

Understanding shoulder pseudoparalysis: Part I: Definition to diagnosis

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- Variable definitions of pseudoparalysis have been used in the literature.
- Recent systematic reviews and biomechanical studies call for a grading of loss of force couple balance and the use of the terms 'pseudoparesis' and 'pseudoparalysis'.
- Pain should be excluded as the cause of loss of active function.
- Key players for loss of force couple balance seem to be the lower subscapularis as an anterior inferior checkrein and the teres minor as a posterior inferior fulcrum.
- Loss of three out of five muscle–tendon units counting upper and lower subscapularis separately is predictive of pseudoparalysis.
- Shoulder equator concept: loss of all three posterior, or all three superior, or all three anterior muscle–tendon units is predictive of pseudoparalysis (loss of fulcrum for deltoid force).
- Every effort should be made to prevent propagation of rotator cuff tears into the subscapularis and posterior rotator cuff (infraspinatus and teres minor) to maintain force couple balance (value of partial cuff repair).
- Clinical assessment of active forward elevation, active external rotation, and active internal rotation is important to define and grade the severity of loss of force couple balance.
- Additional features such as patient age, traumatic aetiology, chronicity, fatty infiltration, and stage of cuff tear arthropathy are useful for a specific diagnosis with implications for treatment.

Keywords

- ▶ shoulder
- ▶ arthroscopy
- ▶ pseudoparalysis

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Introduction

The definition of the term “shoulder pseudoparalysis” remains controversial amongs clinicians (1), with regards to the degree and direction of impaired active shoulder motion, chronicity, whether it is traumatic or atraumatic, and whether the loss of active motion is influenced by pain. There is further debate as to the role and indications for specific non-operative and operative treatments. The variety of definitions for pseudoparalysis found in the literature (1, 2, 3, 4) may include additional features that characterize the different syndromes with impaired force couple balance. These syndromes have implications for potential treatment options, which may include physiotherapy, cuff repair, capsular reconstruction, tendon transfers, arthroplasty, or a combination of these options to restore function. The goal of this review was to clarify the definition of pseudoparalysis and pseudoparesis based on the current literature and to delineate the clinical manifestations as well as the underlying anatomical

structural lesions and biomechanical rationales for both entities. There is increasing evidence for the theory that the lower subscapularis is a key player for pseudoparalysis (5). A differentiated physical examination and thorough evaluation of imaging modalities are important to reach a clear diagnosis.

Definition

Historically, Rössler as well as Gschwend and Patte used the term ‘pseudoparalysis’ in the 1970s and 1980s to describe limited or absent active shoulder movement associated with rotator cuff tears without neurological impairment (6, 7). In recent years, the most widely used definition of shoulder pseudoparalysis has been active forward elevation (AFE) of less than 90° with preserved passive range of motion (ROM) in the setting of a massive rotator cuff tear without neurological impairment (3). However,

a frequently quoted benchmark article by Gerber’s group described reduced AFE of less than 90° more correctly as pseudoparesis, implying the maintenance of some AFE (2). Some authors therefore recommend defining pseudoparalysis as AFE of less than 45° with preserved passive ROM and chronic onset, without a recent traumatic event (4). In a consensus statement developed by Hawkins, eight international leaders in the field of shoulder surgery defined ‘real pseudoparalysis’ as no active elevation with maintained passive elevation, chronic in nature, and usually with anterior–superior escape with no improvements in active elevation after pain-relieving injections (1).

To consider appropriate management options, it is therefore important to distinguish two conditions of impaired AFE:

- (1) AFE pseudoparesis as already defined by Gerber’s group (1, 2) (Fig. 1A; massive rotator cuff tear; <90° of active elevation with full passive elevation and no anterior–superior escape; and pain eliminated with local anaesthetic injection).
- (2) AFE pseudoparalysis (1) (Fig. 1B; massive rotator cuff tear; 0° of active elevation and full passive elevation usually with anterior–superior escape; and pain eliminated with local anaesthetic injection).

For impairment of active external rotation (AER), two conditions must be separated (1):

- (1) AER pseudoparesis (Fig. 2A and B; tested in 20° of abduction (8); active external rotation (ER) to neutral with full passive ER lagging back to neutral; and pain eliminated with local anaesthetic injection).
- (2) AER pseudoparalysis (tested in 20° of abduction (8); no active ER with full passive ER lagging back to –40°; and pain eliminated with local anaesthetic injection).

The subscapularis muscle–tendon unit has been identified as a key player for shoulder function and treatment outcomes for non-arthroplasty options (3, 5, 9, 10, 11, 12, 13). There is increasing evidence that the lower half of subscapularis is an important factor for maintaining humeral head centring and force couple balance. The need for isolated grading of impairment of active internal rotation (AIR) is a logical requirement. Two entities should be distinguished:

- (1) AIR pseudoparesis (tested and measured with a modified belly-press test (10, 14, 15, 16) with wrist flexion of 30°–60° to keep hand contact to the abdomen).
- (2) AIR pseudoparalysis (Fig. 3; tested and measured with a modified belly-press test (10, 14, 15, 16) with wrist flexion of 90° to keep hand contact to the abdomen).

In patients with irreparable, chronic rotator cuff tears, Boileau (17) classified loss of ER as either isolated (ILER) or



Figure 1 Clinical photographs of patients attempting AFE. (A) Patient with left shoulder massive cuff tear with AFE <90° and (B) massive cuff tear of the right shoulder with no AFE.



Figure 2
Clinical photographs of a patient being examined for ER1 lag. Passive ER starting position with shoulder in 20° of abduction (A) demonstrating a lag with end position (B).

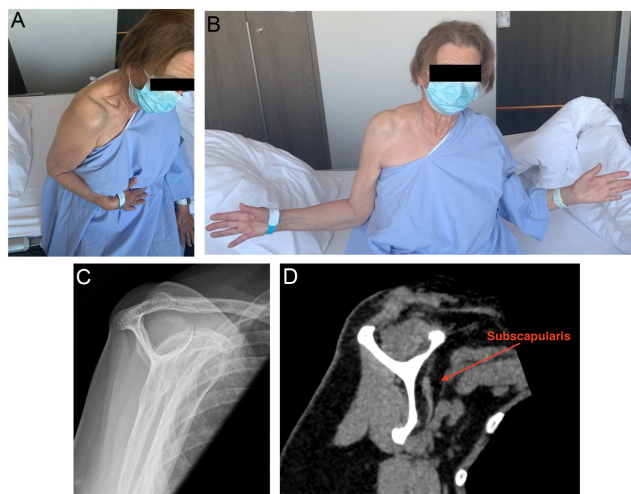


Figure 3
Clinical photograph of a belly-press test in AIR pseudoparalysis, belly-off sign: wrist flexion of 70° (A) before the elbow is brought forward by examiner passively, which would increase wrist flexion to 90°. Clinically an antero-superior escape of the humeral head is seen (A). Increased ER of the right shoulder due to complete subscapularis tear (B). Radiographic antero-superior subluxation (C). Soft tissue CT sagittal images demonstrate grade 4 fatty infiltration of subscapularis (D).

combined with loss of AFE (CLEER). This classification was developed after early observations of poorer outcomes of reverse shoulder arthroplasty (RSA) in combined pseudoparalytic syndromes especially with additional loss of ER (18). Treatment of CLEER is currently controversial, with some surgeons suggesting it should be treated with RSA combined with a simultaneous tendon transfer (17, 19, 20) and others suggesting that using a lateralized RSA prosthesis is adequate (21, 22). It is the authors' opinion and experience that there are patients who still suffer from loss of ER with a hornblower and dropping sign despite RSA lateralization (Fig. 4), so perhaps not all CLEER patients are the same. It would seem useful to distinguish CLEER patients into:

- (1) CLEER grade 1: AFE pseudoparesis or pseudoparalysis+AER pseudoparesis.
- (2) CLEER grade 2: AFE pseudoparesis or pseudoparalysis+AER pseudoparalysis.

CLEER grading has not been undertaken in any study at present and the Activities of Daily Living and External Rotation score proposed by Boileau has not been further studied, graded, or validated (23, 24). In 2018, Boileau further subclassified pseudoparalytic conditions of massive irreparable cuff tears into four groups (23): painful loss of active elevation (PLEA; group 1), isolated loss of active elevation or pseudoparalysed shoulder (ILEA, group 2),



Figure 4
Clinical photograph of a patient with right shoulder hornblower/dropping sign after RSA.

isolated loss of external rotation (ILER; group 3), and combined loss of active elevation and external rotation (CLEER; group 4). We recommend the use of painful loss of elevation or rotation (PLER), a term which has not been presented or published before being more comprehensive including reversible loss of rotational movement due to pain.

Pathobiomechanics

The hand is a crucially important sensitive organ and is the motor executive organ of the highest order in humans. Fine motor ability requires complex central nervous interactions and the hand can be considered as the extension of the human brain (25, 26). Therefore, the ability to position the hand in space, 360° around the human body, is of paramount importance for human life and to function with the highest demands on glenohumeral mobility. This is the reason the shoulder is the most unconstrained and mobile joint with a glenoid socket acting more as a platform than a cavity. Stability and shoulder function are therefore dependent on muscle balance, also called ‘force coupling’, centring the resulting force vector towards the centre of the glenoid surface. It can be broken up into horizontal (Fig. 5A) and vertical (Fig. 5B) muscle balance with specific muscles acting as horizontal

internal and external rotators and vertical elevators and depressors (27).

It is evident that these two directions of muscle balance represent a simplification of multidirectional shoulder balance and force coupling. Since there are insufficient static restraints in any direction, 360° around the centre of the glenoid apart from the acromion and coracoacromial arch, which contribute to limiting superior migration of the humeral head as long as sufficient dynamic joint stabilization, is maintained (28). In cuff tear arthropathy (CTA), the acromion can undergo acetabularisation with maintenance of a functional shoulder in early stages. In advanced stages, dynamic stabilization is lost and this instability can lead to antero–superior escape, detensioning of the deltoid, its length is determined by the acromion, the deltoid muscle origin, and punctum fixum. These CTA stages are described by Seebauer’s classification, the only biomechanical CTA classification to date which is less commonly used than morphological classifications (28). Advanced stages are often associated with pseudoparalysis.

In the normal functioning shoulder, the forces produced by the rotator cuff cause centring compression of the humeral head across the concave glenoid surface, thereby providing a stable fulcrum for the periscapular muscles and the deltoid to move the humerus relative to the glenoid and the centre of rotation of the joint (29). The rotator cuff also provides countertraction against the cranial pull of the deltoid during attempted elevation (Fig. 4B)(30). The deltoid represents the motor and powerhouse of the glenohumeral joint with a divergent force vector to the sum of the rotator cuff force vectors representing the fine biomechanics to centre the joint. Loss of force couple balance is known to lead to pathological conditions such as instability, eccentric wear, decentred osteoarthritis, and CTA. The pathomechanics of pseudoparesis and pseudoparalysis are thought to be multifactorial (31). When pain as a cause is excluded, the biomechanical basis of pseudoparesis and pseudoparalysis is thought to include insufficient centralisation of the humeral head on the glenoid by the rotator cuff and an antero-superior subluxation of the proximal humerus from the cranially directed pull of the deltoid during attempted elevation (32, 33, 34, 35). Glenohumeral balance and stability is therefore defined as the multifactorial ability to keep the humeral head centred in the glenoid fossa (29). Di Giacomo *et al.* (36) suggested that dynamic stabilization through muscle contraction and the resulting compression of the articular surfaces is the most important factor in ensuring shoulder stability. Favre and Gerber (37) postulated that the stability of the glenohumeral joint in all possible positions of the humerus can only be achieved by an interplay of the glenohumeral muscles, equilibrating an external force or moment, while at the same time balancing each other’s

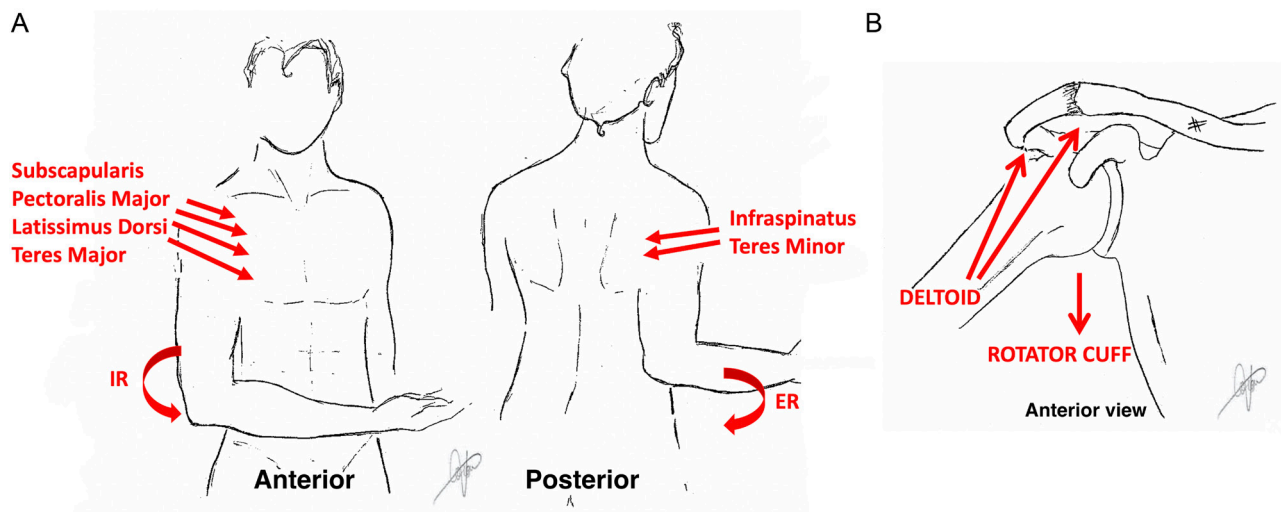


Figure 5

Illustration demonstrating anterior (A) and posterior (B) views of the right shoulder with horizontal (A) and vertical (B) muscle balance vectors.

redundant actions. Superiorly directed forces from the deltoid must be stabilized by the rotator cuff musculature. The biomechanical relationship between the moment arms of these muscles is likely to be a major factor in chronic overloading of the cuff (38). Whether pseudoparesis is clinically seen or not has been shown to depend on the size and location of a rotator cuff tear as well as the degree of tendon involvement. Denard *et al.* (39) concluded from their series of massive rotator cuff tears that one disruption of the two rotator cable attachments, either anterior (anterior supraspinatus) or posterior (inferior infraspinatus) is a prerequisite for loss of AFE to 90°. Collin *et al.* (3) distinguished five rotator cuff muscle–tendon units (separate upper and lower subscapularis unit) and classified them by the involved components: type A, supraspinatus and superior subscapularis tears; type B, supraspinatus and entire subscapularis tears; type C, supraspinatus, superior subscapularis, and infraspinatus tears; type D, supraspinatus and infraspinatus tears; and type E, supraspinatus, infraspinatus, and teres minor tears (Fig. 6A).

They reported that a tear of the entire subscapularis and supraspinatus or the involvement of three tendons are associated with inability to raise the arm to 90°. Looking carefully at the data of this study should also lead to the conclusion that a massive tear either comprising:

- (1) the entire anterior units (lower and upper subscapularis)+the suprapinatus unit (Fig. 6A, type B),
- (2) the entire posterior units (teres minor and infraspinatus)+the supraspinatus unit (Fig. 6A, type E), or

- (3) all three superior units above the equator of the head (infraspinatus to upper subscapularis) (Fig. 6A, type C)

is predictive of pseudoparalysis.

One can conclude that to prevent pseudoparalysis, at least one anterior unit in antero-superior tears, or one posterior unit in posterosuperior tears, or one superior unit in anterior-to-posterior tears above the horizontal equator is needed to provide a rotator cuff fulcrum for rotation powered by the deltoid force. The proximal humerus as a sphere can be separated by horizontal and oblique vertical equators into a superior cuff segment (S), anterior cuff segment (A), and posterior cuff segment (P) (Fig. 6 in blue). Each segment needs at least one functioning muscle–tendon unit to prevent loss of the force couple balance and to provide a rotator cuff fulcrum for rotation powered by the deltoid force. A theory we named ‘the shoulder equator concept’. Wieser *et al.* (13) and Ernstbrunner *et al.* (5) confirmed that loss of the inferior subscapularis is the most important predictor for AFE pseudoparalysis. This underlines the importance of operative subscapularis tendon repair for prevention.

A fluoroscopic, MRI-controlled study by Wieser *et al.* (13) further improved the understanding of pseudoparalytic biomechanics demonstrating complete loss of glenohumeral abduction around a centre of rotation in pseudoparalysis. Interestingly, patients with very similar bilateral tendon tears often have drastically different capacities for AFE unrelated to pain inhibition. The study showed that a tear involving the ‘subscapularis minor’ (inferior subscapularis) (40) is the most significant

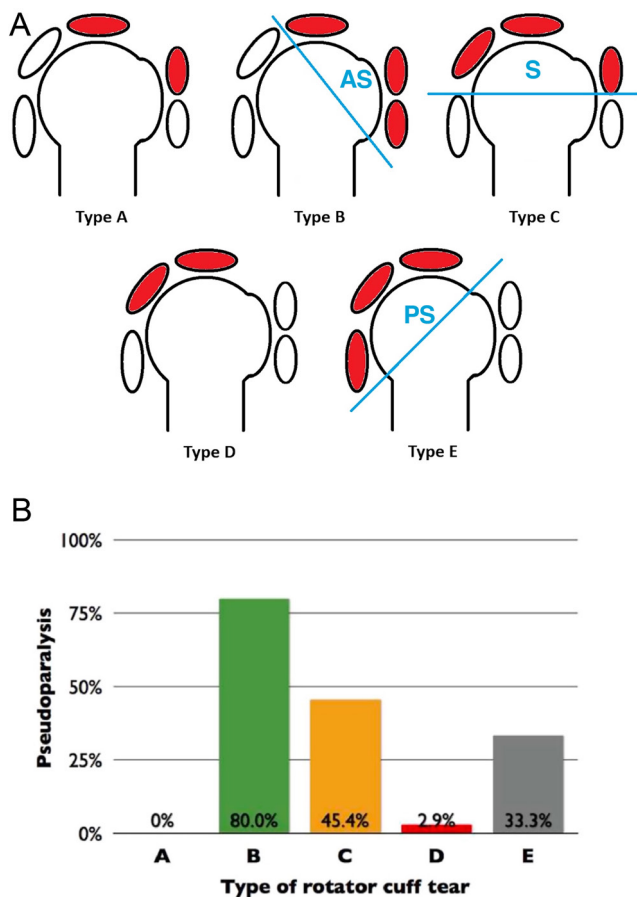


Figure 6 Illustration demonstrating schematic representation of a sagittal slice of the humeral head with rotator cuff tendons, as per Collin *et al.* Horizontal and oblique vertical equators in blue demonstrating the equator concept: type B (complete antero–superior (AS) cuff loss), type C (complete superior (S) cuff loss), type E (complete postero–superior (PS) cuff loss) (A), and percentage of pseudoparalysis (B). Reproduced with permission.

predictive factor for inability to forward flex the arm beyond 90°. A more recent study of the same group (5) refined the impact of impairment of the inferior subscapularis, which lead rather to pseudoparalysis <45° of AFE than to pseudoparesis >45° or <90° of AFE and confirmed the key role of the subscapularis in massive rotator cuff tears and the need for prevention of tear propagation highlighting the importance for repair. The important mechanical role of subscapularis has been pointed out by Gerber in the context of latissimus dorsi transfers (41), by Burkhart *et al.* reporting their results of rotator cuff repair (9, 10), and Kwano *et al.* (12) who have shown in a cadaveric study on humeral head translation that subscapularis has the important function of centring the humeral head to provide an anterior inferior check rain. Kwano *et al.* (12) conclude that propagation of subscapularis tears should be prevented whenever possible.

To better understand the varying clinical function of patients with similar size, location, and fatty infiltration of massive rotator cuff tears, Bouaicha *et al.* examined the contribution of the bony anatomy and the moment arms (30). They conducted a study defining the shoulder abduction moment index (SAM index) as the ratio of the radius of the humeral head to the moment arm of the deltoid. The authors concluded that the SAM index plays a determinant role for the presence or absence of pseudoparalysis. Relatively large deltoid moment arms with SAM indices <0.77 showed significantly increased risk of pseudoparalysis subject to limitations of accuracy and reproducibility of the proposed measurements.

Teres minor was for a long time an under-investigated segment of the rotator cuff (42) until the first long-term outcome study on RSA pointed out its importance (18). Although its atrophy and fatty infiltration on CT or MR imaging is rare (43), it has been reported to have an impact on rotator cuff repair and RSA outcomes (44), as well as outcomes of latissimus dorsi tendon transfers (45). As shown by Collin, high-grade fatty infiltration of teres minor in massive rotator cuff tears is associated with both AFE pseudoparalysis and ER pseudoparalysis (3). It can be concluded that teres minor is the key player providing the posterior inferior check rain of the humeral head.

In conclusion, the importance of the inferior subscapularis has been pointed out as an anterior check rain and subscapularis tear propagation should be prevented at all cost (5, 11, 12, 13) to maintain shoulder function and balance. The long-forgotten teres minor seems to have a similar role as the last posterior check rain in large posterior tears. Collin’s data teaches us further that the loss of all superior rotator cuff units inserting above the humeral head equator is predictive for loss of force couple balance.

History and examination

The history should include the duration of inability to lift up or rotate the arm, whether the onset was acute traumatic, chronic progressive, or acute on chronic, and if the loss of function is pain related. From the outset, it is important to know if symptoms are associated with injuries, chronic stiffness, pain of the cervical spine, or neurological deficit of the limb. Problems encountered during activities of daily living (unable to reach above head level, to comb, shave or apply make-up, to hold a telephone, to eat with a spoon, to pour water from a bottle in a glass, to tuck in a shirt, or reach the trousers back pocket) should be recorded. It is important to question the influence of pain eliminating injections and if physiotherapy was conducted appropriately with adequate exercises over a sufficient time. The history should be completed with the relevant

surgical, rheumatological, and neurological background of the patient.

Examination

Inspection of the anterior, posterior, and superior shoulder girdle with particular attention to the deltoid, trapezius, supraspinatus, infraspinatus, and teres minor atrophy, as well as scapular winging, is the first step of the clinical examination.

A general examination of the sensory and motor function of the affected upper limb is carried out paying attention to C5 (forearm supination and deltoid contraction) and axillary nerve motor function (deltoid contraction during attempted AFE), after passive elevation to 90° and Hertel's (46) deltoid extension lag test (Fig. 7) since isolated impairment of the C5 nerve root described by Mareddu *et al.* (47) or isolated motor impairment of the axillary nerve without impairment of sensation can occur and mimic shoulder pseudoparalysis. In the authors' experience, the sensory assessment of the 'regiments badge area' to evaluate the function of the axillary nerve is not reliable and cases of impaired axillary nerve motor function without complaints about loss of sensation have been seen in clinical practice.

Cervical spine

The ROM of the cervical spine is examined with attention to posture, stiffness, and pain at end ROM. A Spurling test is also carried out which is useful to confirm the absence of a cervical radiculopathy with a reported specificity of 93% (48).

Deltoid extension lag (axillary nerve)

A very useful and validated test for deltoid and axillary nerve function, which could also be affected by a C5 nerve root lesion, was described by Hertel (46) as an arm extension lag test (Fig. 7). The patient is asked to sit on a chair. Both arms with extended elbows are maximally extended by the examiner. The patient is asked to hold the position and the lag is recorded in degrees. In case of a positive test, elbow flexion and supination strength examination can be helpful to distinguish from a C5 nerve root lesion.

Active forward elevation

Examination of AFE can be conducted after elimination or reduction of pain by a subacromial local anaesthetic injection into the subacromial space in the setting of a massive cuff tear (1). The patient is asked to slowly elevate the arm maintaining full elbow extension. The degree of AFE and associated anterior–superior humeral escape are recorded (Fig. 1).



Figure 7

Clinical photograph of a patient's right shoulder being examined demonstrating deltoid extension lag test according to Hertel (46).

Active external rotation and AER lag sign (dropping sign)

Active and passive ER are examined with the arm by the side in 20° of abduction (Fig. 2) as described by Hertel (8). The patient's elbow is supported before positioning of the arm in maximal passive ER by the examiner. The patient is asked to maintain this position before its release. The ER lag is recorded (lag to neutral or to -40°ER and amount of absolute lag). This is the most accurate test for teres minor dysfunction if a lag of more than 40° is found (49, 50). The test needs to be interpreted with care if a subscapularis lesion with increased external rotation and no firm end point is suspected (Fig. 3).

Hornblower sign

The second test is a modification of the Hornblower sign test described by Walch (50). The arm is brought into passive flexion to 90° and passive ER with the forearm reaching a vertical position. The elbow remains supported. The patient is asked to maintain the vertical position of the forearm. Contraction of teres minor can be inspected and palpated at the posterolateral boarder of the scapula. Lagging into IR from the vertical forearm position is recorded (Fig. 4).

Belly-press, belly-off, and lift-off test

Since some patients are unable to position the arm adequately behind the back for a lift-off test (51) and lift-off lag sign (8), the belly-press test (52) has been studied and modified to assess AIR. The flexion of the wrist can

be measured with a goniometer for grading of the subscapularis deficiency. We recommend the modification by Scheibel (16). The patient is asked to place the hand flat on the abdomen with the elbow close to the body. Next, the patient is asked to bring the elbow forward and extend the wrist (Fig. 3A). The flexion angle of the wrist is measured. This modified test yields a sensitivity of 80% and a specificity of 88% (14). The lift-off test with a sensitivity of 100% for a complete subscapularis rupture (15) and the lift-off lag sign with a sensitivity of 95% and a specificity of 96% (8) should be used to confirm the diagnosis paying attention to flex the elbow to 90° to rule out compensation by elbow extension with triceps contraction (Fig. 8).

Radiographic evaluation and classification

Mandatory radiographs include a true anterior–posterior (AP) (5) view and supraspinatus outlet view (53). The true AP view (Fig. 9) allows assessment of the greater tuberosity, cranial decentring of the humeral head (54), acromiohumeral interval (AHI) to radiographically grade massive cuff tears according to Hamada *et al.* (55, 56). The supraspinatus outlet view allows the assessment of acromion morphology (57), its slope (58), and if the humeral head is horizontally centred. Valuable additional radiographs involve the axillary view (59) to further evaluate osteophytes, horizontal centring (53) and to exclude an os acromiale (60), and AP external rotation and internal rotation views which load the posterior and anterior joint space and display eccentric wear if present.

Hamada classification

The most commonly used and simple radiographic grading of massive cuff tears was proposed by Hamada *et al.* (55) in 1990 and has stood the test of time. It consists of five grades based on the AHI on true AP radiographs for grade 1–2 (AHI >6 mm; AHI <5 mm) and addition of grade 3 (acetabularisation), grade 4 (glenohumeral joint space narrowing), and grade 5 (humeral head collapse). The AHI has been considered in the literature to be a sensitive indicator for full-thickness rotator cuff tears (61).

CT and MR imaging and classifications

Additional investigations include CT scans with 3D modelling and MR imaging, ideally with intra-articular contrast.

Patte classification

The widely used coronal classification of supraspinatus retraction is only a subclassification of the comprehensive work published by Patte in 1990 (42). The grades are:



Figure 8 Clinical photograph of a patient's right shoulder being examined demonstrating lift-off-lag test (A) and lift-off test (B).

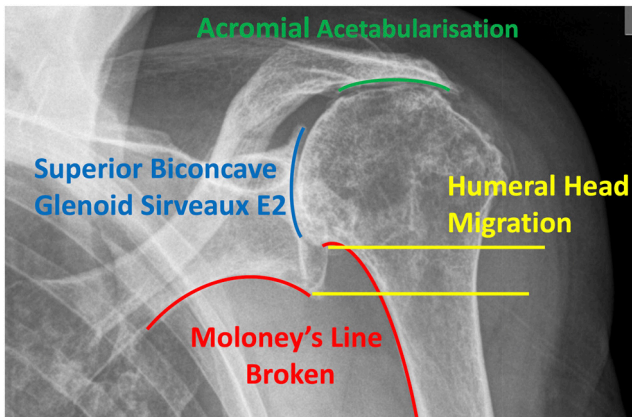


Figure 9
Plain AP radiograph of a left shoulder with cuff tear arthropathy.

1. Proximal stump near the bony insertion.
2. Proximal stump is at the level of the humeral head.
3. Proximal stump at the level of glenoid or more proximal.

It is important to point out that coronal cuts mimicking grade 3 retraction to the glenoid level must be carefully examined whether they represent L-shaped or reverse L-shaped tears which are reducible and therefore repairable (62, 63).

Goutallier classification

Based on sagittal CT imaging, Goutallier *et al.* (64) published a bench mark classification on fatty degeneration also termed as ‘fatty infiltration’ in 1989 and 1994. Tears with stage 3 or 4 fatty degeneration have a poor prognosis for repair.

A more recent reliability study by Williams and Walch (65) concluded that the axial CT plane should be used for Goutallier staging of fatty infiltration, that the fish backbone sign (Fig. 10A) is the visual cue for stage 3 and that the CT-based tangent sign is valid for determining the presence of muscle atrophy correlating with stage 3/4 fatty infiltration. According to the authors, the tangent sign is acceptable for clinical decision-making.

Zanetti's tangent sign

To facilitate the diagnostic cut-off for a poor prognosis Zanetti *et al.* (66) published the tangent sign, a line from the superior aspect of the coracoid to the superior aspect of the scapular spine failing to transect the supraspinatus muscle volume. This MRI evaluation is performed using the most lateral image where the scapular spine is in contact with the body of the scapula.

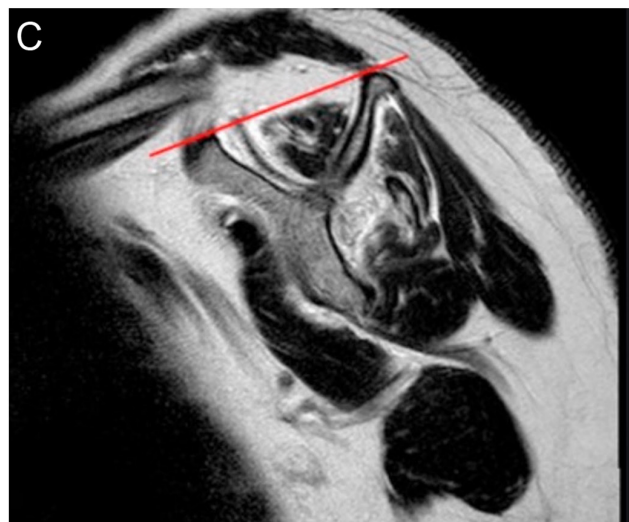
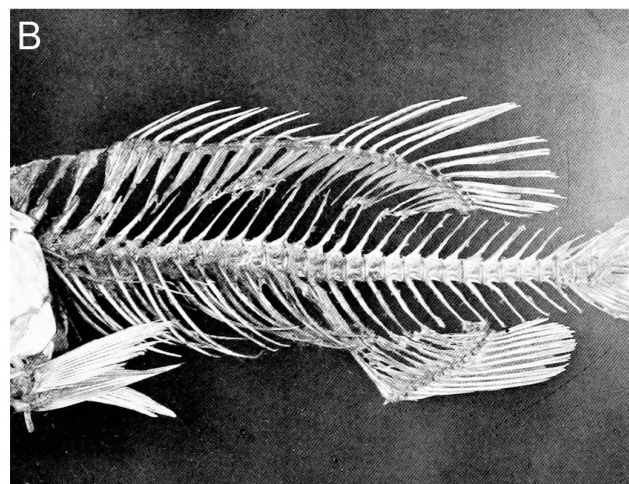
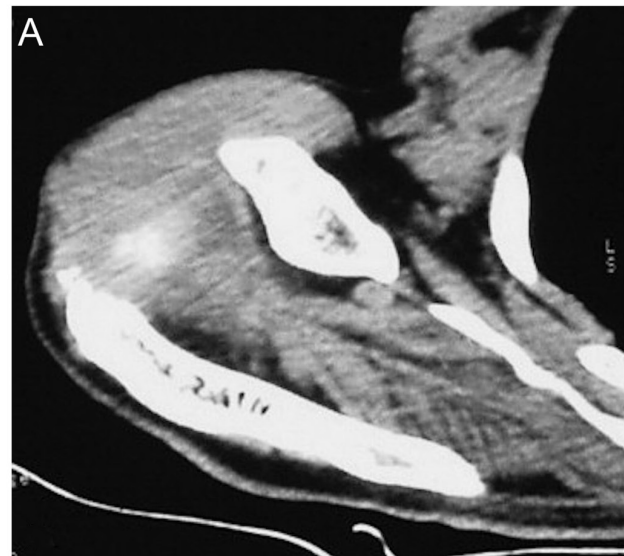


Figure 10
Axial CT with fish backbone sign (A), fish backbone (B), and tangent sign (C). Reproduced with permission from (65).

Impact of fatty infiltration

Fatty infiltration is irreversible and progressive if left untreated, but slight reversal of atrophy after repair has been noted (67). Poorer outcomes of repair have particularly been demonstrated with fatty infiltration of infraspinatus (68) and especially in Goutallier grade 4 fatty infiltration of more than 75% (9). Despite reports of reparability of tears with stage 3 fatty infiltration, Melis and Walch (69) concluded after follow-up of 1688 patients that the objective of early rotator cuff surgery is to prevent stages of intermediate fatty infiltration (stage 2) which is associated with irreversible functional loss. They also examined the natural history of infraspinatus fatty infiltration and recommended repair within 2.5 years of onset of symptoms prior to intermediate fatty infiltration (70) which occurs earlier than supraspinatus fatty infiltration (71).

Discussion

To make the definitive diagnosis of pseudoparesis and pseudoparalysis, the conditions of true paralysis and paresis need to be excluded. C5 neurological lesions can occur in isolation or with rotator cuff tears and mimic AFE pseudoparalysis (47). Isolated suprascapular nerve impairment can also be caused by nerve compression in the suprascapular notch without sensory impairment affecting the supraspinatus and infraspinatus innervation. More distal on its course, the nerve can also be exposed to compression by a spinoglenoid notch ganglion or cyst creating a selective paresis or paralysis of the infraspinatus muscle. In isolated chronic ER pseudoparesis/pseudoparalysis, an MRI is mandatory to confirm the diagnosis and to evaluate the muscle status of the infraspinatus and teres minor muscle units.

Massive rotator cuff tears are not infrequently caused by a chronic degenerative rotator cuff tear aggravated by a traumatic shoulder dislocation after a fall which can potentially be associated with an axillary nerve or a brachial plexus lesion. Massive rotator cuff tears can present with a coexisting neurological dissociative motor lesion of the axillary nerve without sensory impairment or with a C5 nerve root lesion due to trauma or degenerative disease of the cervical spine. Hertel's deltoid extension lag sign (46) is a good clinical test to differentiate AFE pseudoparesis/pseudoparalysis from true paresis/paralysis.

To establish a detailed diagnosis as a basis for appropriate management and treatment, it is recommended to independently evaluate loss of force couple balance for AFE, AER, and AIR with grading into paresis and paralysis. Traumatic aetiology, chronicity, patient age, fatty infiltration of involved muscle–tendon units, and arthritis (Hamada classification) are important features to guide treatment.

The importance of the inferior subscapularis has been pointed out as an anterior check rain, and every effort should be made to prevent subscapularis tear propagation (5, 11, 12, 13) to maintain shoulder function and balance. The often-forgotten teres minor seems to have a similar role as the last posterior check rain in large posterior tears. Collin's data teaches us further that the loss of all superior rotator cuff units inserting above the humeral head equator is predictive for loss of force couple balance.

Conclusions

AFE, AER, and AIR should be assessed independently, the severity of loss of force couple balance should be graded, and paresis and paralysis should be distinguished. Pain must be excluded as a cause of pseudoparesis and pseudoparalysis. Loss of function of three out of five shoulder muscle–tendon units is predictive of loss of force couple balance. The vertical and horizontal shoulder equator concept derived from previous studies illustrates that above the horizontal and vertical oblique equators, at least one muscle–tendon unit is necessary to maintain a fulcrum to counter the deltoid force enabling humeral head rotation instead of the pure translation associated with humeral head escape.

ICMJE Conflict of Interest Statement

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