Risk Factors for Intra-articular Bone and Cartilage Lesions in Patients Undergoing Surgical Treatment for Posterior Instability

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Background: Patients with posterior shoulder instability may have bone and cartilage lesions (BCLs) in addition to capsulolabral injuries, although the risk factors for these intra-articular lesions are unclear.

Hypothesis: We hypothesized that patients with posterior instability who had a greater number of instability events would have a higher rate of BCLs compared with patients who had fewer instability episodes.

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

Methods: Data from the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Group instability patient cohort were analyzed. Patients aged 12 to 99 years undergoing primary surgical treatment for shoulder instability were included. The glenohumeral joint was evaluated by the treating surgeon at the time of surgery, and patients were classified as having a BCL if they had any grade 3 or 4 glenoid or humeral cartilage lesion, reverse Hill-Sachs lesion, bony Bankart lesion, or glenoid bone loss. The effects of the number of instability events on the presence of BCLs was investigated by use of Fisher exact tests. Logistic regression modeling was performed to investigate the independent contributions of demographic variables and injury-specific variables to the likelihood of having a BCL. Significance was defined as $P < .05$.

Results: We identified 271 patients (223 male) for analysis. Bone and cartilage lesions were identified in 54 patients (19.9%) at the time of surgical treatment. A glenoid cartilage injury was most common and was identified in 28 patients (10.3%). A significant difference was noted between the number of instability events and the presence of BCLs ($P = .025$), with the highest rate observed in patients with 2 to 5 instability events (32.3%). Multivariate logistic regression modeling indicated that increasing age ($P = .019$) and 2 to 5 reported instability events ($P = .001$) were significant independent predictors of the presence of BCLs. For bone lesions alone, the number of instability events was the only significant independent predictor; increased risk of bone lesion was present for patients with 1 instability event (OR, 6.1; $P = .012$), patients with 2 to 5 instability events (OR, 4.2; $P = .033$), and patients with more than 5 instability events (OR, 6.0; $P = .011$).

Conclusion: Bone and cartilage lesions are seen significantly more frequently with increasing patient age and in patients with 2 to 5 instability events. Early surgical stabilization for posterior instability may be considered to potentially limit the extent of associated intra-articular injury. The group of patients with more than 5 instability events may represent a different pathological condition, as this group showed a decrease in the likelihood of cartilage injury, although not bony injury.

Keywords: posterior shoulder instability; glenohumeral cartilage injury; posterior dislocation; shoulder arthritis

Posterior glenohumeral instability is less common than anterior glenohumeral instability, representing about 10% of all cases of shoulder instability.[13,15,16,22] In addition, posterior instability presents with significant differences in history and patient symptoms compared with anterior instability. As opposed to anterior instability, where more than 80% of patients undergoing stabilization had an injury resulting in glenohumeral dislocation, only 10% of patients undergoing surgery for posterior instability had a posterior glenohumeral dislocation and 80% had no single acute injury.[3] Most cases of posterior instability result from repetitive microtrauma to the posterior glenohumeral capsulolabral structures from loading the shoulder in activities including baseball, weightlifting, and football rather than frank posterior dislocations.[6,11,17] The primary presenting symptom for patients with posterior instability is pain (90% of patients), with instability noted only in a minority of patients.[3]

Although many patients with posterior instability have damage to only the posterior capsulolabral structures, some patients have bone and cartilage lesions associated with posterior instability, including defects of the cartilage

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or bone of the posterior glenoid rim and reverse Hill-Sachs lesions of the anteromedial humeral head.[1,17] The incidence and clinical effect of bone and cartilage lesions in posterior instability remain poorly described,[8,12] but rates may be higher than previously thought, as a study from a military cohort described 22% of patients with more than 13.5% posterior glenoid bone loss.[8] Duchman et al[5] recently described an 18.4% rate of bone and cartilage injuries in patients undergoing primary anterior stabilization in a large multicenter cohort, with a rate of 47.6% among revision anterior stabilization procedures. Detailed understanding of the risk factors for and prevalence of cartilage and bony lesions in patients with posterior shoulder instability is important to identify and prevent these lesions. In addition, understanding these lesions may elucidate the factors associated with inferior outcomes and recurrence after posterior stabilization.

The purpose of this study was to describe intraoperative incidence of glenohumeral bone and cartilage lesions in a cohort of patients undergoing primary posterior stabilization through use of data from a prospectively collected, multicenter shoulder instability cohort. In addition, we sought to determine patient demographic and injury factors associated with bone and cartilage lesions. We hypothesized that patients with posterior instability with a greater number of instability events would have a higher rate of bone and cartilage injuries compared with patients who had fewer instability episodes.

METHODS

Data from the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Group instability patient cohort were used for this study. This is a multicenter study encompassing a prospective evaluation of patients ages 12 to 99 years undergoing surgical treatment for shoulder instability. The procedures for this study were approved by the individual institutional review board of each participating site, and all patients provided documented informed consent to participate in the study.

Patients were recruited prospectively before surgical treatment by 24 orthopaedic surgeons at 11 sites in the United States. Surgical treatment was based on a discussion between the patient and treating surgeon and the treating surgeon's impression that the patient's history, examination findings, and imaging findings were consistent with symptomatic posterior instability. Surgeons completed standardized forms to describe intraoperative findings. All patients undergoing treatment between December 2012 and November 2018 with a primary diagnosis of posterior instability (n = 281) were included. Patients undergoing revision surgery were excluded (n = 10), leaving 271 patients eligible for analysis.

Demographic data and specifics regarding each patient's instability history were recorded, including patient age, sex, body mass index (BMI), history of smoking, and Beighton score. The number of instability events was classified as 0, 1, 2-5, or more than 5. The duration of symptoms was classified as less than 1 month, 1 to 3 months, 4 to 6 months, 7 to 12 months, or more than 1 year. The Western Ontario Shoulder Instability (WOSI) score and the Shoulder Activity Score (SAS) were reported by the patient. Study data were collected and managed through use of REDCap (Research Electronic Data Capture) tools hosted at the University of Iowa.[7] REDCap is a secure, web-based application designed to support data

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capture for research studies, providing (1) an intuitive interface for validated data entry, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for importing data from external sources

The glenohumeral joint was evaluated by the treating surgeon at the time of arthroscopic surgery. The cartilage from the humeral head and glenoid was graded according to the Outerbridge classification.[14] Reverse Hill-Sachs lesions, bony Bankart lesions, and glenoid bone loss were recorded. Patients were classified as having a bone or cartilage lesion (BCL) if they had a grade 3 or 4 glenoid or humeral cartilage lesion, reverse Hill-Sachs lesion, bony Bankart lesion, or glenoid bone loss.

Statistical Analysis

Demographic variables, including age, BMI, patient sex, smoking status, and the presence of hyperlaxity, were compared between patients with and without BCLs through use of univariate testing, including Mann-Whitney *U* tests for continuous variables and Fisher exact tests for categorical variables. The effects of symptom duration and number of instability events on the presence of BCLs were investigated through Fisher exact tests. Cartilage lesions and bony lesions were evaluated separately as well. Multivariate analysis using logistic regression modeling was performed to investigate the independent contributions of demographic variables and injury-specific variables to the likelihood of having a BCL at the time of surgical treatment. Multivariate modeling was then repeated for cartilage lesions alone and then bony lesions alone. All statistical analyses were performed with Stata version 14.2 (StataCorp). Significance was defined as $P < .05$.

RESULTS

There were 271 patients treated surgically for primary posterior shoulder instability. The mean ± SD age was 23.5 ± 8.3 years and BMI was 26.8 ± 4.8 kg/m^2. The patients were predominantly male (n = 223; 82.3%), white (n = 247; 91.1%), and nonsmokers (n = 259; 95.9%). The majority of injuries were attributed to a sporting activity (n = 179; 66.1%), with football being the most commonly identified sport (n = 73; 26.9%).

Bone and cartilage lesions were identified in 54 patients (19.9%) at the time of surgical treatment (Table 1). The most common lesion was a glenoid cartilage injury, which was identified in 28 patients (10.3%). Patients with any BCL most frequently had only 1 lesion present (n = 44; 81.4%). At least 1 cartilage lesion was present in 36 patients (13.3%), and at least 1 bone lesion was present in 23 patients (8.5%).

Patients with BCLs had a significantly higher BMI than those without any BCLs (28.1 ± 4.8 vs 26.5 ± 4.8 kg/m^2; $P = .024$) (Table 2). A trend toward older age was found for patients with BCLs ($P = .052$), but no differences were observed between groups with regard to hyperlaxity ($P = .15$) and smoking status ($P = .24$). The preoperative patient-reported outcome scores showed no difference between groups, WOSI score ($P = .19$), or SAS ($P = .26$).

TABLE 1
Frequency of Bone and Cartilage Lesions Identified in Patients Undergoing Primary Surgery for Posterior Instability

Intra-articular Lesion	n	%
Glenoid cartilage injury[a]	28	10.3
Humeral cartilage injury[a]	9	3.3
Reverse Hill-Sachs	16	5.9
Glenoid bone loss	3	1.1
Bony Bankart	8	3.0
Any bone or cartilage lesion	54	19.9
Any cartilage lesion[a]	36	13.3
Any bone lesion	23	8.5

[a]Indicates Outerbridge grade 3 or 4 lesions.

A significant difference was found between the number of instability events and the presence of BCLs ($P = .025$) (Figure 1). The highest rates of BCLs was observed in patients with 2 to 5 total instability events (32.3%), whereas the lowest rates were in patients with no reported clear instability events (14.2%) (Table 3). The rate of BCLs was significantly higher in patients with any instability event (25%) relative to those with no instability event (14.2%; $P = .033$). A significant difference was found between the number of instability events and the presence of any bony injury ($P = .008$), although no significant difference was seen with the presence of any cartilage injury ($P = .12$). Bone lesions were observed most frequently in patients with 1 dislocation (18.8%), and the lowest rate was in patients without any clear instability event (3.2%).

A significant difference was observed between the duration of reported symptoms and the presence of BCLs ($P = .020$) (Figure 2). Patients with shorter reported duration of symptoms had a higher rate of BCLs, including 28.6% for patients with less than 1 month of symptoms and 32.7% for patients with 1 to 3 months of symptoms. No statistically significant difference was observed between the duration of reported symptoms and cartilage lesions alone ($P = .07$) or bone lesions alone ($P = .58$).

Through multivariate logistic regression modeling, increasing age ($P = .019$) was identified as a significant independent predictor of the presence of BCLs. Patients with 2 to 5 reported instability events had significantly increased odds of BCLs (odds ratio [OR], 3.75; $P = .001$). No significant effects were observed for BMI, patient sex, hyperlaxity, or symptom duration. For cartilage lesions alone, increasing age ($P = .015$) and 2 to 5 instability events (OR, 2.8; $P = .022$) were significant predictors for the presence of advanced cartilage injury. For bone lesions alone, the number of instability events was the only significant independent predictor, with increased risk of bone lesion present for patients with 1 instability event (OR, 6.1; $P = .012$), patients with 2 to 5 instability events (OR, 4.2; $P = .033$), and patients with more than 5 instability events (OR, 6.0; $P = .011$).

TABLE 2
Comparison of Patients With and Without Bone and Cartilage Lesions[a]

	No Bone or Cartilage Lesion (n = 217)	Bone or Cartilage Lesion (n = 54)	*P* Value
Age, y	23.0 ± 7.9	25.5 ± 9.5	.052
Body mass index, kg/m^2	26.5 ± 4.8	28.1 ± 4.8	.024
Male sex	177 (81.6)	46 (85.2)	.69
Smoker	7 (3.2)	4 (7.4)	.24
Hyperlaxity (Beighton >4)	53 (24.4)	8 (14.8)	.15
Preoperative WOSI score	43.4 ± 18.4	39.2 ± 17.9	.19
Preoperative SAS	13.1 ± 4.5	14.0 ± 4.2	.26

[a]Values are expressed and mean ± SD or n (%). SAS, Shoulder Activity Score; WOSI, Western Ontario Shoulder Instability.

TABLE 3
Frequency of Bone or Cartilage Lesions According to the Number of Instability Events[a]

	0 Events (n = 127)	1 Event (n = 32)	2-5 Events (n = 62)	>5 Events (n = 50)	*P* Value
Any bone or cartilage lesion (n = 54)	18 (14.2)	8 (25.0)	20 (32.3)	8 (16.0)	.025
At least 1 cartilage lesion (n = 36)	15 (11.8)	3 (9.4)	14 (22.6)	4 (8.0)	.12
At least 1 bony lesion (n = 23)	4 (3.2)	6 (18.8)	7 (11.3)	6 (12.0)	.008

[a]Values are expressed as n (%).

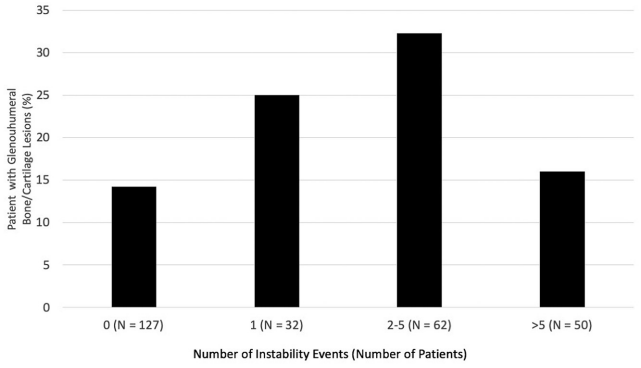

Figure 1. The proportion of patients with bone and cartilage lesions is shown according to the number of instability events. Patients with 2 to 5 instability events had the highest rate of bone and cartilage lesions identified at the time of arthroscopy (*P* = .025).

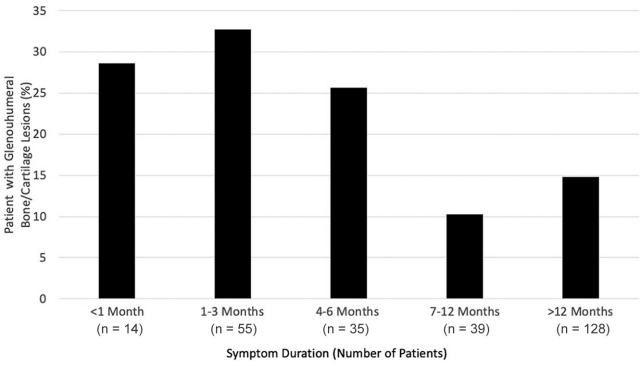

Figure 2. The proportion of patients with bone and cartilage lesions is shown according to preoperative symptom duration. These lesions were identified more frequently in patients with a shorter reported symptom duration and most frequently in patients with symptoms for 1 to 3 months (*P* = .020).

DISCUSSION

Intra-articular bone and cartilage lesions are commonly encountered during treatment of shoulder instability. We observed bone and cartilage lesions in 19.9% of patients undergoing treatment for posterior instability; increasing age and number of instability events were significant predictors of these intra-articular lesions. Although elevated BMI was noted in patients with BCLs in univariate analysis, patient BMI was not seen to have a significant association with multivariate modeling. Duchman et al[5] evaluated the presence of bone and cartilage lesions in patients with anterior instability in the MOON Shoulder Group database and found that intra-articular lesions were observed in 18.4% of patients undergoing primary surgery. Krych et al[10] identified high-grade chondral lesions in 31% of patients with shoulder instability compared with 13.3% of patients in our cohort, although the majority of patients in their series were treated for anterior instability. Glenoid lesions were most common, which is a similar pattern observed in our cohort of patients. The results of the current study help establish the expected frequency for these associated intra-articular injuries.

The presence of bone and cartilage injuries has been established as an important risk factor for poor shoulder function and negative outcomes after surgical treatment of shoulder instability.[2] Options for predictable treatment of symptomatic intra-articular cartilage injuries are

limited. High rates of conversion to shoulder arthroplasty after debridement alone have been reported.[9,21,23] Microfracture has been reported to have 33% to 42% poor outcomes at midterm follow-up.[24] Osteochondral allograft has a graft failure rate of 22% at 5 years after surgery.[18]

Because treatment options for symptomatic lesions are limited, prevention of bone and cartilage lesions may be the best approach for limiting their effect. In this study, we identified that increasing age and number of dislocations, specifically 2 to 5, were significant predictors of these intra-articular lesions. The presence of at least 1 cartilage injury alone was more common in patients with 2 to 5 instability events, whereas the presence of at least 1 bony injury was significantly more common with all frequency groups of instability events. Age has been implicated as an important factor in the presence of cartilage injury.[2] Our findings regarding the number of instability events are consistent with literature on anterior shoulder instability. Rugg et al[19] demonstrated that patients with recurrent anterior shoulder instability are at greater risk for biceps abnormality and glenoid bone loss. Patients with recurrent anterior dislocations also have higher failure rates and lower patient satisfaction.[20] Recently, interest has arisen in surgical stabilization for first-time anterior shoulder dislocations. With our observation that patients with 2 to 5 instability events are at increased risk for bone and cartilage lesions, surgical treatment for a first-time posterior dislocation may limit the extent of intra-articular injury. The group of patients with more than 5 instability events may represent a different pathological group, as the likelihood of cartilage injury, although not bony injury, was decreased in this group.

Posterior instability may be symptomatic even without an overt dislocation, presenting rather with pain, functional limitations, and repetitive subluxations. This clinical picture is challenging but common for posterior instability, in contrast to anterior instability.[4] This group without an overt posterior dislocation had the lowest rates of intra-articular injury in our cohort, although BCLs were still observed in more than 14% of patients. These BCLs consisted primarily of cartilage injuries, as bony lesions were very uncommon (3.2%) in the group of patients with no clear instability event. As well, differences may be present in the pathological characteristics between patients with higher energy traumatic posterior instability and those with posterior labral injuries without an instability event. Further research should be conducted to clarify expected outcomes, but early intervention may limit the extent of intra-articular injury.

Our findings should be interpreted with an understanding of the study limitations. The data presented were collected at the time of surgery and do not provide insight into the effects of BCLs on eventual outcomes after posterior stabilization surgery. We plan to continue to follow this cohort and will analyze early and later term outcome measures. Many of the variables, including number of instability events and duration of symptoms, were patient reported and may be subject to recall bias. The study design is observational, and all treatment decisions were between patient and surgeon. Other factors that were not analyzed or recorded here may also influence the presence of bone and cartilage lesions.

CONCLUSION

We observed bone and cartilage lesions in 19.9% of patients treated surgically for posterior instability, with significantly higher rates with increasing age and in patients with 2 to 5 instability events. Early surgical stabilization for posterior instability may be considered to potentially limit the extent of associated intra-articular injury.

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