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Joseph W. Galvin, Stephen A. Parada, Xinning Li and Josef K. Eichinger

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Critical Findings on Magnetic Resonance Arthrograms in Posterior Shoulder Instability Compared With an Age-Matched Controlled Cohort

MAJ Joseph W. Galvin,[*†] DO, MAJ Stephen A. Parada,[‡] MD, Xinning Li,[§] MD, and LTC Josef K. Eichinger,[†] MD
Investigation performed at the Orthopaedic Surgery Service, Madigan Army Medical Center, Tacoma, Washington, USA

Background: Posterior shoulder instability is less common and potentially more difficult to diagnose clinically and radiographically compared with anterior shoulder instability. Radiographic findings including posterior labral tears, increased retroversion, presence of glenoid dysplasia, and increased capsular area are associated with symptomatic recurrent posterior shoulder instability.

Purpose: This study aimed to determine the prevalence and severity of associated radiographic parameters found on magnetic resonance arthrograms (MRAs) in patients with arthroscopically confirmed isolated posterior labral tears and symptomatic recurrent posterior shoulder instability, compared with an age-matched cohort of patients without posterior instability or labral injury confirmed with shoulder arthroscopy.

Study Design: Cross-sectional study, Level of evidence, 3.

Methods: Patients who received a preoperative standard shoulder MRA at an academic institution over a 5-year period and had symptomatic posterior instability and received a repair of an arthroscopically confirmed posterior labral tear (n = 63) were identified. These patients were compared with an age-matched control group of patients without posterior instability (n = 49) who underwent an isolated arthroscopic distal clavicle resection that included an arthroscopic glenohumeral joint evaluation. Glenoid version, posterior humeral head subluxation, glenoid dysplasia, and linear and capsular area measurements were evaluated between the 2 groups. Interobserver reliability for continuous and categorical variables was assessed for all measurements.

Results: Multivariate logistic regression revealed that the presence of increased glenoid retroversion (P = .0018), glenoid dysplasia (P = .03), and increased axial posterior capsular cross-sectional area (P = .05) were significantly associated with posterior labral tears and symptomatic posterior shoulder instability compared with the age-matched control group. Posterior humeral head subluxation was found to be a statistically significant variable with univariate analysis (P = .001) for posterior shoulder instability but not with multivariate logistic regression (P = .53). Interobserver reliability was good to very good for all measurements (intraclass correlation coefficient [ICC] = 0.74-0.85; κ = 0.64) but was moderate for total capsular area and sagittal capsular area measurements (ICC = 0.43-0.56).

Conclusion: The presence of increased glenoid retroversion, glenoid dysplasia, and increased posterior capsular area on MRA are significantly associated with posterior labral tears and symptomatic posterior shoulder instability. Identification of these critical radiographic variables on magnetic resonance arthrography assists in the accurate diagnosis and management of clinically significant posterior shoulder instability.

Keywords: shoulder instability; posterior instability; arthroscopy; glenoid retroversion; glenoid dysplasia; capsular area; posterior humeral head subluxation

The incidence of posterior shoulder instability in a young population with athletic shoulder instability may be as high as 10% to 24%, and recognition of symptomatic posterior shoulder instability is becoming more common as a result of advancements in diagnostic modalities.[1,11,13] This may be because of the influence of increasing literature from the military population, where posterior shoulder instability is more commonly found.[11,13] However, compared with anterior labral tears and anterior shoulder instability, posterior shoulder instability is often more difficult to diagnose both clinically and radiographically.[8] Patients rarely report a frank

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dislocation episode, because recurrent subluxations are more common than true posterior dislocations, and the physical examination maneuvers for posterior shoulder instability are often less demonstrative and more subtle than the anterior apprehension-relocation test for anterior instability.[7,10] In addition, magnetic resonance imaging (MRI) and even magnetic resonance arthrography may not always demonstrate a clear labral tear or other associated lesions.[9] Despite this, the less specific patient history and physical examination findings make these advanced imaging studies an important modality for assisting in the accurate diagnosis and management of posterior shoulder instability.

Prior researchers have associated several factors with posterior shoulder instability, including glenoid retroversion, posterior humeral head subluxation, increased posterior capsular area, and the presence of glenoid dysplasia.[3,11,15,16] The purpose of this study was to determine the prevalence and severity of associated radiographic parameters on magnetic resonance arthrograms (MRAs) in patients with symptomatic posterior shoulder instability with arthroscopically confirmed isolated posterior labral tears, compared with an age-matched cohort without posterior instability or labral injury who received shoulder arthroscopy for a distal clavicle resection (DCR). Furthermore, we sought to analyze or verify the interrater reliability of previously published methods for measuring capsular area and classifying glenoid dysplasia. In addition, we also attempted to determine whether there are threshold values for which the sensitivity and specificity can be calculated to aid clinicians in diagnosing posterior shoulder instability. We hypothesize that there are several radiographic variables that are identifiable on MRAs with good interobserver reliability and are associated with posterior shoulder instability.

METHODS

Patients

We performed an institutional review board–approved retrospective analysis of all active-duty military patients presenting to the Madigan Army Medical Center from January 2010 to January 2015 who underwent arthroscopic posterior labral repair for an arthroscopically confirmed isolated posterior labral tear for symptomatic posterior shoulder instability. In addition, we identified a control group of all patients who underwent shoulder arthroscopy for an arthroscopic DCR for acromioclavicular arthrosis. We reviewed operative reports and electronic medical records to define the primary diagnosis, procedure performed, and operative findings. Only patients who received a preoperative standard shoulder MRA, identified by a review of the Centricity picture archive and communication system

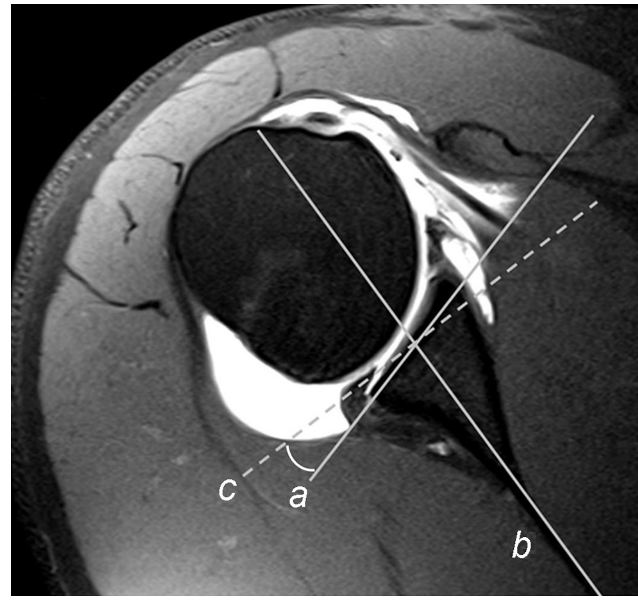

Figure 1. Glenoid version measurement (Friedman angle). Glenoid version was measured by drawing a line from the anterior to the posterior osseous border of the glenoid (*a*). Next, the transverse axis of the scapula was determined by a line from the center of the glenoid fossa to the medial edge of the scapula (*b*); line *c* drawn perpendicular to line *b* is the neutral version. The angle subtended by lines *a* and *c* is the version measurement.

(version 8.0; GE Healthcare), were included in the analysis. In both the study and control groups, we excluded patients with a history of prior surgery, collagen disorders, adhesive capsulitis or limitations in range of motion, associated rotator cuff lesions, or glenohumeral arthritis as well as those with a concomitant anterior labral tear and anterior shoulder instability. There were no female patients who underwent posterior labral repair during the study period, and there was 1 female patient with an MRA who underwent arthroscopic DCR. To match the cohorts, we excluded the 1 female patient in the DCR group.

Radiographic Evaluation

All MRAs were performed per standard protocol by the Radiology Department at Madigan Army Medical Center. The protocol consisted of a 10-mL injection of the following premixed solution: 10 mL Isovue 200 (Bracco Diagnostics Inc), 10 mL 1% lidocaine, and 0.2 mL Magnevist (Bayer HealthCare LLC). From the MRAs, we measured the glenoid version using the Friedman angle (Figure 1).[5]

*Address correspondence to MAJ Joseph W. Galvin, DO, Orthopaedic Surgery Service, Department of Surgery, Madigan Army Medical Center, 9040 Jackson Avenue, Tacoma, WA 98431, USA (email: joseph.w.galvin@gmail.com).
†Orthopaedic Surgery Service, Madigan Army Medical Center, Tacoma, Washington, USA.
‡Department of Orthopaedic Surgery, Eisenhower Army Medical Center, Fort Gordon, Georgia, USA.
§Orthopaedic Surgery, Boston Medical Center, Boston, Massachusetts, USA.
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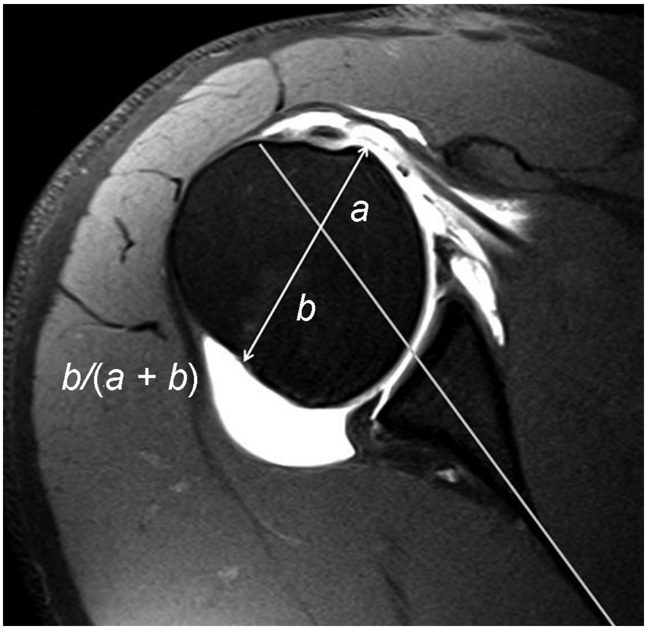


Figure 2. Posterior humeral head subluxation measurement (*b*/[*a* + *b*]). The index of subluxation is the ratio between the part of the head posterior to the midpoint of the glenoid (*b*), and the greatest head diameter (*a* + *b*).

Posterior humeral head subluxation was measured according to the methods described initially by Papilion and Larry[12] and more recently by Walch et al.[15] The index of subluxation is the ratio between the part of the head posterior to the midpoint of the glenoid and the greatest head diameter (Figure 2).

Linear and capsular area measurements were collected according to the methods described by Dewing et al[3] (Figures 3 and 4). In the sagittal-oblique MRA sequence, the measurement was taken in the cut with the largest posterior capsular distention. The ratio (*a*/*b*) was determined by the distance from the posterior coracoid to the posterior capsular distention (*a*) to the distance from the posterior coracoid to the posterior humeral head (*b*). In the axial MRA sequence, the axial cut with the maximum posterior capsular distention was utilized for the measurement. The ratio *a*/*b* is determined by the distance from the anterior aspect of the lesser tuberosity to the most posterior aspect of the capsule (*a*) to the anterior aspect of the lesser tuberosity to the posterior aspect of the humeral head (*b*). We made one modification of the Dewing measuring method. On the linear sagittal-oblique and axial-oblique measurements, we used a difference measurement (*a* – *b*) instead of a ratio (*a*/*b*) to evaluate for the maximum posterior capsular distention. We modified this measurement to potentially provide an easier calculation and value, which may be of assistance to the practicing orthopaedic surgeon in both private practice and academic centers.

The presence of glenoid dysplasia was determined and classified according to the methods described by Edelson[4] and Weishaupt et al[16] (Figure 5).

In this classification, "pointed" is used to describe a normal shape of the posteroinferior glenoid. "Lazy J" and "delta" are terms that describe the shape of a dysplastic posteroinferior glenoid.

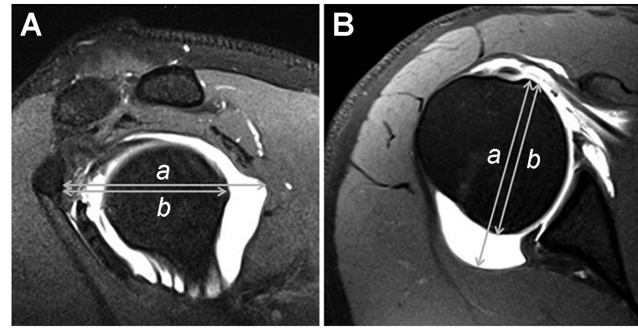


Figure 3. (A) Sagittal and (B) axial linear capsular measurements (*a* – *b*).

Statistical Methods

Measurements were performed by 2 orthopaedic surgeons, and interobserver reliability was calculated by the intraclass correlation coefficient (ICC) for continuous variables and the kappa value (κ) for categorical variables. During MRA evaluation, both orthopaedic surgeons were blinded to the patient diagnosis and clinical history. Descriptive group data and univariate data are presented as the mean and standard error of the mean or the median and range of values for continuous variables, whereas categorical values are presented as numbers with percentages. Univariate analysis was performed with *t* tests for continuous variables and Fisher exact test for categorical variables. Multivariate logistic regression was then performed to identify radiologic features associated with the presence of a symptomatic posterior labral tear. $P < .05$ was used for the determination of statistical significance. Odds ratios (ORs) and 95% CIs were calculated for all variables.

RESULTS

A total of 85 patients underwent arthroscopic posterior labral tear repair and 110 underwent arthroscopic DCR during the 5-year study period. After excluding those patients without an MRA, we identified 71 patients who underwent posterior labral repair and 50 patients who underwent arthroscopic DCR. Six patients underwent an anterior and posterior labral repair, and there were 2 revision posterior labral repairs. Therefore, there were 63 men and 0 women in the posterior instability group and 49 men and 1 woman in the arthroscopic DCR group. We excluded the 1 female in the DCR group to have matched cohorts. Our final cohort consisted of 63 patients in the posterior instability group and 49 patients in the arthroscopic DCR group. Mean age (±SD) was 32 ± 9.5 years (range, 22-45 years) in the instability group and 34 ± 6.17 years (range, 23-45 years) in the DCR group. Of the 63 patients with posterior instability, 53 reported a history of a traumatic event. The remaining 10 patients denied any antecedent trauma. Mechanisms of

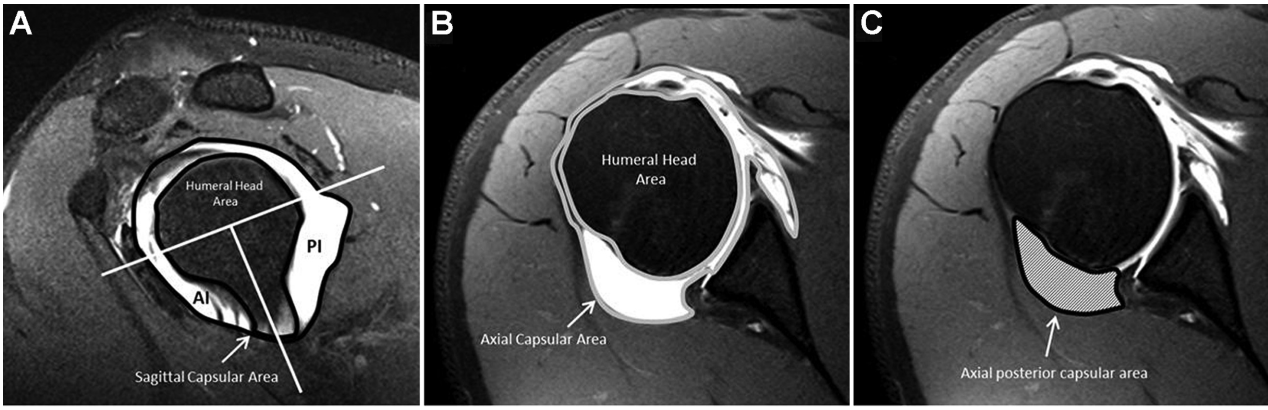


Figure 4. Sagittal and axial capsular area measurements. (A) On the sagittal-oblique cut with the largest amount of contrast material and humeral head in view, the difference between the total sagittal capsular area and humeral head area was recorded. In addition, the area of the capsule was bisected into anteroinferior (AI) and posteroinferior (PI) capsular areas, which were measured separately. (B) On the axial oblique image with the largest amount of contrast material and the glenoid still in view, the difference between the total axial capsular area and humeral head area was recorded. In addition, the total capsular area ([sagittal capsular area – humeral head area] + [axial capsular area – humeral head area]) was recorded. (C) The axial posterior capsular area was determined on the axial oblique magnetic resonance image with the largest posterior fluid pocket and the glenoid still in view.

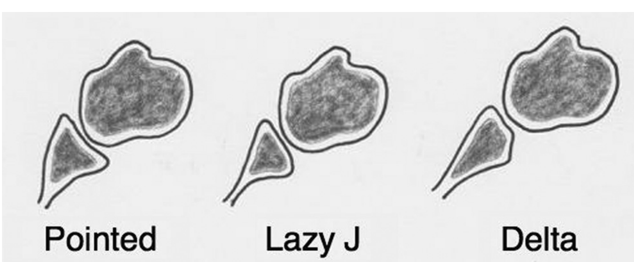


Figure 5. The qualitative classifications of glenoid dysplasia as developed by Edelson[4] and Weishaupt et al.[16]

trauma included an injury during bench press or weight lifting, heavy lifting, military combative training, and falls. All but 4 of the 63 patients had posterior labral tears identified on MRA. However, all patients had posterior labral tears identified on shoulder arthroscopy.

Interobserver reliability for continuous variables was good to very good (ICC = 0.74-0.85) except for total capsular area, sagittal anteroinferior capsular area, and sagittal posteroinferior capsular area measurements, which were moderate (ICC = 0.43-0.56). The interobserver reliability for our 1 categorical variable (presence of glenoid dysplasia) was good (κ = 0.64) (Table 1).

On univariate analysis, we found that the difference in glenoid version between the 2 groups was statistically significant ($P < .001$), with a mean of −8.16° and −2.9° for the instability and DCR groups, respectively. Negative numbers were utilized for retroversion of the glenoid and positive numbers represented anteversion. In addition, posterior humeral head subluxation, the presence of glenoid dysplasia, and posterior capsular area measurements were statistically significantly different. Furthermore, the sagittal and axial linear capsular measurements were statistically significantly different on univariate analysis (Table 2).

TABLE 1
Interobserver Reliability for Magnetic Resonance Arthrogram Measurements[a]

	Intraclass Correlation Coefficient	Kappa Value
Glenoid version	0.74	
Posterior humeral head subluxation	0.85	
Sagittal linear capsular measurement	0.76	
Axial linear capsular measurement	0.80	
Total capsular area	0.43	
Sagittal anteroinferior capsular area	0.47	
Sagittal posteroinferior capsular area	0.56	
Axial posterior capsular area	0.78	
Presence of glenoid dysplasia		0.64

[a]The intraclass correlation coefficient was used for continuous variables and the kappa value was used for categorical variables.

On multivariate logistic regression analysis, we found that posterior humeral head subluxation was not statistically significantly different (P = .53). However, glenoid version (P = .0018), the presence of glenoid dysplasia (P = .03), and the axial posterior capsular area measurement (P = .05) were statistically significantly different. ORs and 95% CIs were calculated (Table 3). While holding all other variables constant, we found an OR for glenoid version of 1.15 (95% CI, 1.136-1.164; P = .0018) and an OR for the presence of glenoid dysplasia of 2.84 (95% CI, 1.14-7.09; P = .03). ORs for the other radiographic variables were 1.01 for posterior humeral head subluxation and 1.006 for posterior capsular area.

Receiver operating characteristic (ROC) curves for axial posterior capsular area and sagittal and linear capsular

TABLE 2
Demographics and Univariate Analysis Results[a]

	Posterior Instability Group (n = 63)	Arthroscopic DCR Group (n = 49)	*P* Value
Mean age, y (range)	32 (22-45)	34 (23-45)	.068
Sex, male:female, n	63:0	49:0	n/a
Affected side, left:right, n	29:34	22:27	>.99
Instability type, traumatic:atraumatic, n	53:10	n/a	n/a
Mean glenoid version, deg	−8.16	−2.9	.001[b]
Posterior humeral head subluxation, %	58	52	.001[b]
Presence of glenoid dysplasia, n (%)	31 (49)	10 (20)	.05
Mean measurements			
Axial posterior capsular area, mm²	218	172	.003[b]
Sagittal linear capsule, mm	9.1	6.2	.001[b]
Axial linear capsule, mm	9.1	6.5	.001[b]
Total capsular area, mm²	1547	1480	.23
Sagittal anteroinferior capsular area, mm²	211	232	.26
Sagittal posteroinferior capsular area, mm²	275	226	.08

[a]DCR, distal clavicle resection.
[b]Statistically significant difference between groups ($P < .05$).

TABLE 3
Multivariate Analysis Results

	Odds Ratio (95% CI)	*P* Value
Glenoid version	1.15 (1.136-1.164)	.0018[a]
Posterior humeral head subluxation	1.01 (0.97-1.06)	.53
Presence of glenoid dysplasia	2.84 (1.14-7.09)	.03[a]
Axial posterior capsular area	1.006 (1.001-1.011)	.05

[a]Statistically significant difference between groups ($P < .05$).

measurements were plotted to determine critical cutoff values for identification of patients with posterior shoulder instability. We determined that an axial posterior capsular area greater than 300 mm² is 96% specific and 20% sensitive for a diagnosis of posterior shoulder instability (Figure 6A). In addition, based on the ROC curve for sagittal linear capsular measurement, we found that a sagittal measurement (sagittal capsular distance – sagittal humeral head distance) of greater than 12 mm represented a 90% specificity and 25% sensitivity for posterior shoulder instability (Figure 6B). Also, an axial linear capsular measurement (axial capsular distance – axial humeral head distance) of greater than 14 mm represented a 95% specificity and 7.8% sensitivity for posterior shoulder instability (Figure 6C).

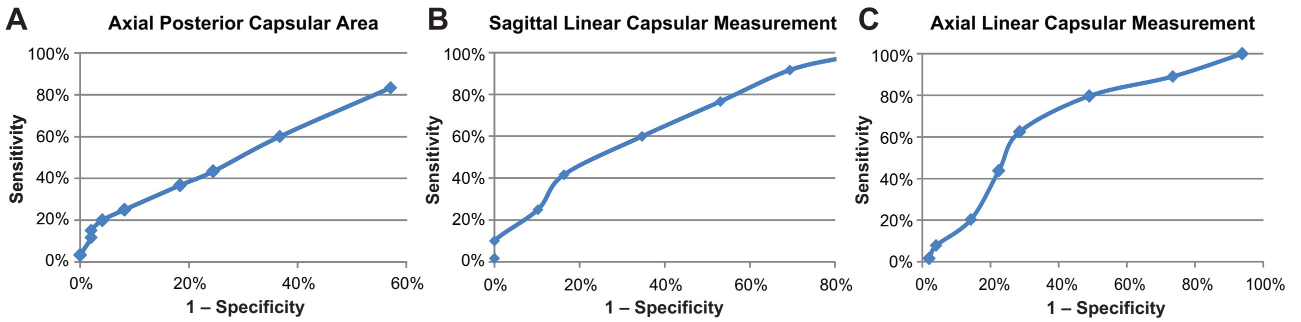
Another interesting finding from this cohort involved 5 patients who underwent arthroscopic posterior labral repair with severe glenoid retroversion and dysplasia. The glenoid version measurements for these patients were −20°, −20°, −22°, −29°, and −37°. We found that these patients with significant glenoid retroversion and posteroinferior glenoid deficiency did not have increased capsular area. For example, the patient with glenoid retroversion of −37° had an axial posterior capsular area of 190 mm² and a sagittal linear capsular measurement of 5.8 mm, which was below the mean values for the DCR group (Figure 7). The patient with glenoid retroversion of −29° had an axial posterior capsular area of 209 mm² and a sagittal linear capsular area measurement of 5.2 mm. On the basis of a review of our cohort, we found that patients with severe glenoid retroversion and dysplasia tend to not have an increased posterior capsular area.

DISCUSSION

The high incidence of glenoid dysplasia in symptomatic patients with posterior labral tears in our study (49% vs 20% in the control group) is consistent with the findings of previous authors studying the entity of glenoid dysplasia. Edelson[4] found a 19% to 35% prevalence of glenoid dysplasia (varying by ethnicity) in a museum population of scapula specimens. In a study using computed tomography scans, Weishaupt et al[16] found a 93% incidence in 15 patients with recurrent atraumatic posterior shoulder instability manifested by increased bony retroversion and posteroinferior glenoid rim deficiency. In a study using MRI, Harper et al[6] found a 73% incidence of glenoid dysplasia in patients with surgically documented posterior labral tears.

In our review of MRAs and the classification of glenoid dysplasia, we found that the classification of glenoid dysplasia by Weishaupt et al[16] demonstrated good interobserver reliability (κ = 0.64), although it was at the lower end of this classification (range, 0.61-0.80). This lower value can be explained by the challenge in reliably differentiating between lazy-J and delta forms of glenoid dysplasia on MRA. When we calculated the interobserver reliability for the presence (lazy J or delta) or absence (pointed) of glenoid dysplasia, our interobserver reliability improved from a kappa value of 0.64 to 0.82 (good to very good). For this reason, it may be more clinically useful and reliable between observers to classify glenoid dysplasia as a dichotomous finding, either present (lazy J or delta) or absent (pointed).

Additional radiographic variables are also associated with posterior shoulder instability, including glenoid retroversion, posterior humeral head subluxation, and increased capsular area.[3,11,15,16] There is a paucity of data identifying



Cutoff Value	Sensitivity	Specificity	1 – Specificity
150	83.33%	42.86%	57.14%
200	60.00%	63.27%	36.73%
225	43.33%	75.51%	24.49%
250	36.67%	81.63%	18.37%
275	25.00%	91.84%	8.16%
300	20.00%	95.92%	4.08%
325	15.00%	97.96%	2.04%
350	11.67%	97.96%	2.04%
375	3.33%	100.00%	0.00%

Cutoff Value	Sensitivity	Specificity	1 – Specificity
2	98.3%	16.3%	83.7%
4	91.7%	30.6%	69.4%
6	76.7%	46.9%	53.1%
8	60.0%	65.3%	34.7%
10	41.7%	83.7%	16.3%
12	25.0%	89.8%	10.2%
14	10.0%	100.0%	0.0%
16	1.7%	100.0%	0.0%

Cutoff Value	Sensitivity	Specificity	1 – Specificity
2	100.0%	6.1%	93.9%
4	89.1%	26.5%	73.5%
6	79.7%	51.0%	49.0%
8	62.5%	71.4%	28.6%
10	43.8%	77.6%	22.4%
12	20.3%	85.7%	14.3%
14	7.8%	95.9%	4.1%
15	1.6%	98.0%	2.0%

Figure 6. (A) The receiver operating characteristic (ROC) curve for axial posterior capsular area measurement, demonstrating that a value >300 mm^2 is 95% specific for posterior shoulder instability. (B) ROC curve for sagittal linear capsular measurement, demonstrating that a value >12 is 90% specific for posterior shoulder instability. (C) ROC curve for axial linear capsular measurement, demonstrating that a value >14 is 95% specific for posterior shoulder instability.

Figure 7. Example of a patient with posterior instability with severe glenoid retroversion, dysplasia, and a reduced posterior capsular area (version = −37°, axial posterior capsular area = 190 mm^2).

the prevalence and severity of these critical radiographic parameters in patients with symptomatic recurrent posterior shoulder instability compared with a controlled cohort.

Owens et al[11] prospectively followed 714 West Point cadets for 4 years and found that glenoid retroversion was independently associated with posterior shoulder instability. In their population, patients with posterior shoulder instability had a mean glenoid version of –17.6° compared with –7.7° in the uninjured control group. In addition, Owens et al found an OR of 1.17, meaning that for every 1° increase in retroversion, their study population had a 17% increased odds of posterior shoulder instability.[11] Although our mean version was not as severe (–8.16°) as the cohort of Owens et al, our OR of 1.15 demonstrated similar results. Bradley et al[2] compared MRI scans of 100 patients undergoing posterior labral repair compared with a control group and found that patients with posterior shoulder instability had significantly greater chondrolabral and osseous retroversion but did not quantify the severity or prevalence of this finding in their study. Our findings concur with those of previous authors, which show that increased retroversion is an important factor associated with posterior shoulder instability.[1,2,11]

The presence of posterior humeral head subluxation and increased retroversion have been proposed as risk factors for the development of early glenohumeral osteoarthritis, and it is postulated that posterior humeral head subluxation is a potential risk factor for posterior shoulder instability.[15] In this cohort, we found a statistical difference (P = .001) between posterior humeral head subluxation measurements (posterior instability = 58%, arthroscopic DCR = 52%); however, this variable was not statistically significant on multivariate analysis. Our findings are consistent with those of Tung and Hou,[14] who similarly found that the position of the humeral head relative to the glenoid is significantly more posterior in patients with posterior labral tears and instability compared with normal shoulders. In addition, Tung et al also found that patients with a posterior labral tear and posterior instability on clinical examination had greater posterior humeral head translation, larger posterior labral tears (>15 mm), and more labrocapsular avulsions than patients with a posterior labral tear but a clinically stable shoulder on examination.[14]

Dewing et al[3] studied the capsular area of patients with anterior, posterior, and multidirectional shoulder instability, compared with a control group of 10 patients without instability. They found a significant increase in capsular area in patients with posterior and multidirectional instability. Dewing et al also found good to very good interobserver reliability for all capsular area (ICC = 0.68-0.79) and linear capsular (ICC = 0.74-0.94) measurements. In contrast, we found that several of the capsular area measurements calculated by the method of Dewing et al had only moderate interobserver reliability (Table 1). There is substantial variation in how one can interpret the capsular area on the axial and sagittal-oblique images. Although the 2 surgeons performing the measurements in this study came to an agreement on using the same method and technique, the capsular area measurement calculations were not reproducible and are therefore not a reliable method. However, we found that on the axial MRA image with the glenoid still in view, the largest posterior fluid pocket was the most valuable measurement for capsular laxity with good interobserver reliability (ICC = 0.78); we found this to be associated with posterior shoulder instability (P = .05).

As noted in our results, 5 patients in the posterior labral repair group demonstrated severe glenoid dysplasia with marked retroversion. Interestingly, these individuals did not demonstrate increased posterior capsular area measurements. Therefore, in the situation of marked glenoid dysplasia (version >20°), clinicians should recognize that capsular measurements may not be increased and they are potentially not a reliable measurement for posterior instability in these patients. A larger cohort is necessary to confirm these findings. We theorize that there are 2 distinct entities for recurrent posterior shoulder instability. One group comprises patients with mild glenoid dysplasia and retroversion with recurrent humeral head subluxation that causes the posterior capsule to stretch out over time. Symptoms develop insidiously depending on the severity of the capsular redundancy and tearing of the posterior labrum. Conversely, the other group comprises patients with severe glenoid dysplasia and retroversion (>20°) in which the humeral head has remained centered on the dysplastic glenoid since birth such that there is no capsular redundancy. However, this biomechanically disadvantageous condition still predisposes individuals to dysfunction, pain, labral tears, and development of arthritis.

There are several limitations to the study. Methodological limitations include the study's retrospective design and multiple surgical providers. In addition, the young, male, athletic military population represented in this study may not be comparable with a civilian cohort, which may include female patients with similar diagnoses. Finally, although our study included only patients receiving a standardized MRA from our radiology department, there may be variability in technique between multiple providers. The identification of these radiographic markers themselves is not an indication for surgical treatment; rather, they represent relevant imaging findings that must accompany individual patient history and physical examination findings to determine appropriate treatment options. In addition, as previously discussed by Dewing et al,[3] a more effective technique for MRAs may be pressure-limited insufflation of the shoulder capsule as opposed to current volume-limited arthrography techniques. Future investigation is needed. Finally, although our cutoff values are applicable to our small cohort of posterior instability patients and those undergoing an arthroscopic DCR, they may not be as useful in a population including patients with anterior or multidirectional shoulder instability. Finally, because the sensitivity of these cutoff values is low, they cannot be used for screening purposes.

CONCLUSION

The presence of increased glenoid retroversion, glenoid dysplasia, and increased posterior capsular area on MRA are significantly associated with posterior labral tears and symptomatic posterior shoulder instability. Identification of these critical variables on MRAs can assist surgeons in the accurate diagnosis and management of clinically significant posterior shoulder instability. In our study population, an axial posterior capsular area of 300 mm^2, a sagittal linear capsular measurement greater than 12 mm, and an axial linear capsular measurement greater than 14 mm on a MRA individually indicate greater than 90% specificity for posterior shoulder instability.

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