



## Luxatio erecta of the humerus: the spectrum of injury of inferior shoulder dislocation and analysis of injury mechanisms



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Erecta dislocation/inferior dislocation of the shoulder is considered an uncommon injury and the present knowledge stems from case reports or compilation of cases. We believe that there are reasons to believe that the injury is much more prevalent than previously stated. In this review, we discuss the mechanism of injury and based on the number of patients with unusual injury patterns at our hospitals and in the literature, the anatomical features of different variants of inferior dislocation are described. Only a few patients present with their arm still locked in abduction, and most patients with initial inferior dislocation are diagnosed with other types of dislocation or injury. Irreducible dislocation, with tissue blocking the glenoid appears to be a consequence typical of an initial inferior dislocation. Nerve and vascular injuries are overrepresented, as are humeral avulsion glenohumeral ligaments-injuries. The description of shoulder dislocations should ideally include the dislocation path and not only the final position of the humeral head.

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Luxatio erecta of the humerus (LEH) is said to be an uncommon lesion, considered to represent less than 1% of all anterior glenohumeral dislocations and the term is used synonymously with “inferior dislocation” (ID). Through the years numerous case reports have been published, including a long-term follow-up of 16 cases by Groh et al.<sup>8</sup> At our hospitals we encounter only a few cases of LEH per year, that is, patients who present with their arm locked in elevation. However, we believe that ID is much more prevalent than reported and that true erecta dislocations represent only a subset of ID since the arm may escape from its erect position or fail to lock in the first place. For the arm to stay locked in abduction, the surrounding tissues must have enough strength to withstand the downward pull of the arm from the moment of injury to the presentation at the hospital. It may be assumed that the locked, abducted state is seen in a minority of patients with ID, and that other patients may present either with a reduced dislocation or a dislocation of what appears to be of a more common type, anterior or posterior. However, after an ID, the shoulder is likely to have suffered a spectrum of injuries, of which several are typical for the mechanism involved in ID.

In this review, we will discuss the mechanism of injury including the typical radiographic signs and clinical features (Table I) of different possible variants (Table II) of inferior dislocation of the shoulder. For illustration of the injury panorama, a collection of some recent cases has been summarized in Table III.

### Mechanism of injury

The typical glenohumeral dislocation, whether anterior or posterior, is a dislocation within the envelope of the cuff. Depending on the nature of the force, the capsule may be peeled off the glenoid (anterior labral periosteal sleeve avulsion, ALPSA-lesion), with or without the labrum or its bony attachment. The humeral head ends up resting in pocket between the glenoid neck and the posterior or anterior cuff/capsule. The close contact between the humeral head and the glenoid rim frequently results in a Hill-Sachs lesion and/or glenoid rim fracture. In severe cases, the Hill-Sachs indentation may have an extension, occasionally causing a fracture of the tuberosities and/or the anatomical neck. These fractures are sometimes first noticed after a failed reduction attempt that leaves the humeral head dissociated from the shaft.<sup>23</sup> As long as the humeral head resides within the cuff, the surrounding soft tissues are relatively protected from direct impact by the humeral head and the position of the head is moderately medialized.

ID typically occurs when the patient tries to break a fall with the arm outstretched and elevated. The head of the elevated/abducted

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**Table I**  
Typical clinical and radiological (on plain radiographs and more obvious on CT scans) signs suggestive of inferior dislocation.

- The humeral head far medial to the base of the coracoid
- Possible fracture of the tip of the coracoid
- Superior Hill-Sachs lesion
- GT fracture displaced distally
- Robinson 3b valgus fracture
- Signs of tissue interposed in the joint
  - Absence of posterior Hill-Sachs lesion in “anterior” dislocation
  - Lateral view, Velpeau view: visible distance between anterior glenoid edge and humeral head
  - Tuberosities positioned inside the joint
  - Humeral-glenoid joint incongruent after “successful” reduction
- Clinical sign of extensive soft tissue injury
  - Reduction difficult or impossible
  - Nerve injuries
  - Vascular injuries
  - Cuff dysfunction after reduction

CT, computed tomography.

**Table II**  
Proposed staging of inferior dislocation of the shoulder.

Stage 1, humeral head inside cuff
1a Locked erecta dislocation
1b Spontaneously reduced dislocation, signs of erecta dislocation
1c Apparent anterior or posterior dislocation
Stage 2, humeral head outside cuff
2a Anterior/posterior dislocation, tissue interposition, reduction possible
2b Anterior/posterior/lateral dislocation, tissue interposition, reduction not possible
Stage 3 Head outside tissue envelope, fracture with valgus impaction

humerus is forced downward, between the inferior edges of the anterior and posterior rotator cuff, into the soft axillary pouch. In this position, the humeral head is incompletely covered by the

**Table III**  
Recent patients with inferior dislocation.

Case	Stage	Sex	Age	Fractures	Cuff	Nerve	Reduction attempts	OP
1	1a	F	66	GT			1	
2	1a	F	92	GT		rad	1	
3	1a	F	55	GT		ax	2	GT fix
4	1a	F	80	GT			1	GT fix
5	1a	M	61	GT	complete	rad	1	
6	1a	M	52		ssp	extensive	1	cuff repair
7	1b	M	59	GT	complete		1	cuff repair
8	2a	F	66		ssp, isp		3	
9	2a	F	54		ssp, ssc	ax	1	cuff repair
10	2a	M	66				2	
11	2a	M	58		ssc, ssp	med, uln	1	
12	2a	M	89				3	
13	2a	F	66				1	
14	2a	M	48		complete			cuff repair
15	2b	M	73		complete	med	failed	rTSA
16	2b	F	74		complete		failed	rTSA
17	2b	F	74		complete		failed	rTSA
18	3	F	60	4p valgus				rTSA
19	3	F	66	3p valgus			2, head separated	rTSA
20	3	F	87	4p valgus		med	2	rTSA
21	3	F	54	4p valgus		med, axill	1, head separated	rTSA
22	3	F	85	4p valgus		rad	0	rTSA
23	3	F	70	4p valgus			2, head separated	rTSA
24	3	F	84	4p head, separation		ax	0	HSA
25	3	F	82	4p valgus			2, head separated	rTSA
26	3	F	74	4p valgus			0	rTSA

Observed fractures (greater tuberosity (GT) or ¼ part valgus fractures), cuff injuries (supraspinatus (ssp), infraspinatus (isp), subscapularis (ssc)) and nerve injuries (radial (rad), ulnar (uln), median (med), axillary (ax)) and performed surgery (OP) (reverse shoulder arthroplasty (rTSA)) listed. Due to medical reasons, some patients did not have surgery despite their cuff injuries.

rotator cuff (Fig. 1, A) and little additional force is required for the head to exit the joint. In the typical situation of an ID locked in abduction, the lateral aspect of the humeral head is locked against the inferior glenoid rim with potential associated injuries to the supraspinatus insertion or depression fractures of the superior aspect of the greater tuberosity (Fig. 1, B). If the dislocation progresses, the humeral head may completely escape from the cuff and advance further in the medial direction, causing considerable damage to surrounding tissue by traction or direct impact.

**Staging of LEH**

*Stage 1a (locked erecta dislocation)*

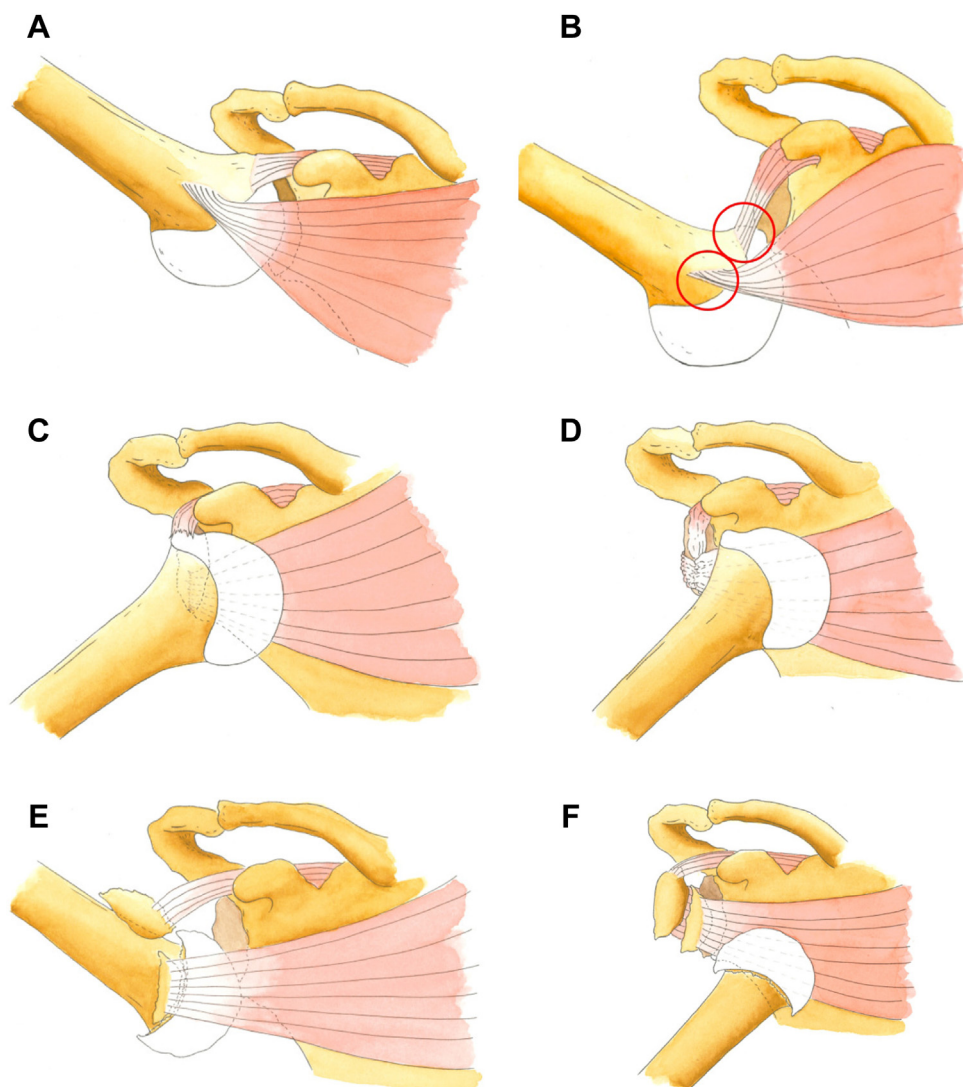
Arm in elevation/flexion with humeral head locked against the inferior glenoid rim. Superior fractures of the greater tuberosity are likely (60%<sup>18</sup>) as well as tears of the inferior portions of the rotator cuff and glenohumeral ligaments. (Fig. 1, B)

*Case 3*

A 55-year-old woman fell on her outstretched arm. Radiographs revealed a luxatio erecta with a distally depressed fracture of the greater tuberosity (GT). The shoulder was reduced with longitudinal traction. At surgery within 2 weeks the GT/supraspinatus was fixed; no additional cuff injuries were observed. (Fig. 2, A and B)

*Stage 1b (reduced dislocation, superior Hill-Sachs lesion, depressed GT)*

Transient inferior dislocation with spontaneous reduction of the humeral head, thus avoiding the locked erecta position. Injuries to the shoulder (inferior glenoid rim fragment, superior Hill-Sachs, depressed GT fragment, partial cuff rupture—typically of the inferior part of the subscapularis or infraspinatus, may go undiagnosed and the nature of the injury not fully clarified.



**Figure 1** Drawings of the shoulder during different phases of motion and dislocation. (A) Abducted arm, head partly exposed below the subscapularis. (B) Locked erecta dislocation. Supraspinatus and inferior subscapularis are severely stretched. (C) Apparent anterior dislocation, but the humeral head has emerged anterior to the avulsed subscapularis. (D) Similar situation as in (C), but entire rotator cuff avulsed and collapsed on the glenoid. (E) In the abducted position a valgus fracture is possible in the elderly. (F) Apparent anterior dislocation, but the humeral head is anterior to the avulsed subscapularis. The glenoid is blocked by avulsed tuberosities and rotator cuff. Drawings by Åsa Ekholm.

*Case 7*

A 59-year-old male fell forward while skiing. Initial radiographs showed a depressed small GT fracture but a congruent joint. An additional computed tomography (CT) scan demonstrated a small posterior avulsion of the GT. Active shoulder motion appeared restricted and the injury suggestive of an ID. At surgery five days later, the humeral head was found completely denuded. Although still intact in its components, the entire cuff was completely avulsed from the insertion as one unit (Fig. 3).

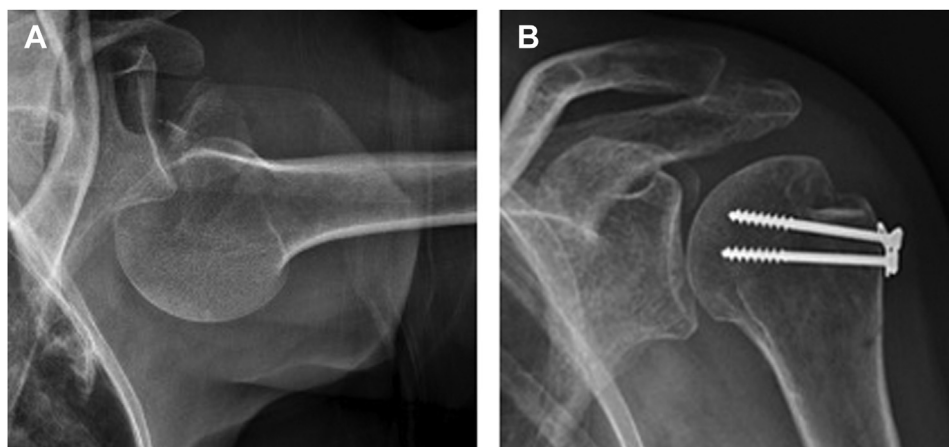
*Stage 1c (hypothetical)*

Similar to Stage 1b, but the head has recoiled from inferiorly and assumed the position of anterior or posterior dislocation, inside the cuff. In such cases, ID will be difficult to verify but the mechanism is nevertheless possible. Indeed, some authors have suggested a two-stage technique to relocate the humeral head in a fixed erecta dislocation, the first step of which is to shift the humeral head from the subglenoid position to that of an anterior dislocation.<sup>19</sup> If this

relocation can be performed manually, a similar process may occur spontaneously. Various degrees of cuff tears could accompany this stage.

*Stage 2a (head anterior to the subscapularis, rotator cuff not completely detached, closed reduction possible)*

When the arm is abducted, the dislocated humeral head will be partly exposed below the inferior edge of the subscapularis. From this position, especially if the subscapularis is partly ruptured, the head may displace anteriorly under the inferior edge of the subscapularis. The humeral head will now be outside the confinements of the cuff and unrestrained by the subscapularis it is often displaced more medial than seen with an intracapsular dislocation and may come to rest close to the brachial plexus. The interposition of the subscapularis between the humeral head and the glenoid can be visualized on plain X-ray lateral view or Velpeau view as a distance between the glenoid and the humeral head. In this injury, reduction may still be possible if the humeral head is first brought



**Figure 2** Stage 1a: 55-year-old female. (A) Initial appearance. (B) Post closed reduction and fixation of typically depressed greater tuberosity.



**Figure 3** Stage 1b: 59-year-old male, fell on outstretched arm, had a sensation of shoulder dislocating. Initial appearance, indirect signs of transient inferior dislocation, at surgery found to have extensive cuff injuries.

under the inferior edge of the subscapularis and then back into the joint. (Fig. 1, C)

A similar injury with the head dislocated posteriorly under the edge of the infraspinatus and the infraspinatus/supraspinatus interposed into the joint is also possible.<sup>12</sup>

#### Case 12

An 89-year-old male fell outside his grocery store on an outstretched arm. He presented with shoulder pain and radiographs showed what were perceived as an anterior dislocation. Kocher reduction was attempted both in the emergency department and under anesthesia but failed. Scrutiny of the radiographic Y-view showed a distance between the anterior glenoid edge and the humeral head indicating soft tissue interposition. A CT scan confirmed the findings. The shoulder could then be easily reduced by longitudinal traction of the humerus followed by manipulation of the humeral head in under the inferior edge of the subscapularis (Fig. 4, A-C).

#### Stage 2b (complete avulsion of the rotator cuff, closed reduction not possible)

When the entire rotator cuff is completely detached, with or without tuberosity fragments, but not ruptured between its components, emptied of the humeral head, it will collapse as a sleeve across the glenoid. Closed reduction of the humeral head is not possible since manipulation of the arm is unable to open the cuff enough to allow reintroduction of the head. After a relocation attempt, the head may appear to be reduced into the joint; however, due to the interposed rotator cuff, the glenohumeral joint is not perfectly congruent, and the head may even appear in a position lateral and superior to the glenoid. (Fig. 1, D)

#### Case 16

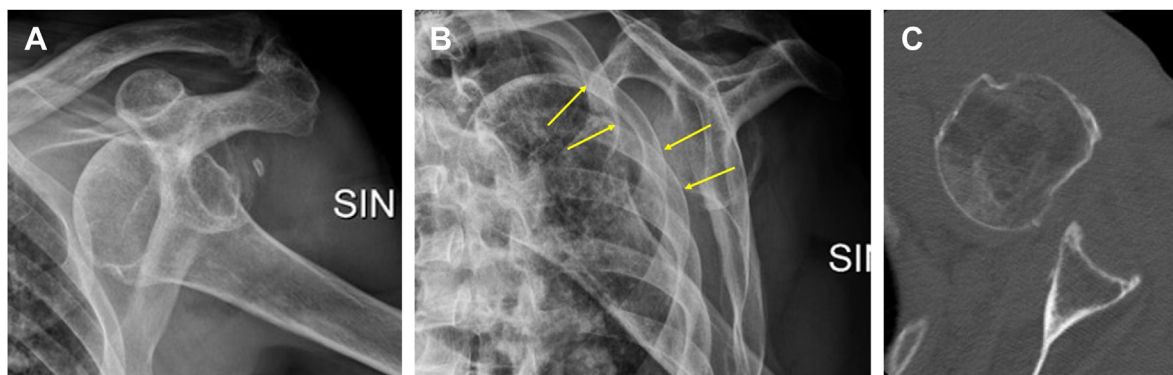
A 74-year-old woman presented after a fall at home on her outstretched arm. X-ray examination showed anterior dislocation, the humeral head medial to the coracoid. Reduction was successful but “indistinct” although the humeral head appeared to be in the joint. CT the next day showed subscapularis interposition and another reduction was tried but failed. Magnetic resonance (MR) examination demonstrated gross rotator cuff interposition with the humeral head completely outside the cuff. She later received a reverse shoulder arthroplasty (Fig. 5, A-D).

#### Stage 3 (valgus fracture and head anterior to the subscapularis with complete avulsion of the rotator cuff, with or without tuberosity fragments)

This scenario has been described by Robinson et al.<sup>23</sup> They describe a valgus impacted proximal humerus fracture combined with an anteroinferior dislocation through the axillary fold where the head comes to rest anterior to the subscapularis (Robinson stage 3b). In Robinson stage 3c, the head has become separated from the shaft, either by the trauma itself or iatrogenically by a failed reduction attempt. Such dislocations are facilitated by the head displaced into valgus position offering less resistance to inferior dislocation. (Fig. 1, E and F)

#### Case 18

A 60-year-old teacher tripped on a cord in the classroom and tried to break her fall with her outstretched arm. Presented as anterior dislocation, the head was impacted in valgus and the tuberosities visible lateral to the glenoid. Reduction was attempted but unsuccessful. CT demonstrated the humeral head outside the



**Figure 4** Stage 2a: 89-year-old male. (A) Initial presentation, AP-view. (B) Initial presentation, lateral view, typical distance between humeral head and glenoid rim (indicated with arrows). (C) Subscapularis interposition verified by CT. CT, computed tomography.

rotator cuff, tuberosities and cuff blocking the glenoid. Reverse shoulder arthroplasty was performed a few days later. (Fig. 6, A-E).

## Discussion

LEH was first reported with the description of two cases by Middeldorpf<sup>17</sup> in 1859, and later followed by cadaver experimental work performed by his assistant Scharm.<sup>25</sup> In 1921 Lynn had collected 18 cases from the literature and added another 3 of his own.<sup>13</sup> Already at this time, it was known that with the force required to produce an LEH, concomitant injuries such as tears of the rotator cuff or fracture of the GT, and occasionally injuries to nerves and vessels, were common. The condition is rare and bilateral dislocations even more so. Nambiar et al (2018)<sup>18</sup> in their review identified 199 published cases, of which 29 were bilateral. From this time on, the literature on LEH consists predominantly of case reports or reports on collections of a limited number of cases. In recent years, two compilations of cases from the literature have been published.<sup>8,18</sup> All the reported patients had undergone plain X-ray examination, and the few patients who had a subsequent CT, MR imaging, or CT arthrograms may not be representative of all LEHs. Associated soft tissue injuries have neither been systematically assessed with modern imaging techniques nor described. The age of the average LEH patients, 44 years,<sup>18</sup> is not clearly different from the age of the patients with anterior dislocation, 47.6 years.<sup>24</sup>

Almost 50% of all dislocations are dislocations of the glenohumeral joint.<sup>2</sup> These dislocations are usually divided into anterior, posterior, or inferior dislocations according to the position of the humeral head at examination. In traumatic shoulder dislocations, the normal balancing muscle forces across the joint must be overcome by an external force, as when trying to break a fall by the parachute reflex. The direction of the initial dislocation is determined by the position of the humerus relative to the glenoid at the time of impact and the forces across the joint, but the resting position of the humeral head depends on the nature of the associated soft tissue injury and possible concomitant fractures. An anterior or posterior final position of the humeral head does not preclude initial inferior dislocation mechanism. However, the most reasonable explanation for the interposition of the rotator cuff, with or without fragment of the tuberosities, is by initial inferior dislocation as shown in Figure 1. The subglenoid position is also highly suggestive of an ID

## Fractures

In the review of 199 patients with LEH, 39% of the patients had a concomitant proximal humeral fracture,<sup>18</sup> 75% of these fractures

were fractures of the GT. These numbers are similar to those reported by Mallon et al.<sup>16</sup> In our case series (Table 1), 6 of 7 patients with locked inferior dislocation also had a fracture of the greater tuberosity, apparently from the contact with the inferior glenoid. In the review by Nambiar et al,<sup>18</sup> scapular fractures were noted in 8% of the patients but only one patient had an acromial fracture, which probably is the same patient as previously reported in the series by Mallon.<sup>16</sup> If the dislocation mechanism involves levering against the acromion, it is surprising that acromial fractures are this rare, and the mechanism of inferior dislocation may not regularly involve this mechanism.

## Cuff and capsular injuries

All our 10 patients with ID stage 2 (rotator cuff avulsion) (Table 1) appeared to have an anterior dislocation but none had a fracture of the tuberosities. The fact that the head was anterior to the subscapularis, as visible on the lateral view, was usually overlooked and reduction typically more difficult than expected and in one case the humerus was left dislocated. Robinson et al reported that 10% of patients with acute anterior dislocation also had sustained a cuff injury.<sup>24</sup> In the reports on soft tissue injury associated with anterior dislocation,<sup>10,24,32</sup> it is reasonable to believe that several of the included injuries are IDs (Stage 1c or 2). The incidence of cuff tears in combination with ID is not known but is probably considerable higher.

In anterior dislocations, the ligament injury is usually on the glenoid side (ALPSA-lesion) and humeral sided lesions (humeral avulsion glenohumeral ligaments - HAGL) are seen in less than 10% of patients with recurrent instability.<sup>4</sup> In a retrospective study on 1000 consecutive MR investigations performed for shoulder pain, only 23 (2.1%) of the 743 patients who later underwent surgery were found to have a HAGL lesion.<sup>14</sup> Bokor et al found that in patients undergoing surgery for recurrent instability 7% had a HAGL injury.<sup>3</sup> Of these, 43% also had injury to the cuff, in contrast to the 1.9% with a cuff injury in the non-HAGL group. The suggested mechanism of HAGL injuries is hyperabduction,<sup>20</sup> similar to the mechanism of ID. This seems to be in line with the observation that the glenohumeral ligament injury in IDs always appears to be on the humeral side, the ligaments being avulsed with the rotator cuff. In our case series, the inferior part of the subscapularis is more often injured than the superior parts, which could be understood from how the subscapularis is stretched during forceful abduction and the injury corresponds to humeral avulsion of the inferior glenohumeral ligament.



**Figure 5** Stage 2b: 74-year-old female. (A) Initial presentation. (B) Post reduction, imperfect congruency. (C) CT verified tissue interposition. (D) MR after attempted rereduction, gross interposition of the rotator cuff. CT, computed tomography; MR, magnetic resonance.

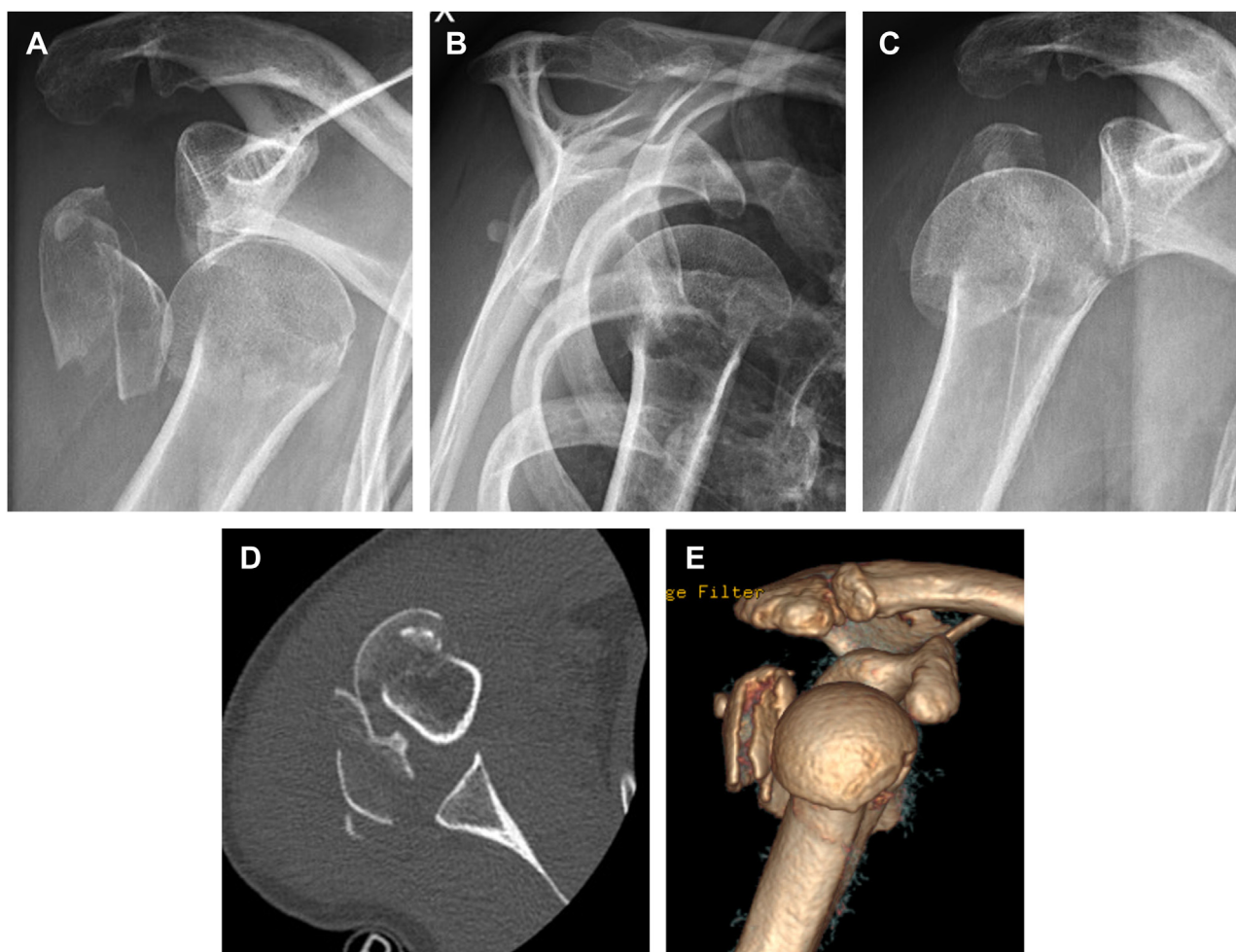
### Nerve injuries

Nerve injuries associated with shoulder dislocation is believed to occur mainly by traction when the nerve is stretched during dislocation. When the humeral head is outside the protective rotator cuff, as in inferior dislocation, the injury mechanism may also involve direct impact.

In a review of 3633 patients with acute anterior dislocation, Robinson et al reported that 13.5% of the patients had a neurologic deficit, usually transient and commonly of the axillary nerve.<sup>24</sup> Of the patients with neurological deficit, 57% also had a GT fracture and 30% of the patients with GT fractures had neurological deficit. It is not clear what proportion of these patients had a possible ID, stages 1c-2. In a review of inferior dislocations, the proportion of nerve injuries was higher: 59% of the 80 cases had some degree of nerve injury,<sup>16</sup> the axillary nerve most commonly affected. In a multicenter study on nerve lesions after shoulder dislocations, Tiefenboeck et al found that the direction of dislocation, anterior,

posterior, or inferior, did not appear to influence the rate of nerve injuries.<sup>31</sup> Interestingly though, in their case series of patients with nerve injuries after shoulder dislocation, inferior dislocation was much more prevalent (17%) than normally would be expected.<sup>31</sup> In our series of 27 patients, 11 had clinical signs of nerve injury, which was found to be transient in all cases (Table III). It is not unlikely that a large proportion of the nerve injuries reported after anterior dislocation could be explained by an ID mechanism and that the incidence of concomitant nerve injuries in pure anterior dislocations is lower than reported.

In an illustrative case by Frank et al,<sup>7</sup> the patient had an irreducible inferior dislocation. During exploration, in addition to rotator cuff injuries, the axillary nerve was found anterior to the humeral neck. The only explanation for this unusual situation is that the humeral head has moved like a crochet-hook, from an inferiorly displaced position, up posteriorly to catch the nerve. The similar mechanism could explain how the musculocutaneous nerve was trapped behind the humeral head in another case of irreducible anterior dislocation.<sup>9</sup>



**Figure 6** Stage 3: 60-year-old woman. (A) Initial presentation, AP-view. (B) Initial presentation, lateral view. (C) After attempted reduction. (D) CT demonstrates cuff and tuberosities blocking access to the glenoid surface. (E) 3D reconstruction. CT, computed tomography; 3D, 3-dimensional.

### Vascular injuries

Vascular injuries caused by closed shoulder dislocations are rare and reported to represent less than 1% of vascular injuries around the shoulder when a fracture is not present,<sup>30</sup> and predominantly involves the axillary artery. The injury is believed to be caused by stretch or shear of the artery and is more common in the elderly with less compliant vessels. In cases of inferior dislocations, additional modes of arterial injury are possible and vascular damage is probably more common than in anterior dislocations.

A few reported cases are illustrative. A patient described by Shah et al<sup>28</sup> had sustained an avulsion of the humeral circumflex artery after an “anterior dislocation.” However, on the prereluction radiograph, it is apparent that soft tissue is interposed between the humeral head and the glenoid, which makes inferior dislocation with subscapular avulsion a more plausible mechanism of injury. Similarly, Magister et al described a 50-year-old patient with “anterior dislocation” and axillary artery injury.<sup>15</sup> On the prereluction radiograph also in this case, soft tissue appears interposed between the humeral head and the glenoid. An unusually young patient was described by Chehata et al who had an “anterior dislocation.”<sup>5</sup> The 17-year-old boy had in addition to an injury of the axillary artery also a complete avulsion of the cuff and the authors presumed that these injuries were the consequences of an initially inferior dislocation.

### Irreducible dislocation

There are several reports on patients with “irreducible” shoulder dislocations in patients appearing to have either anterior or posterior dislocations. In a few cases, the shoulder appears subluxated and the joint space widened with the humeral head slightly lateral and cranial.<sup>1,6,11,12,21,22,26,27,29,33</sup> In many of these reports the deformity is called “posterior dislocation”, but the humeral head has not been engaged against the glenoid. The common obstacle to reduction in these shoulders is the interposition of the rotator cuff, with or without tuberosity fragments. Although the mechanism of injury has not been clarified in these papers, the majority involves high energy trauma, typically motorcycle or bicycle. We believe that many of these injuries were the results of an initial ID, but that the humeral head, more or less denuded, later assumed the position seen on the X-ray films.

### Conclusion

The common description of shoulder dislocation is based on the position of the humeral head at examination but does not reflect the injury mechanism or position of exit for the humeral head. The incidence of ID is therefore underestimated and since only few patients present with an actual locked erecta dislocation, the majority is diagnosed with other forms of dislocations, anterior,

posterior, and lateral. Radiographs should always be examined for signs of tissue interposition as this indicates an ID and reduction will be difficult or impossible. The likelihood of accompanying injuries to the rotator cuff, nerves, and vessels injuries is high. When injured, the glenohumeral ligaments are typically avulsed from the humerus (HAGL injury). The available literature does not allow further epidemiology of these injuries since most publications are case reports. However, the injury may occur in patients of any age, from children to the elderly. The possibility of an ID should always be evaluated when treating shoulder dislocations since the injury could be extensive.

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