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Review Article

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Shoulder Dislocations: A Dedicated Search Strategy for Important Radiographic Signs

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Abstract

Purpose of Review: The glenohumeral (GH) joint is the most commonly dislocated joint in the human body. In acute dislocations, radiographs remain the first line of study. Despite their frequency, important secondary signs of anterior dislocation (such as impaction defects of the humeral head and glenoid rim fractures) are often subtle and easily missed.

Recent Findings: By using a dedicated search strategy, one that applies a comprehensive search for impaction defects at vulnerable sites, glenoid rim fractures, and changes in alignment, one may maximize the diagnostic accuracy of radiographic interpretation.

Summary: This article will provide a review of important indicators of anterior and posterior glenohumeral joint dislocations.

Keywords

Shoulder, Trauma, Fracture, Dislocation, Glenoid, Humerus

Introduction

The glenohumeral (GH) joint is the most commonly dislocated joint in the human body and accounts for over 50% of all dislocations. These injuries occur most frequently in young males in the setting of trauma [1]. Despite their frequency, important secondary signs of anterior dislocation (such as impaction defects of the humeral head and glenoid rim fractures) are often subtle and easily missed without a dedicated search strategy. Frequently, a posterior dislocation is overlooked, as 50% of posterior dislocations are not recognized in their initial presentation. This article serves as a primer on the primary and secondary radiographic signs of anterior and posterior shoulder dislocations and their associated injuries. The following sections are intended to help radiologists and clinicians to better understand the vulnerable areas in the shoulder that are associated with dislocations and the importance of applying a standardized search pattern to optimize diagnostic accuracy.

Anatomy of the glenohumeral joint

The glenohumeral joint is one of two spheroidal (ball-and-socket) joints in the body, the other being the hip joint. It is not a perfect ball-and-socket since the glenoid "socket" only covers one-third of the articular surface of the humeral head "ball" [2]. The glenoid also has a large radius of curvature that, in combination with its relatively small size, allows the shoulder joint to have tremendous mobility. However, this heightened mobility also greatly increases risk of glenohumeral joint dislocation. Furthermore, the shoulder has a relatively weak joint capsule, further contributing to the ease of dislocation of the glenohumeral joint and ultimately making it the most dislocated joint in the human body [3].

Radiography of the shoulder

In any suspected shoulder dislocation, radiographs are the first imaging study performed. It is recommended that conventional radiographs of the shoulder be obtained before reduction to assess the position of the humeral head and assess for fractures. The American College of Radiology (ACR) recommends a minimum

of three radiographic views [4]. A typical trauma shoulder series contains an anteroposterior (AP), Grashey, transcapular Y, and when possible an axillary or similar type view.

The AP view is typically obtained with the arm in internal rotation (IR). With the patient's back against the image cassette, the x-ray beam is directed in a true AP direction [5]. The glenoid fossa and humeral head overlap in this view because the scapula is tilted horizontally about 35 to 45 degrees from the coronal plane. When the humerus is internally rotated, the head appears spherical and, in combination with the proximal shaft, gives an appearance similar to the profile of a lightbulb.

The Grashey view is regarded as the true AP radiograph of the shoulder since it compensates for the scapular oblique inclination [2]. With the patient's back toward the image receptor, the thorax is rotated 35 to 45 degrees towards the shoulder of interest. The preferred position of the arm in this view is in external rotation. There are two major advantages of this projection; it outlines the GH joint as a space between the glenoid fossa and articular surface of the humeral head without osseous overlap, and it depicts a smooth visual arc consisting of the lateral border of the scapular body and neck with the humeral neck and shaft (referred to as Moloney's scapulohumeral arch). If the humeral head overlaps the scapular glenoid in this projection, it is suggestive that the glenohumeral joint may not be in anatomic alignment.

The scapular Y-view provides a true lateral view with the anterior aspect of the affected side rotated 30 to 45 degrees toward the cassette [5]. In this view, several structures make up what appears to be the letter "Y". The upper arms of the Y are formed by the coronoid process anteriorly and the scapular spine posteriorly, while the vertical arm of the Y is formed by the body of the scapula. The glenoid fossa is seen en face at the intersection of these three arms. As accurate positioning is not needed, this view can be advantageous in cases of severe pain or limited mobility in which patient arm movement is restricted. It is possible to obtain this view even when the arm is immobilized in an arm support.

The axillary view is obtained with the arm abducted 70 to 90 degrees in a supine patient. The beam is centered over the GH joint and directed cephalad toward the cassette. There are several alternative variations to this view. It is useful for depicting dislocations and subluxation of the humeral head and in depicting glenoid rim fractures [2]. In contrast to the scapular-Y view, the axillary view may not be possible in settings of acute trauma if the patient is unable to abduct their arm. In these cases, modified axillary radiographs may be obtained such as the Velpeau axillary lateral projection or trauma axillary lateral projection.

Anterior shoulder Dislocations

Anterior dislocations account for 95% of all shoulder dislocations [3]. The prevalence of this injury is about 1% to 2% in the general population [6]. Anterior dislocations frequently occur from fall-on-outstretched-hand (FOOSH) injuries involving extension, abduction, and external rotation of the arm. Dislocations are classified by the terminal location of the humeral head, and there are four types: subcoracoid (the most common type), subclavicular, subacromial, and intrathoracic. Typically, a single AP radiograph with a neutrally positioned arm along with another standard projection is sufficient to diagnose most anterior dislocations [3].

Once a shoulder dislocates, there is increased potential for dislocation to happen again. The most significant risk factors for recurrence are the age that the initial dislocation took place and the gender of the patient [7]. Patients who have a dislocation before the age of 20 years have a 5-fold greater risk of redislocating the same shoulder compared to those over 40 years old. Young men have a 3-fold greater risk of recurrence than females.

Although chronic glenohumeral joint instability may occur with a single dislocation, it is much more likely to occur with repeated episodes. With each recurrence, the joint becomes increasingly unstable. This cumulative effect occurs because repeat dislocations have higher rates of injury to the inferior labro-ligamentous complex, the capsule, and the osseous structures that serve as stabilizers of the shoulder [7].

Hill-Sachs Lesion

A Hill-Sachs lesion is an impaction fracture of the posterolateral surface of the humeral head that is pathognomonic for an anterior GH joint dislocation. Typically, it occurs when the humeral head forcibly strikes the harder compact bone of the anterior glenoid rim when it dislocates, producing a variably-sized impaction defect. This abnormality is optimally visualized on an AP radiograph with an internally rotated humerus since the average location of the lesion occurs about 209 degrees from the anterior margin of the articular surface [8]. When the HS lesion is large, a prominent vertical line of condensation (initially described by Hill and Sachs) is apparent on internally rotated radiographs (Figure 1). However, because the impaction defect can also appear flattened, concave, or wedge-shaped, a high index of suspicion is required for detection. Once the shoulder has been reduced into anatomical position, a Hill-Sachs lesion may be the only radiographic indicator of a prior dislocation. In the literature, the incidence of a Hill-Sachs lesion has ranged from 25% to nearly 100% in patients with recurrent instability [9]. Hill-Sachs lesions involving greater than 40% of the humeral head are nearly always clinically significant, associated with greater joint instability, heightened risk of recurrence, and increased likelihood for surgical treatment [3].

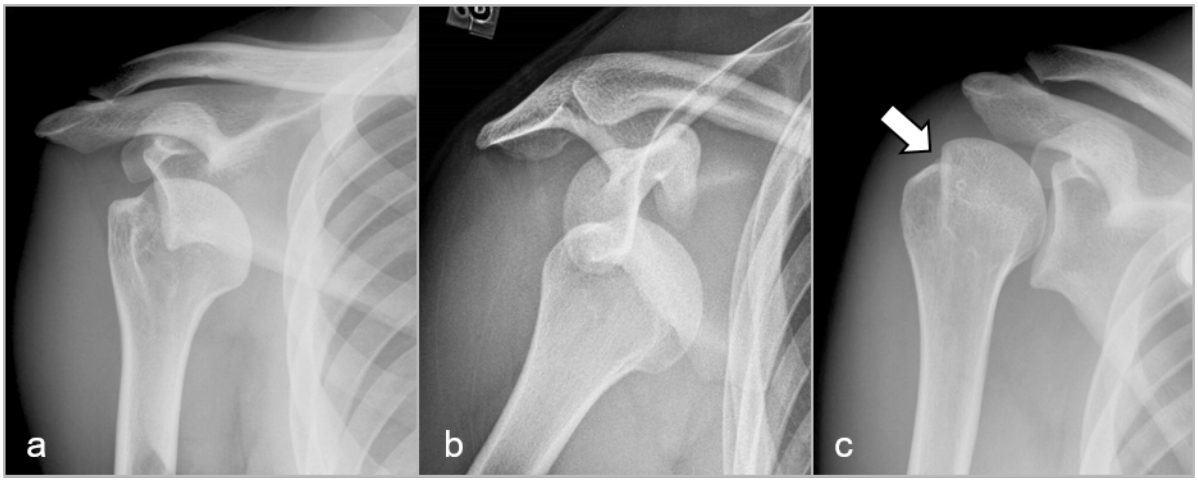

Figure 1: Hill-Sachs Lesion (a) Grashey view of the shoulder shows malalignment of the glenohumeral joint; (b) Anteroposterior view shows the classic terminal position of the humeral head in a subcoracoid-type of anterior dislocation;(c) Impaction of the posterolateral surface of humeral head against anterior glenoid rim produces the Line of Condensation known as the Hill-Sachs lesion (arrow).

A new detection method, referred to as the Broken Circle sign, has recently reported sensitivity of 91% and specificity of 82% for Hill-Sachs lesions of any size [7]. This technique makes use of the markup region of interest (ROI) function within the picture archive and communication system (PACS). This tool allows a circular marker to be superimposed over the cortex of the humeral head on internal rotation shoulder radiographs (Figure 2). Hill-Sachs lesions are revealed in areas where the cortex deviates or "breaks away" from the circle's perimeter in the 10 o'clock to 12 o'clock zones (Figure 3). This technique enables detection of even subtle deviations from the reference circle, often seen with small or shallow defects when the vertical condensation line is absent. The Broken Circle detection method has been shown to improve reader accuracy and sensitivity without dramatically altering specificity [7].

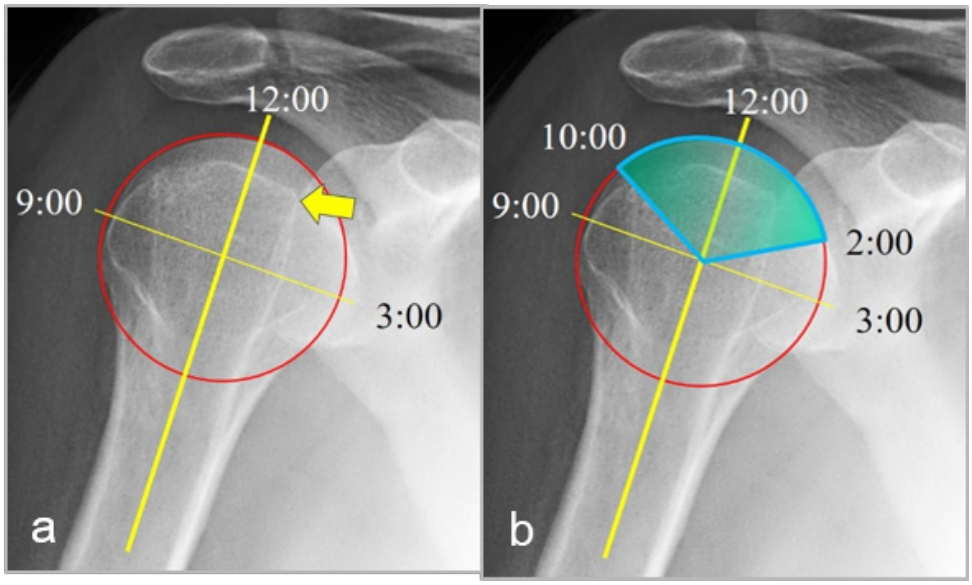

Figure 2: Broken Circle Method (a) This technique applies to internal rotation radiographs. A ROI circle is placed over the humeral head cortex. A line is drawn along axis of the bone, bisecting the humeral head corresponding to the 12 o'clock position. A perpendicular line corresponds to the the 3- and the 9 o'clock positions. Adequate rotation is confirmed when the lateral margin of the intertubercular groove is medial to the long axis reference line (arrow); (b) When a Hill-Sachs impaction defect occurs in the 10 or 11 o'clock zones, it is a positive sign (1 or 2 o'clock in the opposite shoulder). [Used with permission from Yu JS, *et al* [7]].

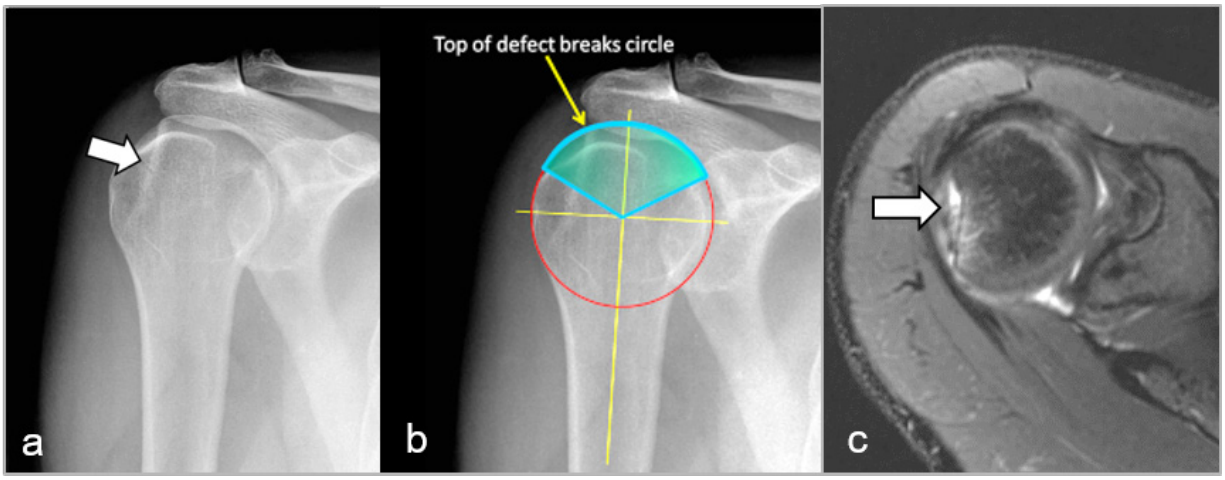

Figure 3: Positive Broken Circle Sign (a) A reduced shoulder shows a Hill-Sachs lesion (arrow); (b) Note that after applying the Broken Circle method, the top of the defect breaks the circle at the 11 o'clock position; (c) Axial fluid-sensitive MR image shows the position and size of the impaction defect (arrow). [Used with permission from Yu JS, *et al* [7]].

Osseous Bakart Lesion

An osseous ("bony") Bankart lesion is a true fracture of the anteroinferior glenoid rim that occurs when the humeral head dislocates. It is important to differentiate an osseous Bankart lesion from a "classic" Bankart lesion that denotes an avulsion of the anterior labrum caused by the inferior glenohumeral ligament with an associated disruption of the anterior periosteum. A "classic" Bankart lesion is radiographically occult. Bony Bankart lesions are evident in about 5% to 8% of patients with acute anterior dislocations, but the majority are radiographically occult either because the fracture fragment is too small, or because the imaging projection is not optimal to depict the rim fracture. A high index of suspicion is required to detect small fractures, so that areas of increased density or dense slivers of bone adjacent to the anterior glenoid rim should be regarded as suspicious (Figure 4).

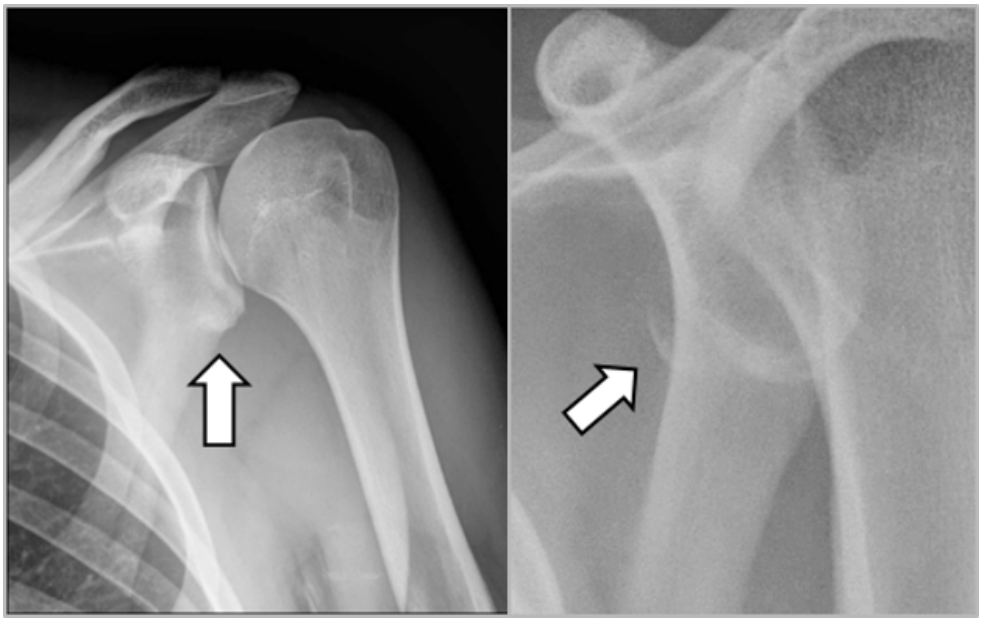

Figure 4: Osseous Bankart Lesion (a) Grashey view an area of increased density in the inferior glenoid rim (arrow); (b) The magnified AP view shows a distracted curvilinear fracture fragment projecting anterior to the anteroinferior rim of the glenoid (arrow).

CT is the preferred imaging modality both to confirm the presence of an osseous Bankart lesion and to quantify its size [10]. Bone deficits that are larger than 25% of the bone width of the inferior glenoid are associated with a high rate of instability and often require more invasive surgical management [2]. This includes the Latarjet-Bristow procedure in which the coracoid process is transferred to the anterior glenoid, and then the ligament is re-anchored with a soft-tissue Bankart repair [11]. When osseous Bankart lesions are identified, quantification of the size of the Hill-Sachs lesion and the glenoid defect together will influence management, so assessment of the glenoid surface involved by CT is usually performed pre-operatively [12].

Associated Findings

Approximately 15% to 25% of anterior dislocations are associated with greater tuberosity fractures, usually occurring adjacent to a Hill-Sachs lesion [1,13]. These fractures may be comminuted or displaced (Figure 5).

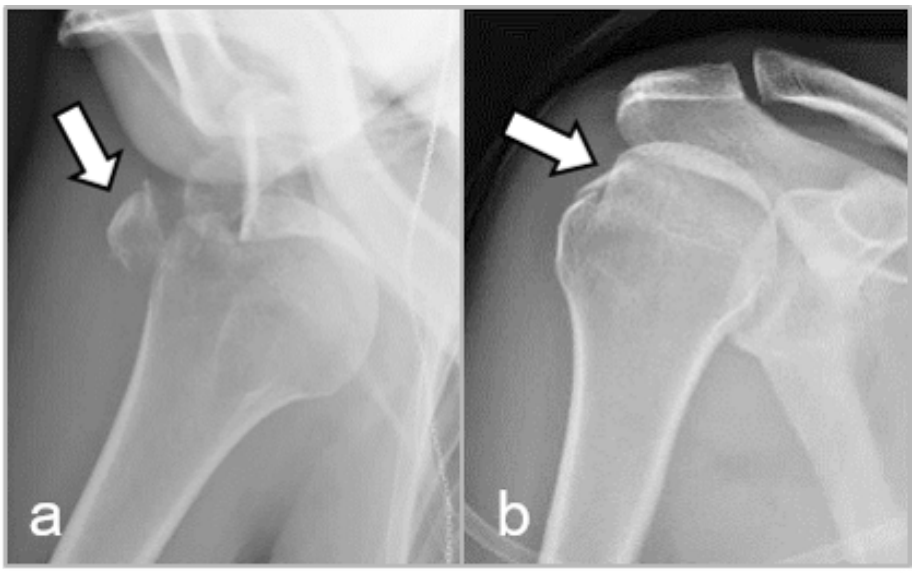

Figure 5: Greater Tuberosity Fracture (a) Grashey view shows a displaced fracture of the greater tuberosity in an anteriorly dislocated GH joint (arrow); (b) The anteroposterior view shows shows a Hill-Sachs lesion after reduction of the shoulder (arrow).

Other fractures that may occur are much less frequent and may involve the proximal humerus at the surgical neck, the body or acromion process of the scapula, or the clavicle.

A soft tissue "classic" Bankart lesion is defined as an avulsion of the anterior labrum by the anterior band of the inferior glenohumeral ligament with an associated disruption of the anterior periosteum. There are a variety of Bankart variants that can be categorized by the involvement of surrounding structures, such as the labrum, articular cartilage, bony periosteum, or bone. A humeral avulsion by the glenohumeral ligament (HAGL), anterior labroligamentous periosteal sleeve avulsion (ALPSA), and glenoid labral articular disruption (GLAD) lesions are important in dislocations and are most optimally depicted and characterized with MR arthrography [14].

Posterior shoulder dislocations

Posterior dislocations account for < 2-4% of all shoulder dislocations and are most often caused by seizures, electrocution, or from falls with the arm adducted, flexed, and internally rotated [15]. Posterior dislocations may also be caused by direct trauma in which the humeral head is internally rotated and forcefully displaced posteriorly [3]. Seizures may result in bilateral dislocations. There are three types: subacromial (the most common at about 98%), as well as the infrequently occurring subglenoid and subspinous types [1]. About 50% of posterior shoulder dislocations are not recognized on initial inspection usually owing to subtle radiographic findings. To increase the diagnostic accuracy, each radiographic projection of the shoulder must be closely scrutinized for clues. In addition to a true AP view and Y view, an axillary radiograph, when obtained, can be essential for diagnosis of posteriorly subluxed or dislocated humeral head [16].

Trough (Reverse Hill-Sachs) Lesion

A trough (or reverse Hill-Sachs) lesion is an impaction fracture of the anteromedial aspect of the humeral head that occurs with a posterior dislocation (Figure 6). It is an important radiographic finding, appearing as a vertically oriented dense linear or curvilinear band that parallels the medial cortex of the humeral head on internally rotated radiographs of the shoulder [17]. If the impaction defect affects greater than 25% of the humeral head, operative management may be considered; if the lesion affects greater than 50% of the head, shoulder arthroplasty becomes the preferred treatment consideration [11,15].

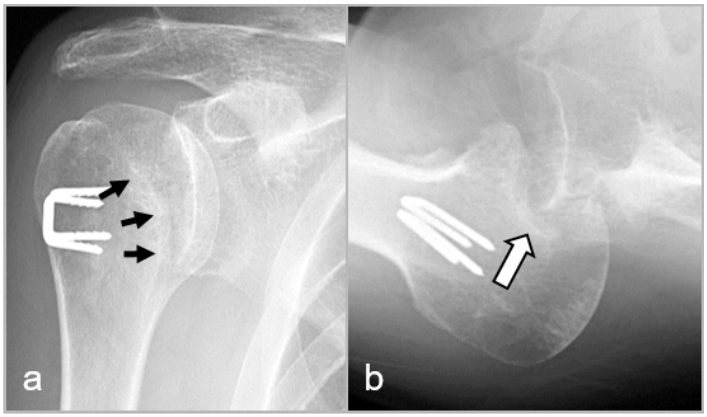

Figure 6: Trough Lesion (a) Grashey view shows a vertically-oriented curvilinear density in the medial aspect of the humeral head (arrows) and malalignment of the glenohumeral joint; (b) Axillary view shows that the anterior aspect of the humeral head is impacted (arrow) and perched against the posterior rim of the glenoid.

Associated Findings

Reverse osseous Bankart lesions and other labrocapsular complex lesions occur with high frequency in traumatic posterior shoulder dislocation [18]. These lesions are extremely difficult to detect radiographically (Figure 7). This is attributable to both the size and position of the posterior rim fracture, as the lesion may displace posteriorly and overlay the cortex of the glenoid fossa. CT is usually required for confirmation particularly when the fragment is small.

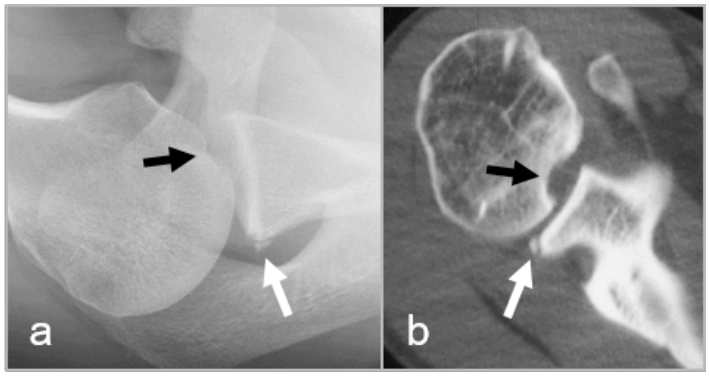

Figure 7: Reverse Osseous Bankart Lesion Axillary view (a) and axial CT image in the same patient show a small subtle fracture in the posterior rim (white arrows in a and b). Note the trough lesion from impaction of the anteromedial aspect of the humeral head (black arrows in a and b).

Additionally, approximately 25% of patients with a posterior dislocation will present with a lesser tuberosity fracture and rotator cuff tears (Figure 8) [1,18]. Rarely, the shaft of the humerus may also fracture [19].

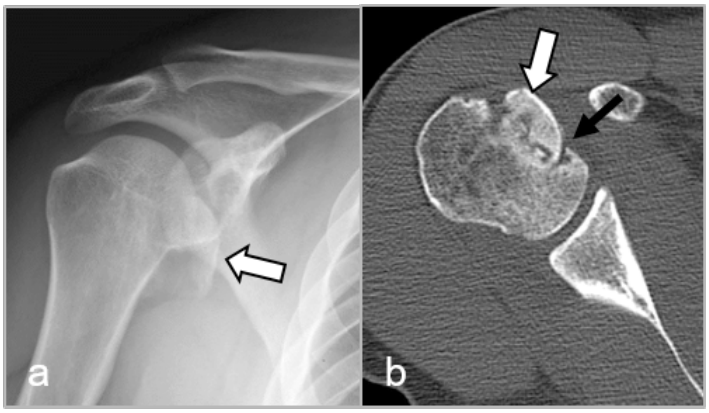

Figure 8: Lesser Tuberosity Fracture (a) Anteroposterior view shows a displaced fracture of the lesser tuberosity (arrow); (b) An axial CT images in the same patient shows that the tuberosity fragment (white arrow) is slightly rotated at the leading edge of a trough lesion (black arrow).

Associated Radiographic Signs

Because the diagnosis may be elusive in some cases, there are important radiographic observations that may be indicative of a posterior shoulder dislocation [1,6]. The *rim* sign indicates widening of the glenohumeral joint space in excess of 6 mm (Figure 9).

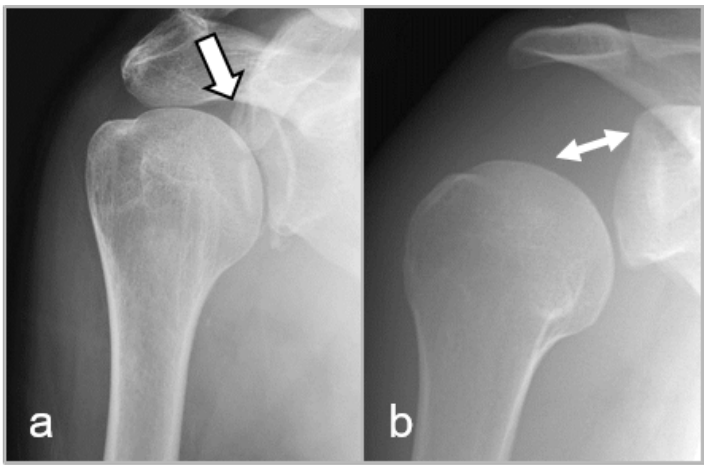

Figure 9: Rim Sign (a) Grashey view shows subtle widening of the superior glenohumeral joint space (arrow) that exceeded 6 mm; (b) Another patient shows more conspicuous widening of the joint (arrow) and inferior subluxation of the humeral head.

The *lightbulb* sign refers to an arm that is "locked" in internal rotation such that all of the views of the shoulder series appear similar because the impaction defect of the head is perched on the posterior glenoid rim.

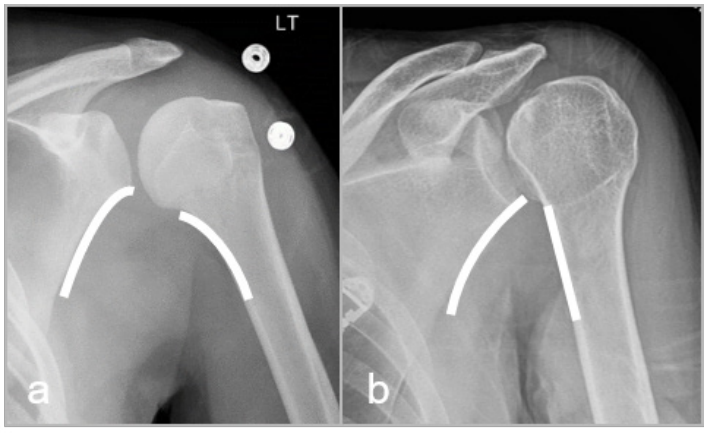

Figure 10: Broken Arch Sign **(a)** Grashey view shows disruption of the scapulohumeral arch (white lines). In a normal shoulder, these lines should connect to form a smooth arch; (b) Grashey view in another patient shows angulation of the scapulohumeral arch (white lines).

A *disrupted arch* sign indicates that there is discontinuity of the scapulohumeral arch owing to subluxation of the humeral head (Figure 10). The *absent half-moon*, or crescent, sign refers to the absence of the normal overlap of bone between the glenoid and humeral head on an AP shoulder radiograph (Figure 11).

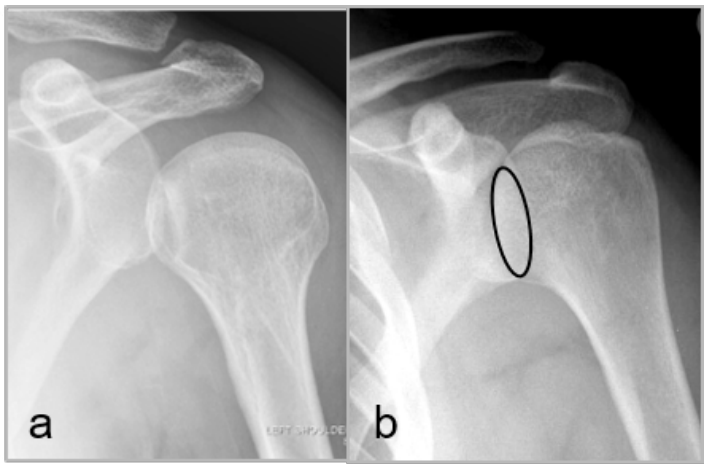

Figure 11: Absent Half-Moon Sign **(a)** Anteroposterior view shows loss of the normal overlap between the medial aspect of the humeral head and the glenoid fossa; (b) Anteroposterior view in a normal shoulder shows the typical expected overlap of the bones (oval).

The *crossover* sign refers to overlapping profiles of the glenoid and the humeral head on a Grashey view. The number of radiographic secondary signs underscores the difficulty of prospectively identifying a posterior dislocation in the urgent or emergent setting.

Conclusion

The glenohumeral joint is the most commonly dislocated joint in the body. Utilizing a standardized search pattern with meticulous evaluation of the glenohumeral joint in search of primary and secondary signs of dislocations is essential for diagnosis. Accurate diagnosis establishes proper treatment early and prevents complications that may arise from delayed detection. Each radiographic projection yields important information, but knowledge of the strengths of each view is essential in the search strategy. A Hill-Sachs lesion is pathognomonic for anterior shoulder dislocations, and the new *Broken Circle* sign provides a novel and effective method for recognizing these lesions. There are a number of secondary signs associated with posterior shoulder dislocation and it is important to recognize them in post-traumatic patients so that diagnosis and timely treatment may be initiated.

Declaration of conflict of interest

The authors have no financial or non-financial conflict of interest that may be directly or indirectly related to the contents of this manuscript.

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