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Authors

Agha, Obiajulu
Rugg, Caitlin M
Lansdown, Drew A
et al.

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Surgical Stabilization of Shoulder Instability in Patients With or Without a History of Seizure: A Comparative Analysis

Obiajulu Agha, BA[a], **Caitlin M. Rugg, MD**[a], **Drew A. Lansdown, MD**[a], **Shannon Ortiz, MPH**[b], **Carolyn M. Hettrich, MD, MPH**[c], **Brian R. Wolf, MD, MS, MS**[b], **MOON Shoulder Group**, **Brian T. Feeley, MD**[a]

[a]Department of Orthopaedic Surgery, University of California San Francisco; San Francisco, CA

[b]Department of Orthopaedic Surgery, University of Iowa; Iowa City, IA

[c]Department of Orthopaedic Surgery, Brigham and Women's Hospital, Harvard Medical School; Boston, MA

Abstract

Purpose: The purpose of this study is to compare patients from a large multicenter cohort with a history of seizure to those without a history of seizure in regard to preoperative and intraoperative findings and surgical procedures performed.

Methods: Patients undergoing shoulder stabilization from 2011 to 2018 at 11 orthopaedic centers were prospectively enrolled. Those with a history of seizure were identified and compared to non-seizure controls. Preoperative demographic, history, physical examination, and imaging findings were collected. Intraoperative findings and surgical procedures performed were recorded. Mann-Whitney tests, Chi Square tests, and logistic regression analysis were employed to examine differences between the groups and define independent risk factors. Due to the number of statistical tests performed, the false discovery method was employed to determine adjusted P values to achieve $\alpha < .05$.

Results: During enrollment, 25 of 1298 shoulder stabilization patients had a history of seizure (1.9%). Sex ratio and age were similar between groups, as was posterior instability incidence (control: 23.2%; seizure: 28.0%). Seizure patients more frequently had >5 dislocations in the year preceding surgery ($P = 0.016$) and had increased preoperative radiographic evidence of bone loss

Corresponding Author Caitlin M. Rugg, MD, Department of Orthopaedic Surgery, University of California, San Francisco, 500 Parnassus Ave, MU 320 West, Room W314, San Francisco, CA 94143-0728, Caitlin.rugg@ucsf.edu.
Contributing Authors to MOON Shoulder Group:
Keith M. Baumgarten, MD (Orthopedic Institute Sioux Falls); Asheesh Bedi (University of Michigan), Julie Y. Bishop, MD (Ohio State University Medical Center); Matthew J. Bollier, MD (University of Iowa); Jonathan T. Bravman, MD (University of Colorado); Robert Brophy, MD (Washington University School of Medicine); Charlie L. Cox, MD, MPH (Vanderbilt University); Rachel M. Frank (University of Colorado), Brian T. Feeley, MD (University of California–San Francisco); John A. Grant, MD, PhD (University of Michigan); Grant L. Jones, MD (Ohio State University Medical Center); John E. Kuhn, MD, MS (Vanderbilt University); C. Benjamin Ma, MD (University of California–San Francisco); Robert G. Marx, MD (Hospital for Special Surgery); Eric C. McCarty, MD (University of Colorado); Bruce S. Miller, MD, MS (University of Michigan); Andrew S. Nevaiser, MD (Ohio State University Medical Center), Adam J. Seidl, MD (University of Colorado), Matthew V. Smith, MD (Washington University School of Medicine); Rick W. Wright, MD (Vanderbilt University), Alan L. Zhang (University of California, San Francisco).

($P < .001$). Intraoperatively, seizure patients had a higher prevalence of reverse Hill-Sachs lesions ($P < .001$) and large (>30% of glenoid fossa) bony Bankart lesions ($P < .001$). Arthroscopic Bankart repair was the most common procedure in both group. However, open procedures were performed in 15.6% of controls and 40.0% of seizure patients ($P = .001$) of which were most commonly bony procedures.

Conclusion: Seizure patients had more prior dislocations, more preoperative bone loss, and underwent more open stabilization procedures than controls due to bone loss. Studies examining recurrence following stabilization will help establish appropriate management practices in this population.

Level of Evidence: III – Retrospective review of prospectively collected cohort.

Introduction

Shoulder instability is a common concern seen by orthopaedic surgeons and other medical providers, with an estimated incidence of 0.08 per 1000 person-years in the United States and especially high rates among young, athletic patients.[1–3] The clinical consequences of pain, functional impairment, and recurrence result in significant morbidity, often keeping patients from work and participating in daily life activities. Within this large patient cohort exists a subset of patients for which their shoulder instability is the product of dislocations sustained during seizures. These dislocations are caused by violent, uncoordinated muscle contractions of the shoulder, as well as by the falls related to seizure activity.[4,5] According to DeToledo et al[6], the incidence of shoulder dislocation during seizure is approximately 0.6%; however, the true incidence is likely higher due to undetected cases. Of note, these patients tend to be young, male, and have epilepsy as the most common etiology of their seizures.[7,8,9] The increasing prevalence of diabetes and sustained drug-use disorder rates may also result in additional hypoglycemia related and drug-induced seizures.[10–14]

There are distinct features of patients with seizure-related shoulder instability that may have important implications for treatment and outcomes. Although anterior instability is most commonly seen with both seizure and non-seizure related shoulder instability, posterior instability is often considered pathognomonic for seizure-related or electrocution-induced shoulder instability .[15,16] While a number of studies have highlighted excellent results with surgical management of posterior instability[17, 18], a recent prospective matched cohort study demonstrated differences in preoperative findings and outcomes after arthroscopic stabilization for anterior and posterior instability.[19] Dislocations from seizure are also more likely to cause glenoid and humeral bone loss due to both the force of seizure and the use of anti-epileptic drugs (AED) that adversely affect bone density.[5] According to Pack et al[20] and Petty et al[21], between 20–75% of patients on AED have evidence of reduced bone mineral density through a range of proposed mechanisms including alterations in Vitamin D metabolism, calcium absorption, and bone turnover.[22] These factors, along with the high rates relapsing seizure activity, may predispose patients to recurrent instability.[21,23] Continued instability may increase the risk of additional dislocations, further bone loss, and damage to surrounding soft tissues.

Comparative studies examining differences between seizure patients and those without a history of seizure undergoing shoulder stabilization are lacking in the current literature. The purpose of this study is to compare patients from a large multicenter cohort with a history of seizure to those without a history of seizure in regard to preoperative and intraoperative findings and surgical procedures performed. We hypothesize that patients with a history of seizure would have more prior dislocations, more posterior instability, increased bone loss, and more open stabilization surgery as compared to patients without a history of seizure.

Materials and Methods

Patients undergoing shoulder stabilization surgery from October 2011 to December 2018 were prospectively enrolled from 11 orthopaedic centers into the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Group as part of an IRB approved study. The group prospectively collects orthopaedic patient data and outcomes for shoulder instability as has been previously described.[24] Two naturally occurring cohorts were identified from the shoulder stabilization patients: patients with a medical history of seizure (seizure group) and patients without a medical history of seizure (control group) (Figure 1). Collection of preoperative evaluation data included demographic characteristics, duration of instability symptoms, history of prior shoulder dislocations and shoulder surgery, and use of anti-seizure medication. Preoperative patient-reported outcomes (PROs) including RAND 36-Item Health Survey 1.0 (RAND 36 Physical and Mental) score[25], American Shoulder and Elbow Surgeons (ASES) shoulder score[26], Western Ontario Shoulder Instability Index (WOSI) score[27], Shoulder Activity Scale (SAS)[28], and EuroQol 5 Dimensions (EQ-5D) score[29] were also collected. Preoperative physical examinations documented shoulder strength and Beighton scores[30] for each patient. Radiographs and magnetic resonance imaging (MRI) findings were also included. For both modalities, surgeons noted evidence of and location of bony defects. Additionally, for MRI, surgeons documented evidence of labral and biceps pathology.

Intraoperative findings were recorded at the time of surgery. These data included any evidence of rotator cuff injury, capsular pathology, and intra-articular pathology such as labral and biceps tendon damage. Superior labral anterior-posterior (SLAP) tears were analyzed separately from biceps tendon pathology. Bony defects such as Hills Sachs and Bony Bankart lesions were also documented. The surgeons specified which type of arthroscopic and open surgical techniques were used for shoulder stabilization and which, if any, ancillary procedures were performed.

Statistical Analysis

Demographic data, preoperative PROs, physical exam, imaging findings, surgical findings and surgical procedures performed were compared between the two groups. Prism 7 software (version 7.0a, Graphpad Software, Inc., San Diego, CA) was used for Mann-Whitney and Chi Square testing. Logistic regression analysis was performed using Stata 16.1 (StataCorp; College Station, TX) to define independent predictors for the presence of pre-operative bone loss on x-ray or MRI as well as the independent predictors for patients undergoing open surgery. A subgroup analysis was performed within the Seizure cohort comparing patients who had sports-related instability and those who had seizure-related instability, using Fisher's exact tests to compare groups due to group size. Because of the number of statistical tests performed, the false discovery method was employed to determine adjusted *P* values to achieve $\alpha < .05$.

Results

Patient Demographics and History

During the enrollment period, there were 1298 patients who had undergone shoulder stabilization surgery. Of these, 25 patients had a medical history of seizure, for an prevalence of 1.9%. The remaining 1273 patients had no history of seizure, representing the control group. Table 1 summarizes demographic information of the two groups. The mean age of seizure patients was 26.3 years and for control patients 24.5 years ($P = .060$). Women represented 19.0% of control patients and 32.0% of seizure patients ($P = .103$). The average BMI was 25.7 for controls and 27.6 for the seizure group ($P = .008$). Anterior instability was present in 75.7% of all patients. There were no significant differences in primary direction of instability between the groups, with 75.8% of control patients and 72.0% of seizure patients experiencing anterior instability ($P = .66$).

The majority of patients in both groups reported symptoms of shoulder instability for more than one year (50.9% control group, 68.0% seizure group). Having more than five dislocations in the year leading up to surgery was more common among seizure patients (44% vs. 23.3%; $P = .016$; Figure 2). Among seizure patients, 15 patients had shoulder instability related to a seizure, and 10 had shoulder instability related to sports. Most patients were having surgery on their shoulder for the first time, with only 13.7% of control and 16.0% of seizure patients having had a previous shoulder surgery. Significantly more patients in the seizure group reported having mental health issues than those from the control group (24.0% vs. 5.8%; $P < .001$). Smoking was more common among the seizure patients (control: 4.9%, seizure: 20.0%; $P < .001$)

Preoperative PROs and Physical Exam Findings

Preoperative PROs were collected from each patient and compared between groups (Table 2). The control and seizure groups had no significant differences in RAND 36 Physical scores (46.5 vs. 46.5; $P = .91$) and Mental health scores (50.5 vs 49.9; $P = .79$). ASES scores for control and seizure patients were 65.5 and 67.3, respectively ($P = .45$). The average WOSI scores for all patients was 42.1, with no significant differences between groups. Additionally, there were no significant differences noted in EQ-5D scores between groups (control 74.5 vs. seizure 68.1; $P = .086$). There was a significant difference between groups in the SAS, with seizure patients having lower activity scores (8.8) compared to controls (13.0; $P < .001$).

Shoulder strength and patient Beighton score were evaluated during their preoperative physical exam (Table 2). Notably, there were no significant differences in strength testing between groups, with the vast majority of patients exhibiting full shoulder strength. Average

Beighton Score for all patients was 1.1, with no significant differences in score between groups ($P = .79$).

Preoperative Imaging Findings

All patients underwent preoperative radiography to assess for bony pathology (Fig 3; Table 3). Humeral sided pathology was identified in 21.5% of all patients, including 20.5% of control patients and 72.0% of seizure patients ($P < .001$). Anterior humeral bony defects were detected in 2.3% of control patients and 32% of seizure patients ($P < .001$) and posterior defects were detected in 18.8% control patients and 40.0% of seizure patients ($P < .008$). Glenoid bone loss was found on radiographs in 11.8% of all patients, with significantly higher prevalence in seizure patients as compared to control group (41.7% vs. 11.2%; $P < .001$). Anterior glenoid defects were twice as likely to be detected for seizure patients than controls (25.0% vs. 10.1%; $P = .018$) and while posterior glenoid defects were less common, they were over ten times more likely to be seen in seizure patients (16.7% vs. control 1.2%; $P < .001$). In aggregate, 80.0% of seizure patients had some bone loss detected radiographically, as opposed to 28.0% from the control group ($P < .001$).

Preoperative MRI was performed in 19 of 25 seizure patients and 1182 of 1273 control patients (Fig 3; Table 3). There were no significant differences in humeral bony defects detected on MRI between the groups (seizure 68.4% vs. control 44.5%; $P = .038$). Anterior humeral defects, which occur in posterior dislocations, were more common among seizure patients than controls (21.1% vs. 2.1%; $P < .001$). On the glenoid, 26.3% of seizure patients and 18.1% of control patients had bony pathology, a difference which was not statistically significant. Overall, 84.2% of patients in the seizure group and 62.6% of patients in the control group had any bony pathology on MRI ($P = .053$). Labral pathology was noted in all seizure patients and in 91.5% of control patients who underwent MRI.

Intraoperative Findings

Intraoperative findings gathered by the surgeon at the time of surgery are listed in Table 4. Rotator cuff pathology was found at similar rates between groups (seizure 5.6% vs. control 6.3%; $P = .896$). There were no significant differences noted in prevalence or location of labral pathology between groups, with 81.2% of all patients exhibiting some form of labral damage. Anterior labral pathology was most commonly observed, in 73.9% of seizure patients and 80.9% of control patients ($P = .398$). Inferior and posterior labral pathology were each found in about half of all patients, without differences between groups.

Bony and cartilaginous pathology were more common among patients with a history of seizure, in general (Table 4). Any articular cartilage pathology (including chondromalacia, Hill-Sachs lesions, and bone loss on the humerus or glenoid) was found in 84.0% patients in the seizure group, versus 57.7% of patients in the control group ($P = .008$). There was no significant difference in prevalence of Hill-Sachs lesions observed between groups (60.0% of seizure patients and 44.1% of control patients, $P = .112$). However, presence of a reverse Hill-Sachs lesion was significantly more common in seizure patients relative to controls (16.0% vs. 1.6%; $P < .001$). Average Hill-Sachs lesion width for seizure and control groups was 10.9 and 8.5mm, respectively ($P = .065$). While there was no statistical difference between the prevalence of bony Bankart lesions between seizure patients (37.5%) and control patients (21.6%; $P = .063$), Bankart lesions involving greater than 30% of the glenoid were significantly more common among seizure patients (seizure 12.5% vs. control 0.1%; $P < .001$).

Procedures Performed

The cohort contained surgical data from 1120 primary shoulder stabilizations (86.3%) and 178 revision shoulder stabilizations (13.7%) with no difference in revision rate between groups. A summary of surgical procedures performed are demonstrated in Figure 4 and Table 5.

Arthroscopic stabilization was performed in 60% of seizure patients and 84.5% of control patients ($P = .001$). Among arthroscopic procedures, most common in both groups was anterior Bankart repair involving the labrum and capsule (57.4% of controls and 36.0% of seizure patients). Posterior labral repair was less common in both groups and there was no statistically significant difference between groups. Seizure patients more commonly underwent arthroscopic debridement than did the control group (32% vs. 10.5%; $P = .001$). Moreover, arthroscopic remplissage procedures were significantly more common in seizure patients, with 20.0% of seizure patients undergoing remplissage versus 5.3% of controls ($P < .002$).

Open procedures were more commonly performed in seizure patients (40.0%) versus control patients (15.6.0%; $P = .001$). Open bony stabilization procedures were similarly more likely in the seizure group (36.0% vs. 10.9%; $P < .001$). The most common open bony stabilization procedure in both groups was Bristow-Latarjet (seizure: 20.0%, control: 9.9%; $P = .097$). Humeral head allograft and glenoid allograft were rarely performed for control patients (0.2% for each), but were performed in 12.0% and 8.0% of seizure patients, respectively ($P < .001$ for both procedures). The most common open soft tissue stabilization was an open inferior capsular shift, performed in 10.9% of controls and 24.0% of seizure patients, which was not a statistically significant difference. While rare, open posterior capsulorrhaphy and open Bankart repair were both significantly more likely to be performed in seizure patients, ($P < .01$ for both procedures).

Logistic Regression Analysis

Multivariate logistic regression analysis was performed to understand the influence of seizures on pre-operative bone loss and on the likelihood of patients undergoing open surgery. Independent predictors in the model for bone loss included seizure history in addition to patient age, sex, BMI, smoking history, and number of dislocations. Independent predictors in the model for open surgery included all of these variables as well as the presence of bone loss on pre-operative imaging. A seizure history was independently associated with significantly increased risk of bone loss (odds ratio (OR) = 9.2; $P = .004$). Other independent risk factors for bone loss were male sex ($P < 0.0001$), and experiencing one or more dislocation events in the year preceding surgery ($P < 0.001$). Seizure history was not a significant independent risk factor (OR = 2.0; $P = .110$) associated with patients having open surgery. Risk factors associated with open surgery included two to five dislocation events (OR = 2.1; $P = 0.011$), more than five dislocation events (OR = 3.8; $P < 0.001$), and bone loss on pre-operative x-ray or MRI (OR = 3.5; $P < .001$).

Sub-group Analysis

Of the patients with a medical history of seizure (n = 25), fifteen had shoulder instability related to a seizure (seizure-related group), and ten patients shoulder instability related to a sports injury (sports-related group). A sub-group analysis was performed to examine differences between these two groups (Supplemental Tables 1–5). Both groups had high rates of more than 5 dislocations in the year proceeding surgery (seizure-related: 40.0% vs. sports-related: 50.0%; $P = .697$). Patient-reported outcome measures were similar between groups with the exception of the Shoulder Activity Scale (seizure-related: 6.7 vs. sports-related: 12.0; $P = .007$). On preoperative radiographs, bone loss was detected in 86.7% of the seizure-related group and 70.0% of the sports-related group ($P = .358$). All patients in the seizure-related group and 66.7% of patients in the sports-related group had some type of bony pathology on MRI ($P = .087$). Intraoperatively, the seizure-related group was found to have significantly more articular cartilage pathology of any kind (seizure-related: 100% vs. sports-related: 60.0%, $P = .017$). There were no significant differences found in types of procedures performed, although there was a relatively high rate of open procedures in both sub-groups (seizure-related: 46.7% vs. sports-related: 30.0%, $P = .679$).

Discussion

In this study, we demonstrated that patients with a medical history of seizure exhibited significantly more dislocations in the year preceding surgery, had greater rates of bony pathology as assessed both by preoperative imaging and intraoperative evaluation, and increased rates of open stabilization procedures, in accordance with our hypothesis. Contrary to our hypothesis, the seizure and control groups had similar rates of posterior instability. In addition, seizure history was a significant predictor of bony pathology on imaging, as was being male and having one or more dislocation events. Seizure history was not an independent predictor for undergoing open surgery, but both imaging evidence of bony defects and having multiple dislocation events were significant risk factors.

There are few studies examining surgical stabilization in seizure patients, and the literature largely encompasses small case series and case reports.[7, 23, 33, 34] Existing studies primarily focus on surgical techniques utilized and outcomes for these patients. However, studies examining differences between patients with shoulder instability due to different mechanisms of injury, including seizure, are lacking in the literature. Such comparisons may serve to inform preoperative planning and expectations for surgeons and patients suffering from seizure-related instability. The availability of a large, prospectively gathered cohort of contemporary shoulder stabilization patients has allowed for this current comparative study of preoperative and surgical findings between those with and without history of seizure.

Both the seizure and control cohorts in this study had relatively similar preoperative histories and demographic characteristics. The average age was in the third decade of life for both groups. The incidence of shoulder dislocation from seizure peaks in the second and third decades of life,[10,35,33] likely related to the peak muscle mass in those decades. This timing mirrors the common age group for traumatic and sport-related shoulder instability.[1, 2, 36] Of note, this cohort study excludes patients requiring rotator cuff repair, and therefore older patients who are at higher risk for rotator cuff injury with dislocation were likely excluded from both groups. Gender was not statistically different between groups, with men representing the majority. Overall, epilepsy has relatively equal distribution across the sexes.[37,38,39] Few studies have examined the sex-based prevalence of seizure-related shoulder instability, but in two published series of patients who were followed for seizure-related shoulder instability, 33%[6] and 31%[4] of the cohorts were women, similar to our findings. Depression was more common among epileptic patients in our study, affecting 28% of the seizure group. Epidemiological studies have demonstrated a bidirectional relationship between epilepsy and depression, with a systematic review demonstrating a prevalence of 23.1% among epileptic patients.[38] In contrast, the annual prevalence of a major depressive episode in the general US population is 7.1%, highest in the 18–25 year old population at 13.1%.[40] Therefore our cohorts roughly mirror the rates seen in the general population in the US. The elevated rates of depression and smoking in the seizure group may both adversely affect the long term outcomes.[41–44]

Contrary to our hypothesis, the rate of posterior instability was not significantly different between groups. Prior studies have shown that, while posterior instability is more common in patients with seizure, anterior instability remains the most common direction of instability overall. [7,9,15, 16] Anterior dislocations are thought to be 15 to 25 times more common than posterior dislocations in the general population[45,15], although posterior dislocations may represent a larger proportion of injuries in the young, athletic population.[46] Nearly a quarter of all patients in this study had posterior instability; it is possible this high rate of posterior instability is due to the tertiary referral nature of many of the centers involved in this multicenter study resulting in selection bias for more complex problems. While direction was similar between groups, number of dislocations in the year leading up to surgery was significantly higher among seizure patients, with over 40% experiencing greater than 5 dislocations in the year leading up to surgery. This is likely multifactorial. First, the relapsing nature of epilepsy places these patients at higher risk of recurrent dislocations secondary to recurrent seizures, highlighting the important role of AED in management of these patients. In this study, 90.9% of seizure patients were taking an AED; yet, 30% of epilepsy patients may continue to have seizures even after AED treatment is initiated.[47, 48] According Thangarajah et al[35], poor adherence to AED regimens is a common finding in these patients and contributes to the significant rates of recurrent instability that can be as high as 69% even after surgical repair.[49] AEDs also have a deleterious effect on bone density, increasing the risk for bony defects with each dislocation.[5,20,21] This may lead to a downward spiral of bone loss and recurrent dislocations related to bone loss. Bony defects are not only a risk factor for recurrent instability but also for failure of soft-tissue-based surgical repair.[50,51] Reevaluating a patient’s need for AED over time may also mitigate the adverse bone health effects by lowering dosages or discontinuing medications when clinically indicated.

As hypothesized, preoperative imaging demonstrated a high rate of bony pathology in seizure patients relative to controls. Radiographically, both humeral and glenoid bone loss were more common among seizure patients, found in 80% of seizure patients and 28% of controls. The rate of radiographic Hill-Sachs lesions in the seizure group (32%) was consistent with prior literature; Thangarajah et al found an incidence of 43% for large (>20% of articular surface) Hill-Sachs lesions[9], and Buhler reported an incidence of 35% in a similarly designed study.[7] On MRI, anterior humeral and posterior glenoid bone loss were significantly more common among seizure patients, indicating that the posterior dislocations experienced by seizure patients were associated with more bony sequelae. Intraoperative examination also demonstrated a higher incidence of bony pathology in the seizure group. In agreement with MRI findings, reverse Hill-Sachs lesions were ten times more common for seizure patients. The incidence of bony Bankart lesions were no different between groups; however, nearly half of Bankart lesions in the control group were less than 10% of the glenoid width, versus less than 15% of those in the seizure group. Large bony Bankart lesions more than 30% were seen in just 0.1% of controls and 12.5% of seizure patients. Even when controlling for other demographic factors, seizure history remained a significant independent predictor of bone loss. To compare to other reports on glenoid pathology in the seizure population, Buhler reported glenoid rim pathology diagnosed on radiographs or arthroscopy in 15 of 34 (44%) shoulders in a group of patients with epileptic seizure-induced shoulder instability, and Thangarajah reported glenoid bone loss in 22% of patients diagnosed by CT or arthroscopy.[7,9] As discussed above and noted by other authors, AED-related bone loss[5,9,20,21] and recurrent instability are two likely mechanisms for the increased bone loss seen in this population[35,52]; however, this is the first study to quantify the rate of bone loss in a surgically managed population of seizure patients relative to controls. In addition to seizures, recurrent dislocation[53, 54,55] and revision surgery[56] are both known risk factors for bone loss. Surgeons managing patients with seizure-related shoulder instability should be aware of the higher rates of bony pathology in this population, both in our study and prior published literature, as this likely impacts preoperative planning.

Open surgical management was more common among seizure patients, reflecting the high incidence of biomechanically significant bone loss. In fact, 40% of seizure patients required open surgery, versus 15.6% of controls. The majority of open surgery in seizure patients was performed to address bony stability, with 36% of patients undergoing a Latarjet or bone grafting procedure. When controlling for bone loss and other demographic factors, however, seizure history alone was not a significant predictor of having open surgery, so this finding does appear to be driven primarily by the association of a seizure history with the presence of bone loss. Previously published data from the MOON Shoulder Group has demonstrated risk factors for open surgery to be recurrent dislocation (24.4% open in patients with > 5 dislocations versus 6.9% in first-time dislocations[54]) and revision surgery (73.3% versus 7.6% of primary stabilizations[56]). In comparison, most studies in seizure patients have demonstrated a high rate of bony augmentation procedures for surgical stabilization. In a retrospective series, Thangarajah et al reported that 13 of 31 patients (39%) managed operatively for epilepsy-related shoulder instability between 1996 and 2011 received a skeletal stabilization, with 9 coracoid transfers and 2 iliac crest bone grafts on the glenoid and 2 humeral head allografts. This study did not specify open versus arthroscopic surgery

Subgroup analysis comparing patients with a history of seizure who had sports-related instability versus seizure-related instability demonstrated the groups were relatively similar. There was a trend towards more severe bone loss and more open surgery in the seizure-related group, though the analysis was underpowered to detect significant differences. Overall, the seizure patients with sports-related instability were more similar to the seizure-related group than to controls, with regard to bone loss and open surgery. One explanation may be the effect of AEDs on bone quality, and surgeons should account for this effect when working up seizure patients with sports-related instability.

Limitations

This study has a number of limitations. The sample size of patients with history of seizure was limited by the available data from a prospectively gathered database, though it is comparable to prior studies regarding seizure-related shoulder instability. While we found a significant difference between groups in Shoulder Activity Scale, the minimal clinically important difference for this score has not been published. Furthermore, clinical outcomes are not yet available for these cohorts; as prior literature demonstrates a high recurrence rate following stabilization, it will be important to prospectively follow seizure patients and publish results with contemporary arthroscopic and open techniques and with modern AED options. Also, multiple comparisons were performed on the data, and a false discovery method was used to limit the likelihood of Type 1 error. No a priori power analysis was performed as the database was not created to examine a small subgroup such as the Seizure group; however, the large sample size does allow for the opportunity to evaluate a rare condition in this patient population.

Conclusion

Seizure patients had more prior dislocations, more preoperative bone loss, and underwent more open stabilization procedures than controls due to bone loss. Studies examining recurrence following stabilization will help establish appropriate management practices in this population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Shoulder Instability in Patients with Seizure

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References

1. 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. [PubMed: 19339562]
2. Galvin JW, Ernat JJ, Waterman BR, Stadecker MJ, Parada SA. The Epidemiology and Natural History of Anterior Shoulder Instability. Curr Rev Musculoskelet Med. 2017;10:411–424. [PubMed: 29038951]
3. Kraeutler MJ, Currie DW, Kerr ZY, Roos KG, McCarty EC, Comstock RD. Epidemiology of Shoulder Dislocations in High School and Collegiate Athletics in the United States: 2004/2005 Through 2013/2014. Sports Health. 2018;10:85–91. [PubMed: 28556681]
4. Rouleau DM, Hebert-Davies J. Incidence of associated injury in posterior shoulder dislocation: systematic review of the literature. J Orthop Trauma. 2012;26:246–251. [PubMed: 22183196]
5. Mattson RH, Gidal BE. Fractures, epilepsy, and antiepileptic drugs. Epilepsy & behavior : E&B. 2004;5 Suppl 2:S36–40.
6. DeToledo JC, Lowe MR. Seizures, lateral decubitus, aspiration, and shoulder dislocation: Time to change the guidelines? Neurology. 2001;56:290–291. [PubMed: 11235662]
7. Buhler M, Gerber C. Shoulder instability related to epileptic seizures. J Shoulder Elbow Surg. 2002;11:339–344. [PubMed: 12195251]
8. Hauser WA, Annegers JF, Kurland LT. Incidence of Epilepsy and Unprovoked Seizures in Rochester, Minnesota: 1935–1984. Epilepsia. 1993;34:453–458. [PubMed: 8504780]
9. Thangarajah T, Lambert S. The management of recurrent shoulder instability in patients with epilepsy: a 15-year experience. J Shoulder Elbow Surg. 2015;24:1723–1727. [PubMed: 26119633]
10. Goudie EB, Murray IR, Robinson CM. Instability of the shoulder following seizures. The Journal of bone and joint surgery. British volume 2012;94:721–728.
11. Steinmann SP. Posterior shoulder instability. Arthroscopy. 2003;19:102–105. [PubMed: 14673426]
12. Alldredge BK, Lowenstein DH, Simon RP. Seizures associated with recreational drug abuse. Neurology. 1989;39:1037–1039. [PubMed: 2788249]
13. Finkelstein Y, Hutson JR, Freedman SB, Wax P, Brent J. Drug-induced seizures in children and adolescents presenting for emergency care: current and emerging trends. Clin Toxicol (Phila). 2013;51:761–766. [PubMed: 23957582]
14. Zimmet P, Alberti KG, Magliano DJ, Bennett PH. Diabetes mellitus statistics on prevalence and mortality: facts and fallacies. Nature Reviews Endocrinology. 2016;12:616–622.
15. Robinson CM, Seah M, Akhtar MA. The epidemiology, risk of recurrence, and functional outcome after an acute traumatic posterior dislocation of the shoulder. J Bone Joint Surg Am. 2011;93:1605–1613. [PubMed: 21915575]
16. Khayal T, Wild M, Windolf J. Reconstruction of the articular surface of the humeral head after locked posterior shoulder dislocation: a case report. Arch Orthop Trauma Surg. 2009;129:515–519. [PubMed: 18815798]
17. Lenart BA, Sherman SL, Mall NA, Gochanour E, Twigg SL, Nicholson GP. Arthroscopic repair for posterior shoulder instability. Arthroscopy. 2012;28:1337–1343. [PubMed: 22705299]
18. DeLong JM, Jiang K, Bradley JP. Posterior Instability of the Shoulder: A Systematic Review and Meta-analysis of Clinical Outcomes. The American journal of sports medicine. 2015;43:1805–1817. [PubMed: 25862038]
19. Bernhardson AS, Murphy CP, Aman ZS, LaPrade RF, Provencher MT. A Prospective Analysis of Patients With Anterior Versus Posterior Shoulder Instability: A Matched Cohort Examination and Surgical Outcome Analysis of 200 Patients. Am J Sports Med. 2019;47:682–687. [PubMed: 30698986]
20. Pack AM, Olarte LS, Morrell MJ, Flaster E, Resor SR, Shane E. Bone mineral density in an outpatient population receiving enzyme-inducing antiepileptic drugs. Epilepsy & behavior : E&B. 2003;4:169–174.

21. Petty SJ, O'Brien TJ, Wark JD. Anti-epileptic medication and bone health. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA. 2007;18:129–142.
22. Petty SJ, Wilding H, Wark JD. Osteoporosis Associated with Epilepsy and the Use of Anti-Epileptics-a Review. Curr Osteoporos Rep. 2016;14:54–65. [PubMed: 26879819]
23. Ersen A, Bayram S, Birisik F, Atalar AC, Demirhan M. The effectiveness of the Latarjet procedure for shoulder instability in patients with epilepsy. Orthopaedics & traumatology, surgery & research : OTSR. 2017;103:1277–1282.
24. Kraeutler MJ, McCarty EC, Belk JW, et al. Descriptive Epidemiology of the MOON Shoulder Instability Cohort. Am J Sports Med. 2018;46:1064–1069. [PubMed: 29505730]
25. Hays RD, Morales LS. The RAND-36 measure of health-related quality of life. Ann Med. 2001;33:350–357. [PubMed: 11491194]
26. Michener LA, McClure PW, Sennett BJ. American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form, patient self-report section: reliability, validity, and responsiveness. J Shoulder Elbow Surg. 2002;11:587–594. [PubMed: 12469084]
27. Kirkley A, Griffin S, McLintock H, Ng L. The development and evaluation of a disease-specific quality of life measurement tool for shoulder instability. The Western Ontario Shoulder Instability Index (WOSI). Am J Sports Med. 1998;26:764–772. [PubMed: 9850776]
28. Brophy RH, Beauvais RL, Jones EC, Cordasco FA, Marx RG. Measurement of shoulder activity level. Clin Orthop Relat Res. 2005;439:101–108. [PubMed: 16205147]
29. Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. Ann Med. 2001;33:337–343. [PubMed: 11491192]
30. Bird HA, Brodie DA, Wright V. Quantification of joint laxity. Rheumatol Rehabil. 1979;18:161–166. [PubMed: 493803]
31. Riff AJ, Frank RM, Sumner S, et al. Trends in Shoulder Stabilization Techniques Used in the United States Based on a Large Private-Payer Database. Orthopaedic journal of sports medicine. 2017;5:2325967117745511. [PubMed: 29318175]
32. Bonazza NA, Liu G, Leslie DL, Dhawan A. Trends in Surgical Management of Shoulder Instability. Orthopaedic journal of sports medicine. 2017;5:2325967117712476. [PubMed: 28695137]
33. Thangarajah T, Falworth M, Lambert SM. Anatomical shoulder arthroplasty in epileptic patients with instability arthropathy and persistent seizures. Journal of orthopaedic surgery (Hong Kong). 2017;25:2309499017717198. [PubMed: 28659057]
34. Robinson CM, Al-Hourani K, Malley TS, Murray IR. Anterior shoulder instability associated with coracoid nonunion in patients with a seizure disorder. J Bone Joint Surg Am. 2012;94:e40. [PubMed: 22488624]
35. Thangarajah T, Lambert SM. Management of recurrent shoulder instability in patients with epilepsy. J Shoulder Elbow Surg. 2016;25:1376–1384. [PubMed: 27288273]
36. Zacchilli MA, Owens BD. Epidemiology of shoulder dislocations presenting to emergency departments in the United States. J Bone Joint Surg Am. 2010;92:542–549. [PubMed: 20194311]
37. Christensen J, Kjeldsen MJ, Andersen H, Friis ML, Sidenius P. Gender differences in epilepsy. Epilepsia. 2005;46:956–960. [PubMed: 15946339]
38. Fiest KM, Sauro KM, Wiebe S, et al. Prevalence and incidence of epilepsy: A systematic review and meta-analysis of international studies. Neurology. 2017;88:296–303. [PubMed: 27986877]
39. Asadi-Pooya AA, Emami M, Nikseresht A. Early-onset versus typical childhood absence epilepsy; clinical and electrographic characteristics. Seizure. 2012;21:273–275. [PubMed: 22365586]
40. Center TNIoMHIR. Major Depression. 2019.
41. Santiago-Torres J, Flanigan DC, Butler RB, Bishop JY. The effect of smoking on rotator cuff and glenoid labrum surgery: a systematic review. The American journal of sports medicine. 2015;43:745–751. [PubMed: 24859982]
42. Bokshan SL, DeFroda SF, Owens BD. Comparison of 30-Day Morbidity and Mortality After Arthroscopic Bankart, Open Bankart, and Latarjet-Bristow Procedures: A Review of 2864 Cases. Orthop J Sports Med. 2017;5:2325967117713163. [PubMed: 28781973]

43. Koorevaar RC, van ‘t Riet E, Gerritsen MJ, Madden K, Bulstra SK. The Influence of Preoperative and Postoperative Psychological Symptoms on Clinical Outcome after Shoulder Surgery: A Prospective Longitudinal Cohort Study. PLoS One. 2016;11:e0166555. [PubMed: 27846296]

44. Galvin JW, Morte DR, Grassbaugh JA, Parada SA, Burns SH, Eichinger JK. Arthroscopic treatment of posterior shoulder instability in patients with and without glenoid dysplasia: a comparative outcomes analysis. J Shoulder Elbow Surg. 2017;26:2103–2109. [PubMed: 28734714]

45. Kroner K, Lind T, Jensen J. The epidemiology of shoulder dislocations. Arch Orthop Trauma Surg. 1989;108:288–290. [PubMed: 2789505]

46. Lanzi JT Jr., Chandler PJ, Cameron KL, Bader JM, Owens BD. Epidemiology of Posterior Glenohumeral Instability in a Young Athletic Population. The American journal of sports medicine. 2017;45:3315–3321. [PubMed: 28945456]

47. Kwan P, Brodie MJ. Early identification of refractory epilepsy. The New England journal of medicine. 2000;342:314–319. [PubMed: 10660394]

48. Brodie MJ, Dichter MA. Antiepileptic drugs. The New England journal of medicine. 1996;334:168–175. [PubMed: 8531974]

49. Kim SH, Ha KI, Kim SH. Bankart repair in traumatic anterior shoulder instability: open versus arthroscopic technique. Arthroscopy. 2002;18:755–763. [PubMed: 12209434]

50. Dickens JF, Slaven SE, Cameron KL, et al. Prospective Evaluation of Glenoid Bone Loss After First-time and Recurrent Anterior Glenohumeral Instability Events. Am J Sports Med. 2019;47:1082–1089. [PubMed: 30943084]

51. Olds MK, Ellis R, Parmar P, Kersten P. Who will redislocate his/her shoulder? Predicting recurrent instability following a first traumatic anterior shoulder dislocation. BMJ open sport & exercise medicine. 2019;5:e000447.

52. Khater AH, Sobhy MH, Said HG, et al. Latarjet Procedure for Anterior Shoulder Instability Due to Tramadol-Induced Seizures: A Multicenter Study. Am J Sports Med. 2016;44:957–962. [PubMed: 26818452]

53. Griffith JF, Antonio GE, Yung PS, et al. Prevalence, pattern, and spectrum of glenoid bone loss in anterior shoulder dislocation: CT analysis of 218 patients. AJR. American journal of roentgenology. 2008;190:1247–1254. [PubMed: 18430839]

54. Rugg CM, Hettrich CM, Ortiz S, Wolf BR, Zhang AL. Surgical stabilization for first-time shoulder dislocators: a multicenter analysis. J Shoulder Elbow Surg. 2018;27:674–685. [PubMed: 29321108]

55. Matsumura N, Oki S, Kitashiro M, et al. Three-dimensional quantitative analysis of humeral head and glenoid bone defects with recurrent glenohumeral instability. J Shoulder Elbow Surg. 2017;26:1662–1669. [PubMed: 28478901]

56. Duchman KR, Hettrich CM, Glass NA, et al. The Incidence of Glenohumeral Bone and Cartilage Lesions at the Time of Anterior Shoulder Stabilization Surgery: A Comparison of Patients Undergoing Primary and Revision Surgery. Am J Sports Med. 2018;46:2449–2456. [PubMed: 29985051]

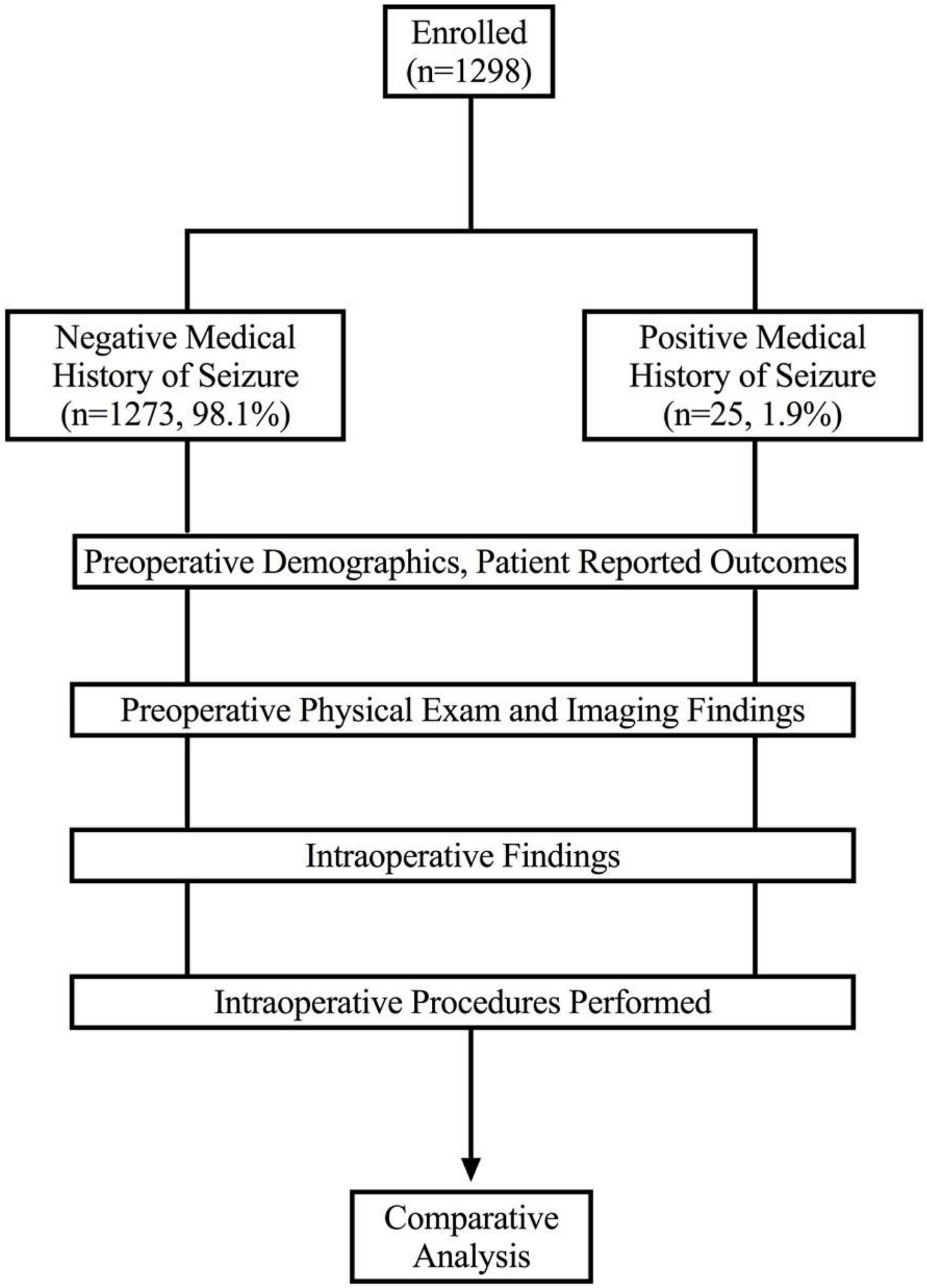

Figure 1:
Study flow chart of patients enrolled and analyses performed.

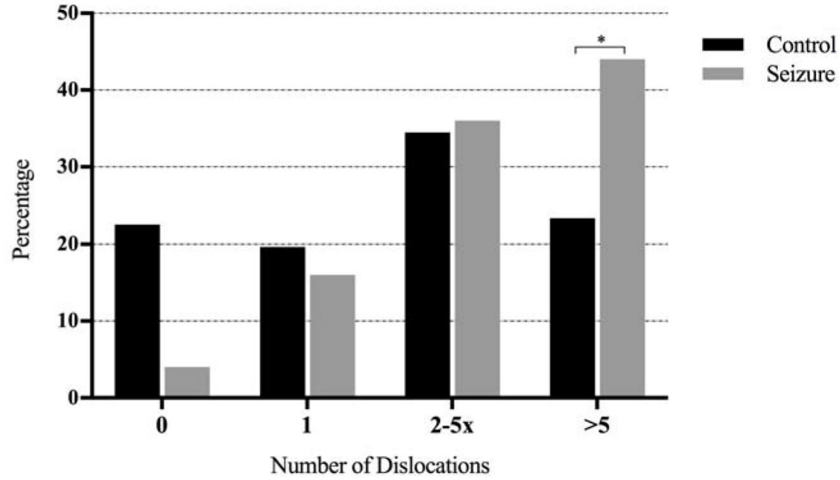

Figure 2: Number of Dislocations in the Last Year Seizure and Control Patients.
Black bars indicate control patients. Grey bars indicate seizure patients. * denotes significance based on adjusted $P < .05$.

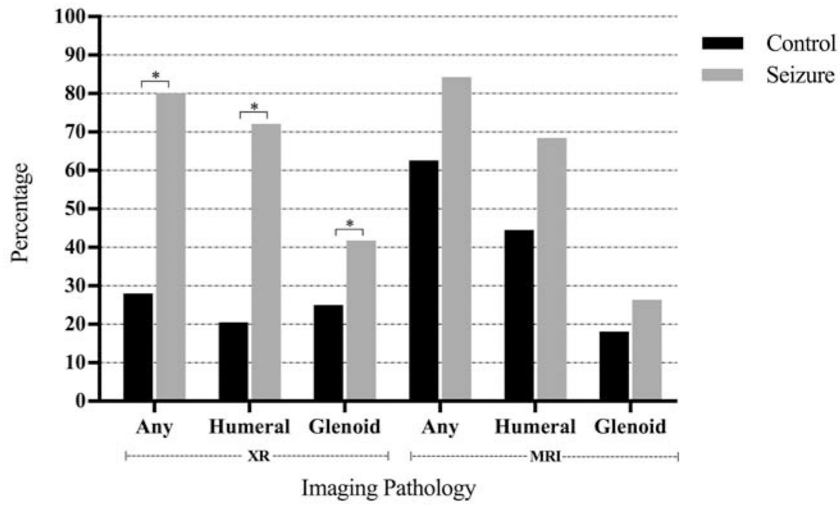

Figure 3: Radiographic and MRI Bony Findings in Seizure and Control Patients.

Black bars indicate control patients. Grey bars indicate seizure patients. * denotes significance based on adjusted $P < .05$.

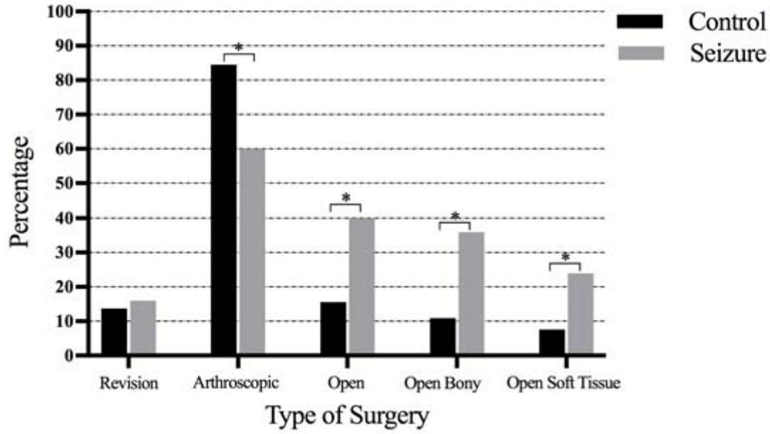

Figure 4: Selected Procedures Performed.

Black bars indicate control patients. Grey bars indicate seizure patients. * denotes significance based on adjusted $P < .05$.

Table 1 –

Patient Baseline Characteristics

Variable	Group		*P* value
	Control (n=1273)	Seizure (n=25)	
Average Age	24.5	26.3	0.06
BMI	25.7	27.6	0.008 *
Male	80.8%	68.0%	0.103
Posterior Instability	23.2%	28.0%	0.572
Depression	10.5%	28.0%	0.005 *
Smoking	4.9%	20.0%	<0.001 *
Dislocations in Last Year			
0x	22.6%	4.0%	0.027
1x	19.6%	16.0%	0.65
2–5x	34.5%	36.0%	0.875
>5x	23.3%	44.0%	0.016 *

* = adjusted *P* value < .05

BMI, body mass index

Table 2 -

Patient Reported Outcomes and Physical Exam

Variable	Group		*P* value
	Control (n=1273)	Seizure (n=25)	
ASES	65.6	67.3	0.45
EQ-5D	74.5	68.1	0.086
RAND-36 Mental	50.5	49.9	0.79
RAND-36 Physical	46.5	46.5	0.91
WOSI	42.1	46.6	0.31
SAS	13.0	8.8	<0.001 *
Full Strength Right	91.2%	92.0%	0.89
Full Strength Left	92.1%	88.0%	0.46
Beighton Score	1.1	1.0	0.79

* = adjusted *P* value < .05

ASES, American Shoulder and Elbow Surgeons; EQ-5D, EuroQol 5 Dimensions; Rand 36, RAND 36-Item Health Survey 1.0; WOSI, Western Ontario Shoulder Instability Index; SAS, Shoulder Activity Scale

Table 3 -

Preoperative Imaging Findings

Variable	Group		*P* value
	Control (n=1273)	Seizure (n=25)	
Radiographic Findings			
Any Bony Pathology	28.0%	80.0%	<0.001 *
Humeral Bony Pathology	20.5%	72.0%	<0.001 *
Humeral Bony Pathology Location			
Anterior	2.3%	32.0%	<0.001 *
Posterior	18.8%	40.0%	0.008 *
Glenoid Bony Pathology	11.2%	41.7%	<0.001 *
Glenoid Bony Pathology Location			
Anterior	10.1%	25.0%	0.018 *
Posterior	1.2%	16.7%	<0.001 *
MRI Findings **			
MRI Performed	92.9%	76.0%	
Any Bony Pathology	62.6%	82.4%	0.053
Humeral Bony Pathology	44.5%	68.4%	0.038
Humeral Bony Pathology Location			
Anterior	2.1%	21.1%	<0.001 *
Posterior	42.5%	47.4%	0.668
Glenoid Bony Pathology	18.1%	26.3%	0.358
Glenoid Bony Pathology Location			
Anterior	16.7%	15.8%	0.919
Posterior	1.4%	10.5%	0.002 *
Any Biceps Pathology	0.9%	0.0%	0.673

* = adjusted *P* value < .05

** MRI findings calculated based on number of patients who underwent MRI; Control: n=1182; Seizure: n=19.

Table 4 -

Intraoperative Findings

Variable	Group		*P* value
	Control (n=1273)	Seizure (n=25)	
Soft Tissue Findings			
Any Biceps Pathology	4.5%	4.2%	0.938
Rotator Cuff Pathology	6.3%	5.6%	0.896
Any Capsule Pathology	48.1%	79.2%	0.003 *
Any Labral Pathology	80.9%	95.8%	0.064
Anterior Labral Pathology	80.9%	73.9%	0.398
Inferior Labral Pathology	45.7%	60.0%	0.203
Posterior Labral Pathology	53.5%	57.9%	0.702
Bone and Cartilage Findings			
Any Articular Cartilage Pathology	57.7%	84.0%	0.008 *
Hill-Sachs	44.1%	60.0%	0.112
Reverse Hill-Sachs	1.6%	16.0%	<0.001 *
Hill-Sachs Lesion Width (mm)	8.5	10.9	0.063
Engaging Hill-Sachs	24.2%	42.1%	0.076
Bony Bankart	21.6%	37.5%	0.063
Bony Bankart Bone Loss (% width of glenoid)			
0–10%	9.6%	4.2%	0.368
11–20%	7.7%	12.5%	0.380
21–30%	3.8%	8.3%	0.260
>30%	0.1%	12.5%	<0.001 *

* = adjusted *P* value < .05

Table 5 -

Intraoperative Procedures Performed

Variable	Group		*P* value
	Control (n=1273)	Seizure (n=25)	
Revision Surgery	13.7%	16.0%	0.737
Arthroscopic Surgery	84.5%	60.0%	0.001 *
Arthroscopic Bankart (Anterior)			
Labrum Only	9.4%	0.0%	0.109
Labrum and Capsule	57.4%	36.0%	0.032
Arthroscopic Bankart (Posterior)			
Labrum Only	3.1%	8.0%	0.162
Labrum and Capsule	26.9%	16.0%	0.221
Arthroscopic Debridement	10.5%	32.0%	0.001 *
Arthroscopic Remplissage	5.3%	20.0%	0.002 *
Open Surgery	15.6%	40.0%	0.001 *
Open Bony Procedure	10.9%	36.0%	<0.001 *
Open Humeral Head Allograft	0.2%	12.0%	<0.001 *
Open Bristow-Latarjet	9.9%	20.0%	0.097
Open Glenoid Allograft	0.2%	8.0%	<0.001 *
Open Soft Tissue Stabilization	7.6%	24.0%	0.003 *
Open Bankart Repair	0.4%	4.0%	0.009 *
Open Posterior Capsulorrhaphy	0.3%	4.0%	0.003 *
Open Inferior Capsular Shift	10.9%	24.0%	0.04

* = adjusted *P* value < .05