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Pathoanatomy of First-Time, Traumatic, Anterior Glenohumeral Subluxation Events

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Background: Relative to dislocations, glenohumeral subluxation events have received little attention in the literature, despite a high incidence in young athletes. The pathoanatomy of first-time, traumatic, anterior subluxation events has not been defined, to our knowledge.

Methods: As part of a prospective evaluation of all cases of shoulder instability sustained during one academic year in a closed cohort of military academy cadets, a total of thirty-eight first-time, traumatic, anterior glenohumeral subluxation events were documented. Clinical subluxation events were defined as incomplete instability events that did not require a manual reduction maneuver. Twenty-seven of those events were evaluated with plain radiographs and magnetic resonance imaging within two weeks after the injury and constitute the cohort studied. Magnetic resonance imaging studies were independently evaluated by a musculoskeletal radiologist blinded to the clinical history. Arthroscopic findings were available for the fourteen patients who underwent arthroscopic surgery.

Results: Of the twenty-seven patients who sustained a first-time, traumatic, anterior subluxation, twenty-two were male and five were female, and their mean age was twenty years. Plain radiographs revealed three osseous Bankart lesions and two Hill-Sachs lesions. Magnetic resonance imaging revealed a Bankart lesion in twenty-six of the twenty-seven patients and a Hill-Sachs lesion in twenty-five of the twenty-seven patients. Of the fourteen patients who underwent surgery, thirteen had a Bankart lesion noted during the procedure. Of the thirteen patients who chose nonoperative management, four experienced recurrent instability. Two of the thirteen patients left the academy for nonmedical reasons and were lost to follow-up. The remaining seven patients continued on active-duty service and had not sought care for a recurrent instability event at the time of writing.

Conclusions: First-time, traumatic, anterior subluxation events result in a high rate of labral and Hill-Sachs lesions. These findings suggest that clinical subluxation events encompass a broad spectrum of incomplete events, including complete separations of the articular surfaces with spontaneous reduction. A high index of suspicion for this injury in young athletes is warranted, and magnetic resonance imaging may reveal a high rate of pathologic changes, suggesting that a complete, transient luxation of the glenohumeral joint has occurred.

Dislocation of the glenohumeral joint frequently occurs in young athletes[1]. This instability event is defined as a complete dissociation of the articular surfaces, and historically documentation of complete dissociation (classically, a radiograph showing the dislocated humeral head) or the performance of a manual reduction maneuver has been required

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for a diagnosis of dislocation. It has been determined that, when a first-time, traumatic, anterior dislocation occurs in a young athlete, the most common injury pattern is an avulsion of the anteroinferior aspect of the glenoid labrum and the capsular attachments from the glenoid rim (the Bankart lesion)[2].

A glenohumeral subluxation involves translation beyond the physiologic limits with some amount of glenohumeral contact maintained. This instability event has been classically defined as one that does not require a manual reduction maneuver. Subluxation is a topic that has received a disproportionately small amount of attention in the literature, despite the frequency of its occurrence. A recent study of young athletes documented that 85% of shoulder instability events were subluxations and only 15% were dislocations[3] (with a dislocation requiring a manual reduction by definition). Most reports that discuss the epidemiology or treatment of shoulder subluxation are of series that include both dislocations and multidirectional instability. Few reports have focused strictly on anterior traumatic shoulder subluxations[4-10].

The subject of subluxation is difficult to study because of the inexact determination of the occurrence of this event. Since a persistent complete dislocation (in which the humeral head remains in a dislocated position until it is manually reduced) has not occurred, a subluxation event cannot be objectively quantified with similar accuracy. The diagnosis of a clinical subluxation event is made when the findings of a physical examination are consistent with glenohumeral instability but the patient does not have a history of an acute injury event that required a manual reduction maneuver.

The goal of this study was to determine the pathoanatomy associated with first-time, traumatic, anterior glenohumeral subluxation events with use of patient history, physical examination, radiographs, magnetic resonance imaging studies, and surgical findings. We hypothesized that there is a high prevalence of labral injuries after first-time, traumatic, anterior subluxations.

Materials and Methods

With the approval of the institutional review board at our institution, we prospectively tracked all shoulder instability events that occurred at our institution during one academic year (2004 to 2005). Shoulder subluxation events were defined as incomplete instability events not requiring a manual reduction maneuver by a medical professional[3]. We diagnosed an anterior subluxation event in any patient experiencing a painful shoulder event with a sensation of transient instability who, on physical examination, had anterior apprehension, relief with relocation, and/or pathologic anterior translation on load-shift testing. We determined an anterior subluxation event to be traumatic if it had occurred as the result of a clear athletic action (usually involving contact with another player, an object, or the ground) and had resulted in the temporary cessation of athletic activity. For example, a butterfly swimmer who reported shoulder pain during a training swim would not qualify, but a football player who reported pain after an arm tackle would. First-time events were determined by the patient's report of an absence of a history of previous shoulder instability events.

Cadets who had experienced a documented first-time, traumatic, anterior subluxation event and had been evaluated with magnetic resonance imaging within two weeks after the injury were eligible for inclusion in the study. We excluded individuals who had not undergone imaging within the first two weeks after the injury, as we wished to identify the appearance, on imaging, of the pathologic changes associated with first-time, traumatic, anterior subluxation events.

We evaluated this cohort's demographic characteristics, mechanisms of injury, physical examination findings, magnetic resonance imaging findings, and surgical findings in order to better define the pathoanatomy associated with anterior subluxation events. Plain radiographs consisted of an anteroposterior view in neutral rotation, a scapular Y view, and a West Point axillary view. All radiographs were interpreted by a board-certified radiologist (S.C.). Magnetic resonance imaging studies, without the use of contrast medium, consisted of axial, coronal, and sagittal cuts of T1 and T2-weighted images obtained with a 1.5-T magnet. These images were interpreted independently by a board-certified musculoskeletal radiologist blinded to the clinical history. The diagnosis of a Bankart tear required identification of a detached anteroinferior aspect of the labrum[11]. This was seen as an increased-signal-intensity line deep to the labrum, displacement of the labrum from the glenoid, or fragmentation of the labrum. Cases with an intact periosteum were considered to be Bankart tears if the above findings were seen. An osseous Bankart lesion was diagnosed if signal-intensity characteristics of marrow fat could be seen in the displaced fragment[12], or if there was a defect in the contour of the anteroinferior aspect of the glenoid[13]. A Hill-Sachs lesion was diagnosed if there was an abnormal groove in the posterolateral aspect of the proximal portion of the humeral head[14]. Since imaging was performed within two weeks after the injury, a marrow edema pattern could be seen at the site of a Hill-Sachs lesion[15]. Peripheral capsular detachment was diagnosed if there was discontinuity of the inferior glenohumeral ligament at its humeral insertion with associated thickening and increased signal intensity of the ligament[16].

Nonoperative and operative treatment options were discussed with each patient. Surgical stabilization was offered to patients in whom a Bankart lesion had been documented on magnetic resonance imaging. While the natural history of Bankart lesions in individuals with subluxation of the shoulder has not been defined, a high rate of recurrent instability has been noted in our patients with a shoulder dislocation and this pathologic lesion[17]. Our usual recommendation for operative treatment is arthroscopic Bankart repair with suture anchors[18].

Continued injury surveillance was possible for our patients because of the closed nature of our health-care system. Queries about recurrent injuries were performed with use of the Cadet Illness and Injury Tracking System for subjects

Fig. 1-A

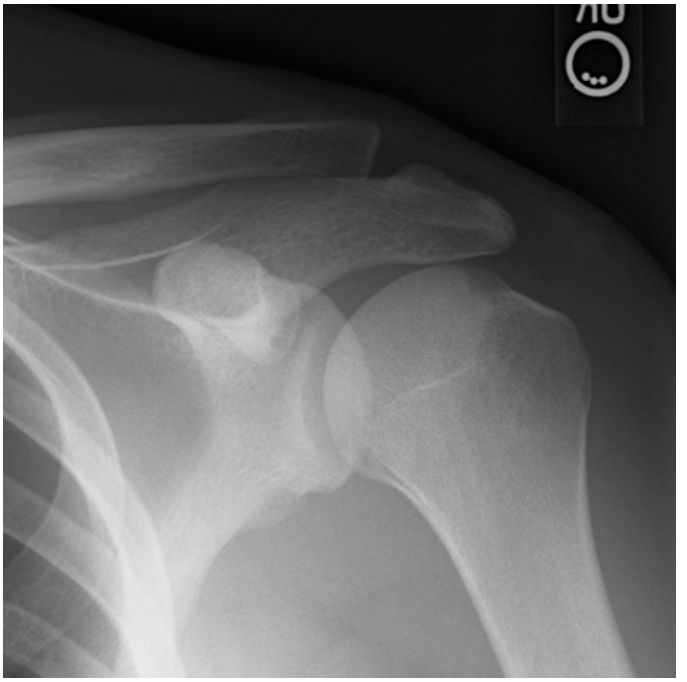

Fig. 1-B

Fig. 1-A West Point axillary radiograph showing an osseous Bankart lesion. **Fig. 1-B** Anteroposterior radiograph showing a Hill-Sachs lesion.

during their time at the academy and with use of the Armed Forces Health Longitudinal Technology Application (AHLTA) electronic medical record. In addition, subjects were contacted through e-mail or by telephone to ensure accuracy.

Source of Funding
This study received no outside funding.

Results

Among 4141 students (3509 male and 632 female), thirty-eight sustained a first-time, traumatic, anterior glenohumeral subluxation event during the study period[3]. Twenty-seven of these individuals were evaluated with magnetic resonance imaging during the acute period and thus met our inclusion criteria, whereas eleven patients were excluded because a magnetic resonance imaging scan was not acquired within two weeks after the injury. There were twenty-two men and five women with a mean age of twenty years (range, eighteen to twenty-four years). Thirteen individuals sustained an injury to the shoulder on the dominant side, ten injured the shoulder on the nondominant side, and hand dominance was not documented for four patients.

The sports or other activities associated with the greatest number of injuries were boxing (ten), indoor-obstacle-course test (seven), and rugby (five). Skiing, snowboarding, military training, cheerleading, and football accounted for one injury each. The most common mechanisms of injury were tackling (five), falls (five), and missed punches (five). A complete list of the sports during which the subluxation was sustained and the mechanisms of injury is provided in the Appendix.

Plain radiographs revealed three osseous Bankart lesions and two Hill-Sachs lesions (Figs. 1-A and Figs. 1-B). Magnetic resonance imaging revealed six osseous Bankart lesions and twenty soft-tissue Bankart lesions (Fig. 2-A). A Hill-Sachs lesion was visible on magnetic resonance imaging in twenty-five of the twenty-seven patients (Fig. 2-B). The magnetic resonance imaging indicated that two patients had sustained a capsular stretching injury in addition to Bankart and Hill-Sachs lesions.

Ten patients opted for surgical treatment within three months after the initial subluxation event. An additional four patients resumed activity but elected to have operative treatment after experiencing pain and recurrent instability. Of these fourteen patients, thirteen had a Bankart lesion documented during arthroscopy. One patient had cracking and scuffing of the anteroinferior aspect of the labrum (presumably as a result of the incident subluxation event) and underwent arthroscopic capsulorrhaphy. Therefore, one patient with a magnetic resonance imaging scan suggestive of a Bankart lesion did not have a frank avulsion noted at arthroscopy; however, the remaining Bankart lesions were confirmed surgically. Of note, the two patients with both Bankart and capsular injuries noted on magnetic resonance imaging had confirmation of the Bankart lesion but not of the capsular injury at surgery. Both patients with a Hill-Sachs lesion noted on plain radiographs had arthroscopic confirmation of an osteochondral Hill-Sachs lesion. However, an osseous Hill-Sachs lesion was not noted in the other patients at the time of surgery; five additional patients had a chondral Hill-Sachs lesion noted at surgery. Therefore, only seven of the twenty-five patients with a Hill-Sachs lesion diagnosed on

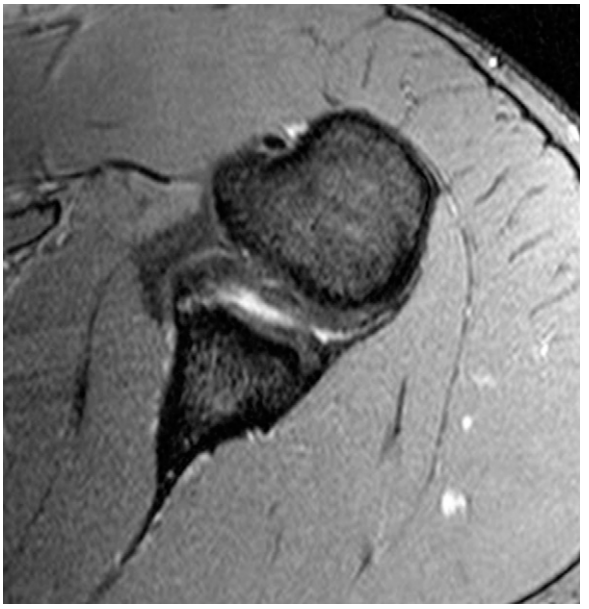

Fig. 2-A

Fig. 2-B

Axial T2-weighted magnetic resonance images showing a Bankart lesion (Fig. 2-A) and a Hill-Sachs lesion (Fig. 2-B) sustained in a first-time, traumatic anterior glenohumeral subluxation.

magnetic resonance imaging had surgical confirmation of that lesion.

Of the thirteen patients who declined surgery, two left the academy for nonmedical reasons and were lost to follow-up. Three patients sustained documented recurrent subluxations. One additional patient had both recurrent subluxations and dislocations, and surgical stabilization was pending at the time of writing. The remaining seven patients remained on active-duty service and had not sought care for recurrent instability events by the time of writing.

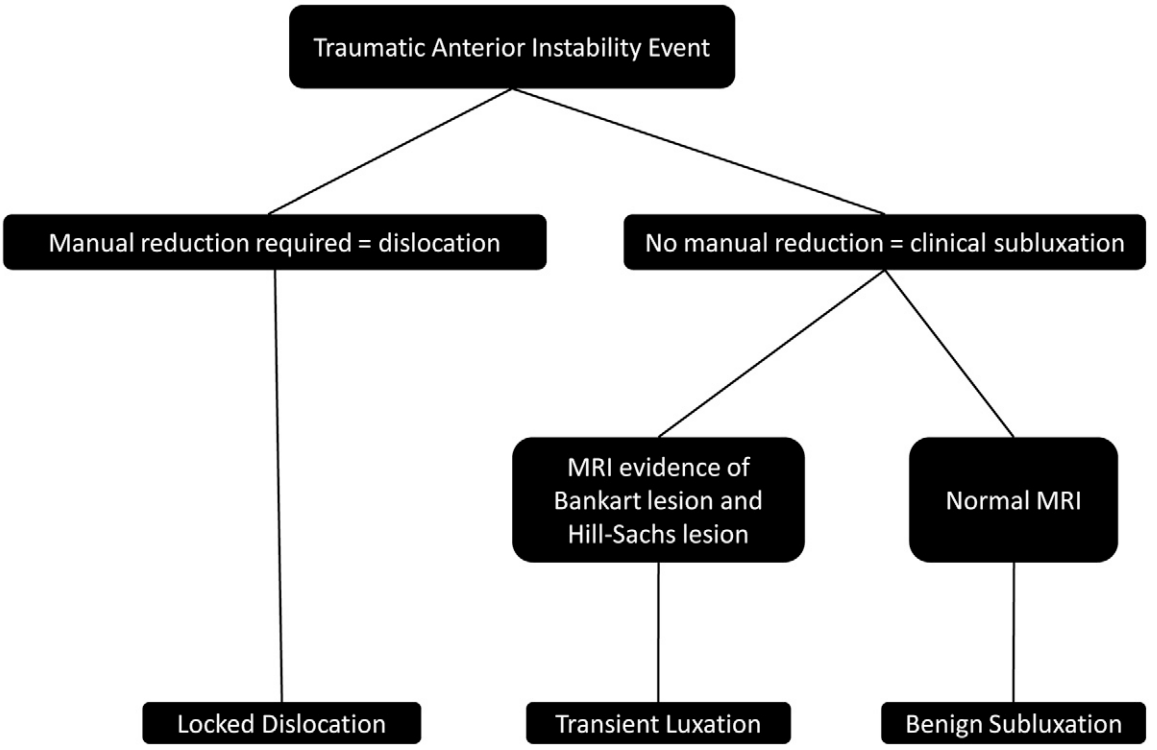

Fig. 3

Proposed classification scheme for traumatic anterior instability. MRI = magnetic resonance imaging.

Discussion

In this study, we focused on the pathologic changes associated with first-time, traumatic, anterior glenohumeral subluxation events. As has been found following dislocations[2], clinical subluxation events resulted in a very high prevalence of both labral and humeral head lesions. The presence of a Hill-Sachs lesion suggests that a complete dissociation of the articular surfaces occurred, but these events did not result in a sustained dislocation. This finding suggests that dichotomization of instability events into dislocations and subluxations, as is done currently, does not adequately classify them. We therefore propose that a third category of instability events be considered: the transient luxation. In a transient luxation event, the humeral head can translate substantially, to the point that resulting pathologic findings can be consistent with a complete dislocation; yet, the head spontaneously reduces to its anatomic position and does not lock in a dislocated position (Fig. 3). The fact that clinical subluxation events constitute the majority (85%) of all shoulder instability events underscores the need to subclassify this injury in a way that assists with clinical decision-making[3].

While we confirmed the Bankart lesions surgically in the patients who elected to have surgical treatment, the chondral Hill-Sachs lesions often were not confirmed. This suggests that the magnetic resonance imaging revealed a bone-edema or bone-bruise phenomenon, similar to that seen in the knee after an anterior cruciate ligament injury. Of the eleven patients who had undergone nonoperative management and were not lost to follow-up, only four had recurrent instability. This study was not designed to evaluate the natural history of the subluxation events, which would require larger numbers of patients and initial nonoperative treatment for the entire population. Further investigation is necessary to clarify the natural history of clinical subluxation events.

While much of the literature on shoulder instability focuses on the treatment of dislocations, there are some reports that deal strictly with subluxation events. Warren reported on a series of patients who had undergone a stabilization procedure for the treatment of anterior instability and noted a 33% and 50% prevalence of Hill-Sachs and Bankart lesions, respectively, on the plain radiographs of the patients with a subluxation[4]. This cohort was not limited to first-time traumatic injuries. As a result, it is unclear whether the subjects had sustained multiple, recurrent subluxation events. Still, a surprisingly high number of pathologic changes were noted on plain radiography, before magnetic resonance imaging was routinely performed. In comparison, we found only three osseous Bankart lesions (11%) and two Hill-Sachs lesions (7%) on plain radiographs.

Burkhead and Rockwood reported on a series of shoulders with a history of traumatic glenohumeral subluxation, including thirty-four with anterior instability and six with posterior instability[10]. A 55% prevalence of osseous Bankart lesions was noted on plain radiographs. While the exact number of instability events in this group was not detailed, this high rate of pathologic changes evident on plain radiographs suggests that these patients may have presented after multiple,

recurrent events. They were treated with an exercise program, which resulted in a good or excellent result (as assessed with the Rowe score) in only six of the thirty-four shoulders with traumatic anterior subluxation.

In a series of fifty-five patients with recurrent traumatic anterior subluxations, Mizuno and Hirohata also noted a high prevalence of pathologic changes[7]. They found a Bankart lesion on plain radiographic arthrograms of forty-five patients, with confirmation of the labral injury in the thirty-five patients who underwent arthroscopy. Arthrography allowed the identification of soft-tissue lesions in addition to osseous lesions, which perhaps explains the 82% incidence of Bankart lesions noted in that series.

Garth et al. also reported on a series of patients with a history of anterior subluxation[8]. They reviewed plain radiographs and noted a Hill-Sachs lesion in twenty-three of twenty-eight patients and an osseous Bankart lesion in two of the five without a Hill-Sachs lesion. These findings were confirmed with arthroscopy in eleven of these patients. McGlynn and Caspari reported the presence of a Bankart lesion in all nineteen shoulders of patients with a history of anterior subluxation[19].

The results of the current study suggest that a high rate of pathologic changes is associated with first-time, traumatic, anterior subluxation events. While previous studies of patients with recurrent subluxation suggest a high rate of Bankart and Hill-Sachs lesions, we are aware of no other reports of the pathologic changes associated with a single, traumatic, anterior subluxation event.

Given the high rate of pathologic changes (especially Hill-Sachs lesions seen on magnetic resonance imaging) that we noted, our study cohort may have included patients who experienced a complete dissociation of the articular contact between the humeral head and the glenoid fossa (a dislocation event)—with spontaneous reduction to the anatomic location. In light of this, we propose that these events be termed "transient luxations" on the basis of the magnetic resonance imaging findings. Clinically, these transient luxation events would be considered subluxations—as there was no history of dislocation requiring reduction. It is only retrospectively that a complete dissociation of the joint surfaces (luxation) can be inferred from the presence of a Hill-Sachs lesion on imaging. Therefore, magnetic resonance imaging may be helpful for determining if a transient luxation occurred in a young athletic patient with a clinical subluxation.

A primary strength of the study was our ability to obtain imaging of these shoulders within two weeks after the injury. The postinjury edema resulted in a high rate of pathologic changes noted on magnetic resonance imaging studies made without contrast medium. While many different methods have been proposed for magnetic resonance imaging of the shoulder labrum, it has been shown that, with appropriate pulse-sequence techniques, magnetic resonance imaging without contrast medium is accurate in the diagnosis of both Bankart[20,21] and Hill-Sachs lesions[14,15].

In summary, glenohumeral subluxation events constitute the majority of instability events in young athletes, and they involve a spectrum of injury. A high rate of pathologic changes is seen with first-time, traumatic, anterior subluxation events. The presence of Hill-Sachs lesions suggests that spontaneously reducing dislocation events may have occurred—and these injuries should be described as transient luxations. Following a clinical subluxation event, magnetic resonance imaging may be helpful prognostically given the high rate of pathologic changes seen in this study.

Appendix

eA A table showing clinical and radiographic details of all study subjects is available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on "Supporting Data"). ■

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