



# Sequelae of bilateral luxatio erecta in the acute post-reduction period demonstrated by MRI: a case report and literature review

Pei Ing Ngam<sup>1</sup> · James Thomas Hallinan<sup>1</sup> · David Soon Yiew Sia<sup>1</sup>

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## Abstract

Luxatio erecta humeri (LEH), also known as inferior shoulder dislocation, is uncommon, comprising about 0.5% of all cases of shoulder dislocation. Synchronous bilateral LEH is exceedingly rare and, to our knowledge, there are no descriptions of axillary nerve injury on magnetic resonance imaging (MRI) following LEH. We present a case of traumatic bilateral LEH in a 59-year-old woman who fell from a fast-moving mobility scooter and sustained direct axial loading forces on the fully abducted shoulders. Both shoulders were successfully reduced using the traction–countertraction technique in the emergency department. In this article, we describe the characteristic features of LEH on plain radiography and the pattern of acute soft-tissue injuries on MRI. We emphasize the importance of reviewing the axillary neurovascular bundle, which by virtue of its location beneath the shoulder joint, is prone to injury in inferior shoulder dislocation and thus has a substantial impact on functional recovery. This important complication is unfortunately not routinely examined by radiologists, partly because of the paucity of literature highlighting its clinical significance.

**Keywords** Luxatio erecta humeri · LEH · Inferior shoulder dislocation · Axillary nerve · Neurapraxia · Nerve palsy  
Magnetic resonance imaging · MRI

## Introduction

The shoulder joint is a highly mobile but inherently unstable joint, owing to a large humeral head articulating with a relatively small glenoid cavity [1]. The glenoid labrum acts as a passive stabiliser, deepening the glenoid cavity, whereas the rotator cuff muscles and glenohumeral ligaments act as dynamic stabilizers of the glenohumeral joint. Injuries to the static and/or dynamic stabilizers render the shoulder joint susceptible to dislocation, with unilateral anterior dislocation being the most common subtype. Inferior shoulder dislocation (luxatio erecta humeri, LEH) is uncommon, consisting of about 0.5% of all the reported shoulder dislocations [2]. Bilateral LEH is even rarer than unilateral luxatio erecta. To date, a total of 199 patients have been reported to have LEH and only 29 of them presented with bilateral LEH [3]. Only one of the 29 reported cases briefly

described the associated MRI findings in bilateral LEH, but no MR images were provided [4].

We present a case of bilateral traumatic LEH involving a personal mobility device. This is the first known incident of shoulder dislocation resulting from a fall from a mobility scooter, which has become a ubiquitous mode of short-range transportation in the young and middle-aged commuters in our population. To our knowledge, this is the first description emphasizing MRI findings of an acute axillary nerve injury in a rare case of bilateral LEH. It is essential to raise awareness of axillary nerve palsy, in particular when clinical examination has failed to detect axillary nerve palsy, as in this case.

## Case report

A 59-year-old woman was brought to the emergency department after a high-impact motor vehicle accident. She was riding a motorised mobility scooter when she skidded and fell forwards onto her outstretched arms. She was found by paramedics in a prone “hands-up” position in which both her arms were locked in a forward-flexed posture. There was no history of previous shoulder dislocation.

✉ David Soon Yiew Sia  
soon\_yiew\_sia@nuhs.edu.sg

<sup>1</sup> Department of Diagnostic Imaging, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074, Singapore

On physical examination, her arms were abducted at the shoulders and flexed at the elbows. The patient was unable to adduct both arms. Soft-tissue fullness was palpated at both axillary regions, but no definite osseous structures were felt. The radial pulses were present and equal. No sensory impairment was documented, particularly at the axillary nerve distribution (regimental patch) of both shoulders.

Radiographs of the shoulders (Fig. 1) demonstrated that both humeral heads were at the subglenoid regions, and the humeral shafts were abducted almost parallel to the scapular spine. The findings were in keeping with bilateral LEH. No fracture was detected.

Closed manipulation and reduction under procedural sedation was performed at the emergency unit after intravenous administration of 50 mcg of fentanyl and 80 mg of propofol in two divided doses. This was achieved by using the traction-countertraction technique. Both shoulders were successfully reduced at the first attempt and this was confirmed on plain radiographs. No fracture was evident once again. Repeat neurovascular assessment revealed no new deficits.

During inpatient monitoring, serial physical examinations revealed persistent restricted motion of both shoulder joints, despite earlier successful reduction. There were 20 degrees of active abduction and up to 90 degrees of passive abduction in both shoulder joints.

Magnetic resonance imaging of both shoulders performed 6 days after the accident revealed bilateral, fairly symmetrical full-thickness supraspinatus tendon tears (Fig. 2). There were also humeral and glenoid avulsions of the anterior and posterior bands of the inferior glenohumeral ligaments (IGHLs) in both shoulders (Fig. 2). High-grade partial intramuscular tears with hematomas of the bilateral inferior subscapularis muscles were also found. Extensive oedema and haemorrhage in both quadrilateral spaces were observed on the T2-weighted fat-suppressed sequences (Fig. 3). Both axillary nerves were clearly seen and demonstrated normal signal. However, the

left axillary nerve was significantly thickened (Fig. 3). There were no MRI features of vascular injury with normal flow voids seen in the posterior circumflex humeral arteries (Fig. 4). Marrow contusions in the right posterosuperior glenoid fossa and the superior aspect of the right humeral head (Fig. 5) were seen. No fracture line was visible. Both long heads of the biceps tendons were intact. No cartilage shear or labral tears were detected.

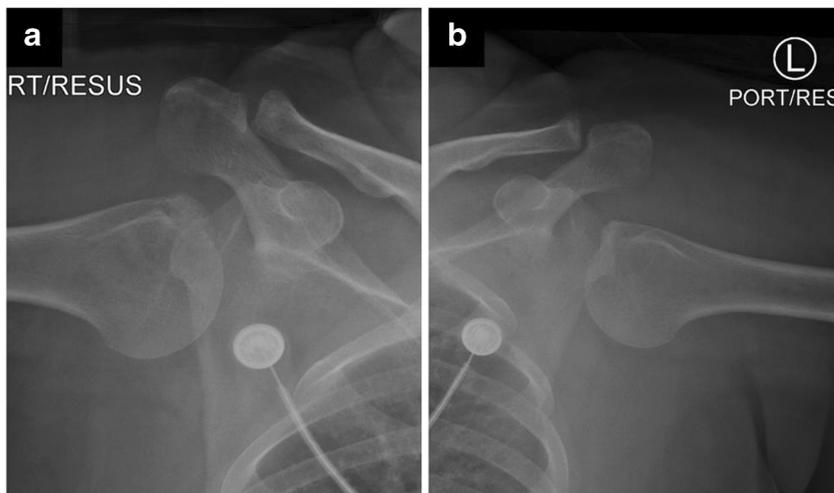
The patient was managed conservatively and discharged on day 8 of the incident. Upon review in an outpatient clinic 10 days after discharge, an improved pain score was reported for both shoulders, but flexion, abduction, internal and external rotations remained significantly impaired. In addition, there was slightly decreased sensation in the left shoulder regimental patch compared with the right. A left axillary nerve palsy secondary to neurapraxia was diagnosed. The patient was advised to continue with physiotherapy with future consideration of surgical repair of the rotator cuff tear if no clinical improvement was observed.

Three months after the incident, there was remarkable improvement in the range of motion in both shoulders. Full power was elicited in bilateral rotator cuff muscles except for a mild weakness in both supraspinatus muscles. No numbness was reported in either regimental patch. The patient was allowed to return to work as a bus driver.

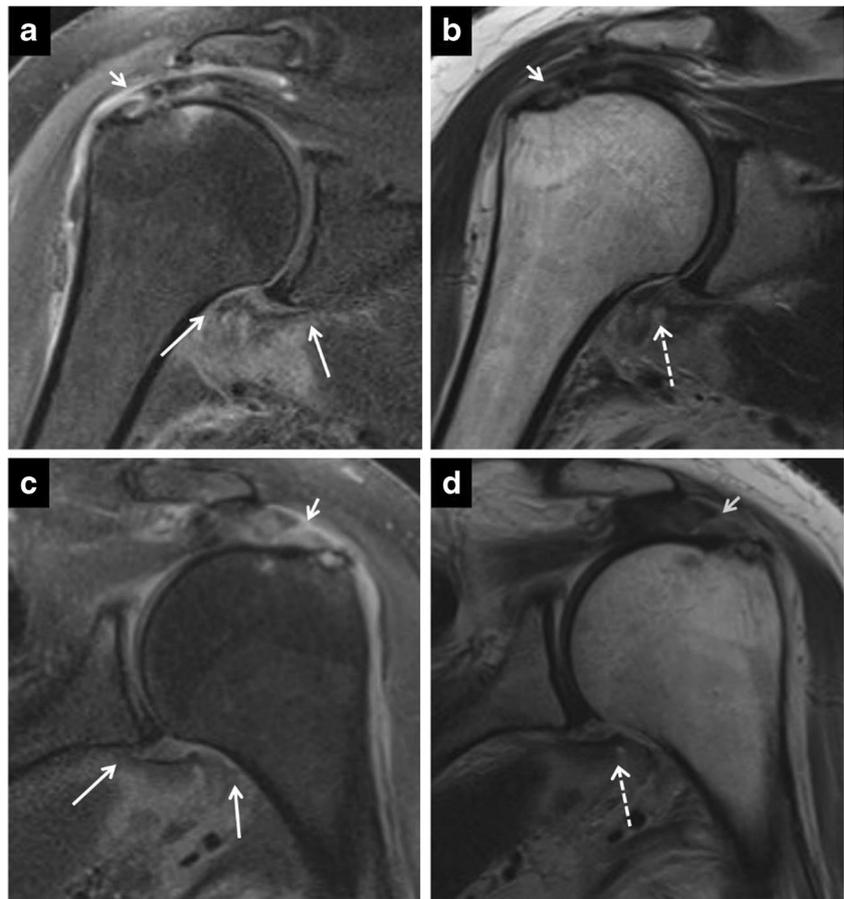
## Discussion

Bilateral LEH is extremely rare, with only 29 cases reported to date [3]. The mean age at presentation ranges between 31 and 40 years old, with infants as young as 3 months and adults as old as 80 years also reported [5, 6]. Our case illustrates a classic but rare example of bilateral LEH with the patient's arms fixed in an over-the-head position, albeit an uncommon presentation involving a fall from a high-speed mobility

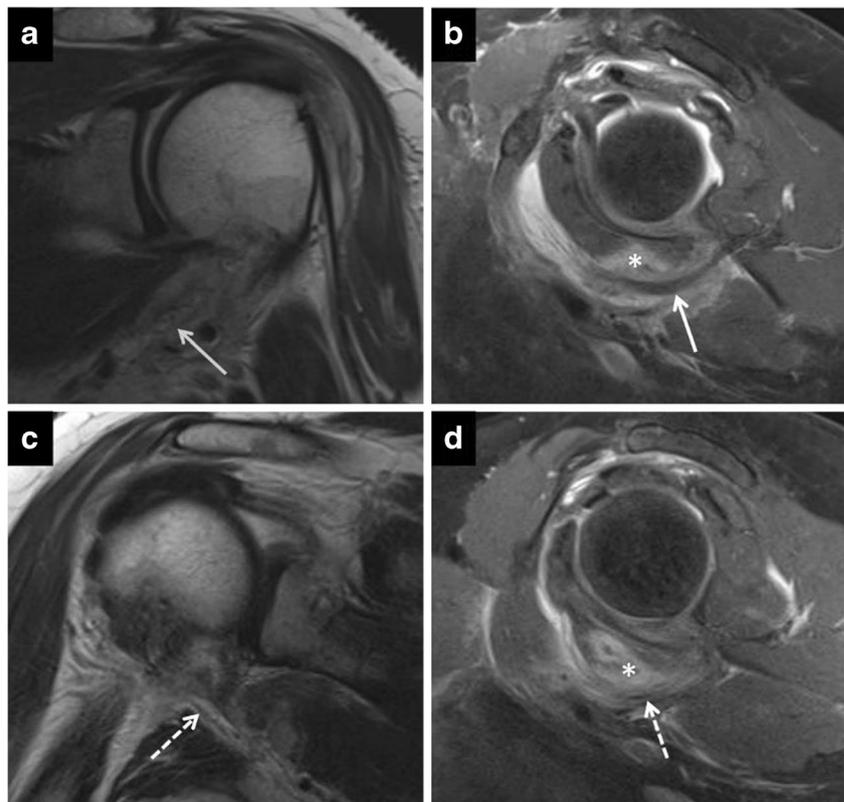
**Fig. 1** **a** Right and **b** left frontal shoulder radiographs show that both humeral heads were at the subglenoid regions with the humeral shafts abducted almost parallel to the scapular spine



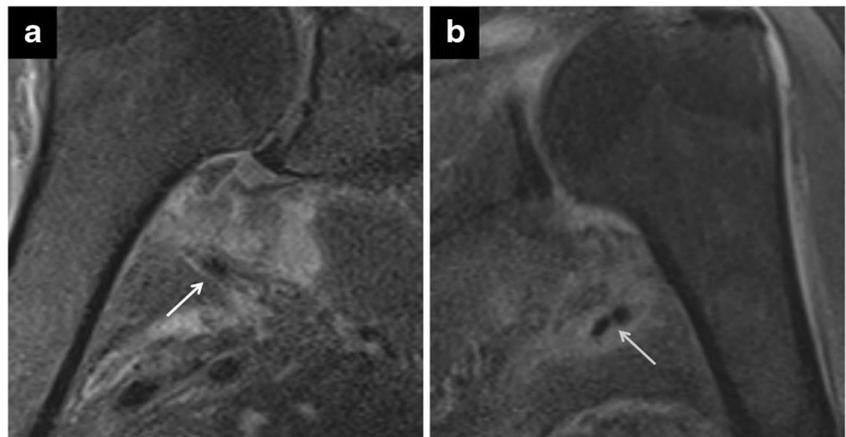
**Fig. 2** Coronal proton density (PD) fat-suppressed (FS; repetition time [TR]/echo time [TE] 2,150/35 ms) and coronal turbo-spin echo (TSE) T2-weighted (T2-w; TR/TE 3,270/150 ms) images of **a, b** the right shoulder and **c, d** left shoulder () show fairly symmetrical full-thickness tears of the supraspinatus tendons (*short solid arrows*). There is retraction of the left supraspinatus tendon by approximately 1 cm. Bilateral anterior and posterior bands of the inferior glenohumeral ligaments are avulsed at the humeral and glenoid attachments (*long solid arrows*). Note the loss of normal U-shaped axillary pouches on both sides (*dashed line arrows*), indicating inferior capsular rupture



**Fig. 3** **a** Coronal TSE T2-w (TR/TE 3,270/150 ms) and **b** sagittal PD FS (TR/TE 1,900/28 ms) images of the left shoulder show that the left axillary nerve is significantly thickened (*solid arrows*). **c** Coronal TSE T2-w (TR/TE 3,270/150 ms) and **d** sagittal PD FS (TR/TE 1,900/28 ms) images of the right shoulder demonstrate the right axillary nerve with normal thickness (*dashed line arrows*). Both shoulders show high-grade partial intramuscular tears of the inferior subscapularis muscles (*asterisks*)



**Fig. 4** Coronal PD FS (TR/TE 2,150/35) images of **a** the right shoulder and **b** the left shoulder show normal flow voids in the posterior circumflex humeral arteries (*arrows*), affirming their patency



scooter. The shoulder is locked in abduction and external rotation, the elbow is flexed, and the forearm is pronated. This unique position is described as the “hands-up” posture [7]. Palpation of the axillae typically finds the inferiorly displaced humeral heads, although in individuals with a high body habitus, this may not be obvious.

### Mechanisms

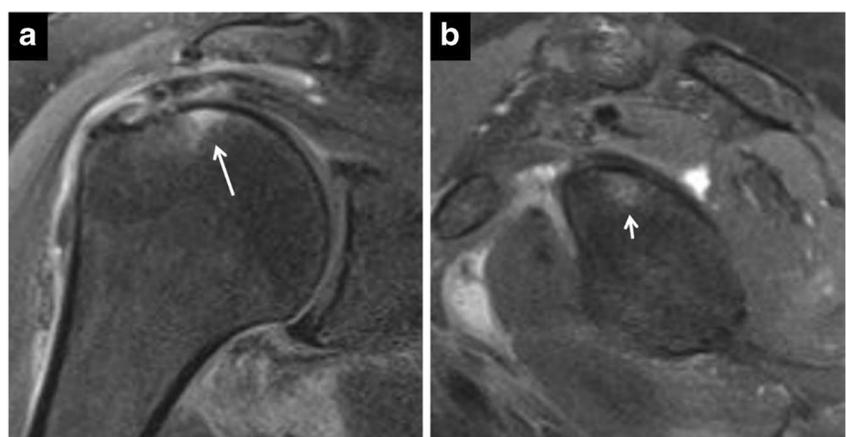
The mechanisms of injury in LEH can be divided into direct and indirect. The indirect mechanism is more common, accounting for approximately 70% of the cases. This happens due to forceful hyperabduction causing the humerus to lever on the acromion, resulting in stretching and tearing of the inferior joint capsule, and inferior humeral head displacement [8, 9]. The humerus is maintained in the erect position by persistent contraction of the pectoralis major muscle.

Although the direct mechanism of LEH is less common, it is important to recognise. As depicted in our case, the axial loading force applied to the shoulder, with the arm abducted at the shoulder joint and extended at the elbow joint, drives the greatest diameter of the humeral head against the thinnest and

weakest portion of the glenohumeral capsule [8, 9]. The girdle muscles cannot compensate for the sudden exertion of downward force. The unopposed sudden descent of the humerus results in tearing of the inferior capsule and the rotator cuff tendons. Avulsion fracture of the greater tuberosity has also been described as a consequence of shearing on the inferior glenoid labrum as the humeral head dislocates inferiorly with reciprocal distracting force by the supraspinatus tendon attaching onto the greater tuberosity [3].

Regardless of the mechanism, all cases involve hyperabduction of both arms such as that seen in falls from heights: examples including a plunge from a ladder or a dive down a flight of stairs [4, 5, 10] and even a ground level fall on outstretched arms [7, 11]. There are case reports of bilateral LEH in individuals who broke their fall by supporting their arms on the armrests of a treadmill or clinging on to the banisters of a staircase. Apart from the mechanism of fall, the authors postulate that age and joint stability are important factors predisposing to inferior dislocation. Hence, elderly patients, individuals with pre-existing rotator cuff tears or patients with a history of previous dislocation may be more susceptible to LEH. For younger patients, inferior dislocation may occur in incidents involving a higher velocity on impact.

**Fig. 5** **a** Coronal PD FS (TR/TE 2,150/35) and **b** sagittal PD FS (TR/TE 1,900/28 ms) images of the right shoulder reveal bone marrow contusions in the superior aspect of the right humeral head (*long arrow*) and the posterosuperior glenoid fossa (*short arrow*). This is consistent with the impaction from hyperabduction seen in luxatio erecta



## Radiographic features

Although clinical diagnosis of bilateral LEH can be made confidently, imaging is usually required to confirm the diagnosis and to assess for potential complications. Anteroposterior shoulder radiographs of our case demonstrate typical features of LEH with the humeral head at or below the inferior rim of the glenoid or sub-coracoid in location, and the humeral shaft abducted and oriented almost parallel to the scapular spine [12]. LEH can mimic anterior shoulder dislocation as the humeral head can be projected at or below the inferior glenoid rim in both cases. The latter shows an adducted humeral shaft, which forms an acute angle to the scapular spine.

Systematic reviews found five publications describing MRI features of inferior shoulder dislocation (Table 1) [2, 4, 8, 13, 14]. Up to 80% of luxatio erecta is associated with other injuries such as fractures, soft-tissue injury and neurovascular deficit [6]. The associated fractures may involve the proximal humerus, greater tuberosity fracture being the most common with a reported incidence of up to 60% [2]. Impaction fracture of the humeral head against the inferior glenoid may be seen simulating a Hill–Sachs lesion; however, this is located more superiorly and laterally than a typical Hill-Sachs lesion which is usually at the posterolateral surface [9]. Computed tomography (CT) is a better tool than plain radiographs to evaluate for associated occult fractures. CT 3D reconstruction is useful for pre-operative planning in cases with complex fracture–dislocation. CT scan was not performed in our case because there was no radiographic evidence of a fracture.

Other than bony injury, LEH is associated with various soft-tissue injuries such as rotator cuff tear, inferior capsular and ligamentous tears, and neurovascular injury. MRI is an excellent modality for establishing the extent of soft-tissue injuries. Up to 75% of adult patients with luxatio erecta were reported to have rotator cuff injuries on MRI [8]. In the scenario of LEH with rotator cuff injury, none of the cases were reported to have greater tuberosity fracture [7, 14, 15]. Stensby and Fox concluded that avulsion fracture of the greater tuberosity tends to spare the rotator cuff from tearing and vice versa. The hypothesis [8] was affirmed in our case, which revealed fairly extensive bilateral soft-tissue injuries (rotator cuffs and IGHL tearing) in the absence of a fracture.

Magnetic resonance imaging is excellent at evaluating the neurovascular structures around the shoulder after reduction of LEH [16]. The quadrilateral space is a compartment located just inferior to the shoulder joint, and is an important location because it contains the axillary nerve and the posterior circumflex humeral artery. MRI can demonstrate the absence of normal flow voids in the axillary or posterior circumflex humeral arteries, which may represent vascular injury such as acute thrombosis or dissection. Although vascular injury of the axillary artery is rare, it is seen more frequently in inferior glenohumeral dislocation compared with other forms of

shoulder dislocation, making it a vital structure to be evaluated by the radiologist. None of the referenced MRI-based studies described neurovascular complication in inferior shoulder dislocation. A recent review on LEH revealed that 29% of the patients were found with neuronal injury post-dislocation and vascular injury was detected in 10% of the patients [3]. Groh et al. reported that out of 18 shoulders with inferior dislocation, 6 had axillary nerve injury [5].

As shown in our case, the axillary nerve is visible on MRI and is best evaluated in the sagittal plane with T2-weighted fat-suppressed or short tau inversion recovery (STIR) sequences. The nerve can be examined to look for thickening, signal hyperintensity or transection, although the presence of marked oedema and haemorrhage can obscure this structure. Risk factors for axillary nerve injury in shoulder dislocation include the presence of humeral or scapular fractures, vascular injuries, delay in reduction for more than 2 h, neurological deficits and neuropathic pain [17]. In our case, the axillary nerves were seen traversing through the quadrilateral spaces in both shoulders. However, the left axillary nerve is visibly swollen compared with the right secondary to traumatic neurapraxia. This important MRI observation must be conveyed to the clinician and requires attention on follow-up, especially when no neurological deficit was documented initially. Knowledge of nerve injury helps to formulate a treatment plan and to manage patient expectations of the course of clinical recovery.

## Management

Treatment of LEH is largely successful, with good or excellent results in 83% of the shoulders [5]. Most cases can be treated with closed reduction as their definitive management. Adequate analgesia along with muscle relaxation and conscious sedation play important roles in closed manipulation and reduction. It eases muscle tension, avoids undesirable complications such as neurovascular injury and ensures patient safety during the procedure [18, 19].

Although LEH can usually be reduced under closed manipulation and reduction, there are a few reported cases that required reduction under general anaesthesia and/or further operative measures. A few causes of irreducibility have been identified:

1. The presence of concurrent forearm fracture hampering adequate traction during reduction [20].
2. Entrapment of the humeral head in a button-hole defect through the inferior joint capsule and surround soft-tissue envelope [20]. Open reduction required widening of the button-hole while protecting the axillary neurovascular bundle.
3. A rare reported case of an aberrant axillary nerve impeding a closed reduction of LEH [21].

**Table 1** A summary of the literature review on the MRI findings of luxatio erecta humeri

Studies (number of cases with MRIs/MRAS)	Site of pathological conditions						
	Age/gender	Rotator cuff	Long head of the biceps	Glenoid labrum	Joint capsule/humeral ligament	Articular cartilage	Bone
Hassanzadeh et al. [2] (4)	81/female	Full-thickness retracted tears of SS and IS tendons with muscular atrophy	Intact	Non-displaced anteroinferior tear	Chronic injury of IGHL (anterior and posterior band)	Intact	NS
	49/male	Full-thickness retracted tears of SS and IS tendons without muscular atrophy; high-grade partial-thickness tear of SC tendon	Intact	Mildly displaced antero-inferior tear	Humeral avulsion of IGHL (anterior and posterior band)	Anterior glenoid cartilage defect	Bone marrow oedema
	23/male	Intact	Intact	Chronic displaced antero-inferior tear	Intact	Antero-inferior full-thickness glenoid defect	Impaction fracture of humeral head, antero-inferior glenoid fracture
	33/male	Intact	Intact	Chronic displaced antero-inferior tear, ALPSA	Intact	Intact	Impaction fracture of humeral head, antero-inferior glenoid fracture
Krug et al. [14] (4)	53/male	Full-thickness retracted tears of SS and IS tendons; tear of SC tendon	<sup>b</sup> One patient had complete tear of LHBT Dislocation of a partially torn LHBT	Tear of superior labrum	Injury of IGHL (anterior band); humeral avulsion of the IGHL (posterior band)	<sup>b</sup> One patient had glenoid cartilage defect NS	Bone marrow contusion of superior lateral humeral head
	74/female	Full-thickness retracted tears of SS and IS tendons; SC tendinosis	NS	Antero-inferior and posterior labral tears	Injury of IGHL (anterior and posterior band)	NS	Normal
	69/male	Small full-thickness tear of SS tendon; partial-thickness tear of IS tendon; SC tendinosis	NS	Antero-inferior and superior labral tears; posterior labral injury	Intrasubstance tears of IGHL (anterior and posterior band)	NS	Normal
	33/male	Normal	NS	Detachment and tear of anterior inferior labrum; posterior labroligamentous tear	Glenoid labral avulsion of IGHL (anterior band); injury of IGHL (posterior band)	NS	Impaction fracture of superior lateral humeral head
Stensby and Fox [8] (1)	15/male	Intact	NS	NS	NS	Humeral avulsion of IGHL (anterior and posterior bands)	Greater tuberosity fracture
<sup>a</sup> Karaoglu et al. [4] (1)	70/male	Complete tears of bilateral SST	NS	NS	NS	NS	NS
<sup>a</sup> Mohseni [13] (1)	18/male	NS	NS	Superior and inferior labral tear	NS	NS	NS

*SS* supraspinatus, *IS* infraspinatus, *SC* subscapularis, *LHBT* long head of biceps tendon, *ALPSA* anterior labroligamentous periosteal sleeve avulsion, *IGHL* inferior glenohumeral ligament, *NS* not specified

<sup>a</sup>No MR images are available for studies by Karaoglu et al. [4] and Mohseni [13]

<sup>b</sup>Two patients with LHBT tear and glenoid cartilage defect are not included in the table, but are described in the body of the paper by Krug et al. [14]

Surgical treatment such as shoulder hemi-arthroplasty, capsular reconstruction and/or rotator cuff repair are reserved for patients with recurrent instability secondary to rotator cuff and IGHL tears, open dislocation or humeral head fractures [5].

Neurovascular injury is not uncommon, axillary nerve injury being the most frequent and accounting for nearly 30% of recurrent instability. Neurapraxia or low-grade axonal injuries demonstrate good functional recovery within 3 to 6 months. High-grade axonal injuries and ruptures have a poor prognosis. Early detection and intervention such as surgical exploration and grafting, will be the key to improving the outcome. A salvage nerve transfer can be considered, should the previous options fail [17].

## Conclusion

Bilateral luxatio erecta humeri is rare and, to our knowledge, this is the first MRI description of acute soft-tissue injuries in the immediate post-reduction period and the first MRI documentation of post-LEH axillary nerve injury. Bilateral LEH is an important entity to recognise because of the potential musculoskeletal and neurovascular injuries. The prognosis of the latter is directly influenced by early diagnosis and successful reduction of shoulder dislocation. Although MRI is neither essential nor feasible in the emergency setting, we suggest that MRI might be performed early after LEH reduction. MRI can provide vital information to direct treatment and to advise on the prospect of functional recovery. The findings on MRI, together with risk factors for axillary nerve injury, may alert the clinician and initiate an early referral to a specialist centre for further management.

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## Compliance with ethical standards

**Conflicts of interest** The authors declare that they have no conflicts of interest.

**Ethical treatment of human/animal subjects** Not applicable.

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