treated nonsurgically. As demonstrated in our results, several patients with recurrent instability (16 with >5 episodes of instability) were treated nonoperatively. Conclusions regarding the presence of certain imaging findings and their association with need for surgery should be interpreted with caution as only a fraction of the patients in the study had complete imaging data available for review. Nevertheless, our report may still be valuable to the physician treating shoulder instability as it confirms that risk factors for recurrent instability and failure after instability surgery are congruent to variables that contribute to patients having surgery in the first place. Furthermore, this report provides a framework in the FEDS system for clinicians to identify and guide patients who may be more likely to eventually end up undergoing surgery. Strengths of this study include its relatively large patient population that was collected through the collaboration of multiple sites. Although the study's multicenter nature introduces further subjectivity regarding which patients ultimately underwent surgery, it also perhaps allows our results to be generalizable across a larger spectrum of the population. Finally, this study is novel in that it seeks to associate patient variables with shoulder instability surgery in the framework of the FEDS classification system, a reproducible and facile classification system for shoulder instability.

CONCLUSION

Shoulder instability is a common cause of pain and dysfunction in young, active patients. There is still debate regarding the precise role for surgical treatment in this condition. Variables associated with surgical intervention appear to be similar to those associated with recurrent instability and instability after stabilization surgery. Specifically, patients who have instability and present to medical attention at a younger age, experience recurrent episodes of instability, and relate their instability to an injury sustained while playing sports may be more likely to ultimately have surgery for their instability. The FEDS classification may be useful in the evaluation and counseling of high-risk potential surgical candidates.

REFERENCES

1. Balg F, Boileau P. The instability severity index score: a simple preoperative score to select patients for arthroscopic or open shoulder stabilization. *J Bone Joint Surg Br*. 2007;89:1470-1477.
2. Cameron KL, Mountcastle SB, Nelson BJ, et al. History of shoulder instability and subsequent injury during four years of follow-up: a survival analysis. *J Bone Joint Surg Am*. 2013;95:439-445.
3. Dickens JF, Owens BD, Cameron KL, et al. Return to play and recurrent instability after in-season anterior shoulder instability: a prospective multicenter study. *Am J Sports Med*. 2014;42:2842-2850.
4. Hovelius L. Incidence of shoulder dislocation in Sweden. *Clin Orthop Relat Res*. 1982;166:127-131.
5. Kerr ZY, Collins CL, Pommering TL, Fields SK, Comstock RD. Dislocation/separation injuries among US high school athletes in 9 selected sports: 2005-2009. *Clin J Sport Med*. 2011;21:101-108.
6. Krøner K, Lind T, Jensen J. The epidemiology of shoulder dislocations. *Arch Orthop Trauma Surg*. 1989;108:288-290.
7. Kuhn JE. A new classification system for shoulder instability. *Br J Sports Med*. 2010;44:341-346.
8. Leroux T, Wasserstein D, Veillette C, et al. Epidemiology of primary anterior shoulder dislocation requiring closed reduction in Ontario, Canada. *Am J Sports Med*. 2014;42:442-450.
9. Nordqvist A, Petersson CJ. Incidence and causes of shoulder girdle injuries in an urban population. *J Shoulder Elbow Surg*. 1995;4:107-112.
10. Owens BD, Agel J, Mountcastle SB, Cameron KL, Nelson BJ. Incidence of glenohumeral instability in collegiate athletics. *Am J Sports Med*. 2009;37:1750-1754.
11. Owens BD, Campbell SE, Cameron KL. Risk factors for anterior glenohumeral instability. *Am J Sports Med*. 2014;42:2591-2596.

12. Owens BD, Campbell SE, Camerson KL. Risk factors for posterior shoulder instability in young athletes. *Am J Sports Med*. 2013;11: 2645-2649.
13. Owens BD, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. *J Bone Joint Surg Am*. 2009;91:791-796.
14. Owens BD, Duffey ML, Nelson BJ, DeBerardino TM, Taylor DC, Mountcastle SB. The incidence and characteristics of shoulder instability at the United States Military Academy. *Am J Sports Med*. 2007;35:1168-1173.
15. Robinson CM, Howes J, Murdoch H, Will E, Graham C. Functional outcome and risk of recurrent instability after primary traumatic anterior shoulder dislocation in young patients. *J Bone Joint Surg Am*. 2006;11:2326-2336.
16. Simonet WT, Melton LJ 3rd, Cofield RH, Ilstrup DM. Incidence of anterior shoulder dislocation in Olmsted County, Minnesota. *Clin Orthop Relat Res*. 1984;186:186-191.
17. Song DJ, Cook JB, Krul KP, et al. High frequency of posterior and combined shoulder instability in young active patients. *J Shoulder Elbow Surg*. 2015;24:186-190.