Pseudoparalysis and pseudoparesis of the shoulder

Clinical presentation, biomechanics, and implications for treatment

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Abstract

Background: Clinical presentation of massive rotator cuff tears range from pain to loss of active range of motion. Pseudoparalysis and pseudoparesis are defined inconsistently in the literature, but both include limited active with maintained passive range of motion.

Objective: This article aims to provide a consistent definition of pseudoparalysis and pseudoparesis of the shoulder and show structural and biomechanical differences between these two types of rotator cuff tear with their implications for treatment.

Methods: A literature review including key and basic papers discussing clinical symptoms, biomechanical differences, and their impact on therapeutic options for pseudoparalysis and pseudoparesis was performed.

Results: Biomechanically, structural differences between pseudoparalysis (active scapular plane abduction <45°) and pseudoparesis (active scapular plane abduction 45–90°) exist. For massive posteroinferior rotator cuff tears, the integrity of the inferior subscapularis tendon is the most predictive factor for active humeral elevation. Patients with pseudoparalysis have a higher grade of subscapularis tendon involvement (>50%) and fatty infiltration of the subscapularis muscle. Treatment options depend on the acuteness and repairability of the tear. Rotator cuff repair can reliably reverse the active loss of active range of motion in acute and repairable rotator cuff tears. In chronic and irreparable cases reverse total shoulder arthroplasty is the most reliable treatment option in elderly patients.

Conclusion: The most concise definition of pseudoparalysis is a massive rotator cuff tear that leads to limited active (<45° shoulder elevation) with free passive range of motion in the absence of neurologic deficits as the reason for loss of active elevation. The integrity of the subscapularis tendon is the most important difference between a pseudoparalytic and pseudoparetic (active shoulder elevation 45–90°) shoulder. Decision-making for surgical options depends more on reparability of the tendon tear and patient age than on differentiation between pseudoparalysis and pseudoparesis.

Keywords
Rotator cuff injuries · Arthroscopy · Tendon transfer · Arthroplasty, replacement, shoulder · Clinical decision-making

Massive rotator cuff tears (mRCT) comprise approximately 10 to 40% of all treated rotator cuff tears (RCT) [1,13]. In 1985, Cofield [6] introduced a definition of mRCT as a tear greater than 5 cm in diameter. A more reliable and generally accepted definition was reported by Gerber et al. [22], as complete disinsertion of two or more tendons of the rotator cuff (RC). More recently, Lädermann et al. [31] introduced a classification of mRCT considering the group of tendons involved. The pattern of the tear influences the biomechanics of the shoulder, particularly regarding the balance between anterior and posterior forces on the humeral head, resulting in a modification.
of the active centralization of the humeral head [16]. If a mRCT leads to loss of active range of motion, the definition of “pseudoparalysis” or “pseudoparesis” is inconsistent. Werner et al. [46] originally defined pseudoparesis as active shoulder anterior elevation of less than 90° in the presence of free passive anterior elevation caused by an mRCT. Despite paresis being defined as weakness with some motion and paralysis as no motion, most authors use the term pseudoparesis inconsistently to describe a lack of active anterior shoulder elevation greater than 90° with free passive elevation after an mRCT. Tokish et al. [44] suggested clarifying the terms and recommended reserving pseudoparalysis for patients with 0° active range of motion, while pseudoparesis should be referred to in patients who are able to actively elevate their arm up to 90°. Unfortunately, this systematic review does not specify exact values for active motion to differentiate between the two conditions. Therefore, the definition of pseudoparalysis and pseudoparesis of Tokish et al. was combined with recent structural and biomechanical findings [16]: pseudoparalysis is defined as mRCT with maintained passive range of motion and limited active scapular plane abduction <45° without neurologic deficits; pseudoparesis is defined as mRCT with maintained passive range of motion and limited active scapular plane abduction >45° and <90° without neurologic deficits (Table 1).

This article focuses on clinical presentation, biomechanical behavior, and implications for therapy of pseudoparalysis and pseudoparesis of the shoulder based on current literature and the authors’ opinions and experience.

### Clinical presentation

Clinical presentation of patients suffering from mRCT differs substantially and can range from free active range of motion without pain to painful or pain-free inability to actively elevate the affected arm. The diagnosis of an mRCT is based on clinical and imaging findings. Patients with pseudoparalysis or pseudoparesis suffer from loss of active range of motion with almost free passive range of motion. Differentiation of pseudoparalysis and pseudoparesis can be assessed clinically by active scapulo-humeral muscles, thus equilibrating...
Loss of forward elevation

Pseudoparalysis of the shoulder is associated with a complete tear of the SSC and supraspinatus tendon or the involvement of at least three tendons of the RC [7].

external forces and at the same time counteracting redundant actions of similar muscle groups [18]. Pseudoparalysis is caused by a loss of active centralization of the humeral head by the RC followed by cranial subluxation of the humeral head due to excessive pull force of the deltoid during elevation [30].

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Fig. 1 A Acute pseudoparalysis in a 67-year-old patient after a fall on his left shoulder with an acute subscapularis tendon tear and chronic infraspinatus tear. Limited active range of motion with a 30° of abduction and b 30° of anterior flexion. c Anteroposterior radiographs show no cranialization of the humeral head with an acromiohumeral distance of 10 mm. d Axial MRI slides show full-thickness subscapularis tendon tear with e no fatty infiltration of the subscapularis muscle and a chronic grade 4 infiltration of the infraspinatus muscle. This patient was treated with arthroscopic subscapularis tendon repair.

Fig. 2 A Acute pseudoparesis in a 56-year-old manual worker after a fall on his right shoulder with an acute subscapularis, supra-, and infraspinatus tendon tear. Limited active range of motion with a 45° of abduction and b 60° of anterior flexion. c Anteroposterior radiographs show slight cranialization of the humeral head with an acromiohumeral distance of 7 mm. d Coronal MRI shows full-thickness supraspinatus tendon tear with e fatty infiltration grade 2 of the supra-and infraspinatus muscle. This patient was treated with arthroscopic rotator cuff repair.
Chronic pseudo-paresis of the left shoulder in an 84-year-old female. Limited active range of motion with a 60° of abduction and b 60° of anterior flexion. c Cranial migration of the humeral head (Hamada stage 4B) with d complete tear of the supraspinatus tendon and e fatty infiltration of the supra- and infraspinatus muscle grade 4. This patient was treated with f reverse total shoulder arthroplasty.

Wieser et al. [47] performed a fluoroscopic, magnetic resonance imaging, and electrophysiologic assessment of shoulders with massive posterosuperior RCT and showed that involvement of the inferior SSC tendon appeared to be the most predictive factor to lift the humerus above 90°. This finding was confirmed by a recent study [16] that showed that involvement of more than 50% of the SSC tendon with fatty infiltration of stage 3 is associated with active scapular plane abduction of less than 45°. Furthermore, this study showed a difference in structural lesions between pseudoparalysis and pseudoparesis. In a biomechanical computer model, the key function of the SSC in developing pseudoparalysis with inability of active abduction >45° was confirmed [16].

The SSC acts against the posterior deltoid and cuff to initiate the movement of forward flexion when starting with the arm at the side of the body. When SSC is completely torn, the humeral head subluxates anteriorly and superiorly (anterosuperior escape), making any forward flexion impossible (Fig. 1). In pseudoparesis, the remaining SSC (more than 50%) may be active enough to maintain active centralization of the humeral head during the initial phase of the forward flexion movement, to enable the anterior deltoid to take over (Figs. 2 and 3).

Bony anatomy

The etiology of non-traumatic mRCT is not yet fully understood. Some authors suggest including the bony anatomy and the vector forces of the RC and the deltoid muscle to explain tear pattern and their functional consequences. Clinical observation and biomechanical observation of the pseudoparalytic shoulder by Bouaicha et al. [3] led to introduction of the Shoulder Abduction Moment (SAM) index. The SAM index is the ratio of the radii of two concentric spheres based on the center of rotation (COR) of the gleno-humeral joint. One sphere captures the humeral head (so-called “numerator” to capture the stabilizing forces of the rotator cuff), while the other sphere includes the origin of the deltoid muscle around the acromion (“denominator” to capture the destabilizing forces of the deltoid muscles). In the clinical analysis, a total of 36 patients with pseudoparalysis were compared to an age- and gender-matched cohort of 36 patients without pseudoparalysis. All patients showed MRI-confirmed mRCT. A SAM <0.77 corresponded to 11-fold-elevated risk of pseudoparalysis. These findings suggest a strong correlation of anatomical features (small humeral head and lateral acromion and subsequent high critical shoulder angle [CSA] [39]). The initial hypothesis that acromial morphologic characteristics influence the development of pseudoparalysis was confirmed by showing that patients with pseudoparalysis have a larger CSA, smaller acromio-humeral distance (AChD), and a higher-positioned acromion in the sagittal plane [17].

Implications for treatment

Deciding on the treatment for pseudoparetic or pseudoparalytic shoulders remains challenging. The most important differentiation is between acute and chronic mRCT, since this significantly influences the possible surgical treatment. In acute cases, the loss of active range might be influenced by pain and can in general be reliably reversed with early arthroscopic repair of the mRCT [9, 43]. In chronic cases with a decentered humeral head and advanced myotendinous degeneration, RC repair is, however, prone to failure. Therefore, treatment options for chronic pseudoparalysis or pseudoparesis
| Study                  | Year | Study design | LoE | Definition                                                                 | Included patients | Treatment                                                                 | Imaging criteria                                                                 | Follow-up                      | Mean age | Clinical results: forward elevation | Pseudoparalysis reversal |
|------------------------|------|--------------|-----|----------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------|----------|-------------------------------------|--------------------------|
| Levy et al. JSES [32]  | 2008 | Case series  | 4   | Pseudoparalysis not defined, free passive motion                          | n = 17            | Subacromial injection of local anesthetic and long-acting steroid, deltoide re-education | ACHD less than 7 mm, Hamada grade 2 (n = 5), 3 (n = 7), 4 (n = 5) Grade 4 fatty infiltration (SSP & ISP: 100%, SSC: 82%), grade 3 (SSC: 18%) | Minimum: 9 months             | 60 years | Preintervention: 40° Postintervention: 160° | 82%                     |
| Oh et al. AJSM [40]    | 2011 | Cohort study | 3   | Pseudoparalysis/-pare-sis: <90° active elevation with free passive motion | n = 29            | Arthroscopically assisted mini-open repair, n = 11 All-arthroscopic repair, n = 18 | N.A.                                                                            | 33 months (control group: 29 months) | 65 years | Preoperative: 64° Postoperative: 135° (control group: preoperative: 152° postoperative: 159) | 76%                     |
| Denard et al. Arthroscopy [8] | 2012 | Case series  | 4   | Pseudoparalysis: <90° active flexion with free passive motion              | n = 53            | Arthroscopic rotator cuff repair                                            | Hamada grade 1 (76%), 2 (20%), 3 (2%), 4 (2%) positive tangent sign: 57% fatty infiltration grade ≥3: 16% | 75 months | 62 years (group 1: 62 years, group 2: 63 years) | Group 1: Preoperative: 49° Postoperative: 155° Group 2: Preoperative: 43° Postoperative: 109° | 95%                     |
| Denard et al. AJSM [9] | 2015 | Case series  | 4   | Pseudoparalysis: <90° active elevation with free passive motion           | n = 56            | Arthroscopic rotator cuff repair                                            | Complete 2 tendon tear, <grade 3 fatty infiltration | 14 months | 63 years | Preoperative: 47° Postoperative: 159° | 100%                       |
| Spross et al. Arthroscopy [43] | 2019 | Case series  | 4   | Pseudoparesis: <90° active elevation with free passive motion              | n = 21            | Arthroscopic rotator cuff repair                                            | Complete 2 tendon tear, <grade 3 fatty infiltration | 39 months | 61 years | Preoperative: 36° Postoperative: 165° | 100%                       |
| Birmingham and Nevasier JSES [2] | 2008 | Case series  | 4   | Pseudoparalysis not defined, active motion <80°, passive motion >110°    | n = 18            | Diagnostic arthroscopy, open latissimus transfer                            | N.A.                                                                            | 25 months | 60 years | Preoperative: 56° Postoperative: 137° | 100%                       |
| Kanatli et al. Arthroscopy [29] | 2016 | Case series  | 4   | Pseudoparalysis: <90° active elevation and abduction                    | n = 15            | Arthroscopically assisted latissimus dorsi transfer                        | N.A.                                                                            | 26 months | 62 years | Preoperative: 58° Postoperative: 130° | N.A.                     |
| Elhassan et al. JSES [11] | 2020 | Case series  | 4   | Pseudoparalysis: <60° active flexion, <60° active abduction              | n = 19            | Arthroscopically assisted lower trapezius transfer                         | Not specified for pseudoparalytic shoulders | 14 months | 52 years | Not specified for pseudoparalytic shoulders | 95%                     |
| Burkhart and Hartzler Arthroscopy [4] | 2019 | Case series  | 4   | Pseudoparalysis: <45° active flexion with free passive motion            | n = 10            | Arthroscopically assisted superior capsular reconstruction                 | Complete 2-tendon tear, Hamada ≤3 | 13 months | 69 years | Preoperative: 27° Postoperative: 159° | 90%                     |
of the shoulder vary from nonoperative partial RC repair, superior capsular reconstruction, tendon transfers, or reverse total shoulder arthroplasty (RTSA) without or with muscle transfer.

The most challenging aspect in the management of pseudoparalysis and pseudoparesis remains the repair or compensation of SSC tears. As detailed above, the manifestation of pseudoparalysis or pseudoparesis increases with the involvement of the SSC tear. Many chronic tears are well compensated until an acute SSC tear occurs ("acute on chronic RC tear"). This event often leads to emergence of a pseudoparalytic shoulder which can be efficiently treated by addressing the acute component of the tear even if some of the tears remain irreparable. The challenge becomes greater in cases of a pseudoparalytic shoulder with chronic anterior and superior cuff tears and a non-repairable SSC tear in young patients.

### Conservative treatment

Nonoperative management in chronic pseudoparalysis or pseudoparesis involves corticosteroid injections and exercises for strengthening the deltoid and periscapular muscles. In addition, rehabilitation focuses on the work of scapulohumeral and thoracohumeral muscles, e.g., the latissimus dorsi, and on their ability to actively center the humeral head and counterbalance the deltoid forces to maintain a moment arm responsible for the scapular abduction. This treatment is an excellent first option in most patients with painful limitation of shoulder movement [44]. Some other authors add a specific anterior deltoid training to steroid injection and nonsteroidal drugs [32].

### Surgical treatment

When conservative treatment fails, surgical options have to be evaluated. Therefore, the reparable of the RCT has to be assessed. Different instruments exist to decide whether an RCT is still repairable. Most important is to evaluate the fatty infiltration of the musculature according to the Goutallier classification initially described in CT scans [26] and adapted by
If ever an RCT is reparable, arthroscopic rotator cuff repair (SCR) offers the potential for pain relief but also improves the function of the affected shoulder. For irreparable posterosuperior RCT, Gerber et al. [21] introduced the latissimus dorsi transfer (LDT) in 1988, with benefits for the patients concerning pain and function [23]. Birmingham and Neviaser [2] reported on patients with failed RC repair and limited active elevation (mean 56°, range 20–80) but free passive motion (mean 126°, range 110–150) preoperatively treated with LDT and 100% pseudoparesis reversal. Unfortunately, the term pseudoparesis was not defined nor mentioned. Nowadays, different techniques from initially reported open to arthroscopically assisted or full arthroscopic LDT exist, eliciting marked improvement in shoulder pain, strength, and function, with a low risk of complications as reported in a recent systematic review [34]. Preoperative assessment of the remaining RC is crucial, since fatty infiltration of the teres minor, as well as insufficiency of the subscapularis muscle, are negative predictors for a good outcome of LDT [24].

There is increasing interest in using lower trapezius transfer for posterosuperior irreparable RCT, since a biomechanical study showed effectiveness in restoring external rotation [27]. Recently, Elhassan et al. [11] reported good short-term clinical outcomes of an arthroscopically assisted lower trapezius transfer, even in patients with pseudoparesis. Of note, true shoulder pseudoparesis (defined as active shoulder flexion and abduction <60°) was a factor that significantly predicted a negative result.

In the authors’ experience, a tendon transfer cannot by itself restore the function of a chronic pseudoparalytic shoulder, even though it may in a pseudoparetic shoulder, unless anteroposterior stabilization of the humeral head is achieved. Indeed, the misbalance of the anterior and posterior forces must be restored to prevent anterior and superior migration of the humeral head induced by contraction of the posterior and middle deltoid and cuff during the attempt of a forward flexion movement.

The aim of this article was not to provide a description of the tendon transfers, as this has been done previously; however, alongside the historical gold standard for irreparable SSC tears—pectoralis major transfer [28, 42]—anterolateral LDT has gained popularity and is a reasonable option, providing a better force vector with a line of pull which is very similar to that of the SSC [12]. So far, no subgroup analysis of patients with a pseudoparalysis or pseudoparesis exists for irreparable SSC tendon tear.

Superior capsular reconstruction

In 2012, Mihata et al. [38] introduced superior capsular reconstruction (SCR) in a biomechanical cadaveric study where the superior humeral head translation was restored by SCR after cutting the supraspinatus tendon. Early follow-up (mean 34 months) showed promising radiological and clinical results in patients with irreparable RCT [37]. Reversal of pseudoparesis was achieved in 90–96% of the patients treated with an arthroscopic SCR, even after a mean follow-up of 60 months [4, 36]. Surgeons who are familiar with this procedure propagate using a 6–8 mm thick and stiff autologous fascia lata graft to achieve good functional outcome. At
the authors’ institution, this procedure is rarely performed and profound expertise is therefore lacking.

**Reverse total shoulder arthroplasty**

The most valuable option for older patients with chronic irreparable mRCT and pseudoparalysis or pseudoparesis, showing improved outcomes for up to even 20 years after surgery, is RTSA [15]. This is also the authors’ preferred option in elderly patients in whom conservative treatment has failed (Fig. 3). A systematic review showed an increased average active elevation of 56° and reversal of pseudoparalysis in 96% of patients treated with RTSA [10]. It should be mentioned that the term “pseudoparalysis” was inconsistently or incorrectly defined as “ROM less than 90°.” Nevertheless, implantation of RTSA remains the best option for older patients with pseudoparalysis and pseudoparesis and is even a justifiable treatment for patients under the age of 60 years [14]. Despite the improvement of functional outcome scores at a mean follow-up of 12 years after RTSA, the complication rate was 39%, revision rate 17%, and failure rate 9%, so that the indication in patients younger than 60 years has to be considered carefully.

**Conclusion**

Massive rotator cuff tear is a disabling condition for patients and can lead to pseudoparalytic or pseudoparetic shoulders with loss of active range of motion. Structural differences exist between pseudoparalysis and pseudoparesis: patients with pseudoparalysis have a higher grade of involvement of subscapularis tendon tears and a higher grade of fatty infiltration of the subscapularis muscle compared to patients with pseudoparesis. Decision-making regarding therapeutic options is mainly based on acuteness, reparability of the RCT, and patient age. RC repair can reliably reverse the loss of active range of motion in acute and reparable RCT. In chronic and irreparable cases, options vary from nonoperative, partial RC repair, tendon transfer, and SCR, to RTSA. Skillful preoperative patient selection is the key to success. RTSA shows good results in predominantly older patients with painful pseudoparalysis or pseudoparesis. In young and active patients with an intact or repairable SSC lesion for whom shoulder arthroplasty is not yet an option, SCR and tendon transfer can lead to reliable clinical outcomes with improvement regarding the range of motion and function.

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Zusammenfassung

Pseudoparalyse und Pseudoparese der Schulter. Klinische Präsentation, Biomechanik und Auswirkungen auf die Behandlung

Hintergrund: Rotatorenmanschettenmassenrupturen machen fast die Hälfte der behandelten Rotatorenmanschettenrupturen aus. Die klinische Symptomatik erstreckt sich von Schmerzen bis zum Verlust der aktiven Schultergelenkbeweglichkeit. Die Begriffe „Pseudoparalyse und Pseudoparese“ werden in der Literatur inkonsistent verwendet. Beiden Begriffen gemeinsam ist eine limitierte aktive bei simultan vorliegender freier passiver Schulterbeweglichkeit.

Fragestellung: Es soll eine konsistente Definition für Pseudoparalyse und Pseudoparese der Schulter erstellt werden. Die strukturellen und biomechanischen Unterschiede zwischen diesen beiden Typen von Rotatorenmanschettenrupturen werden aufgezeigt, sowie deren Einfluss auf die Behandlung analysiert.

Methoden: Eine Übersichtsarbeiten über die Schlüssel- und Grundlagenstudien bezüglich klinischer Symptome, biomechanischer Unterschiede sowie deren Einfluss auf die Therapieoptionen für Pseudoparalyse und Pseudoparese wurde durchgeführt.

Ergebnisse: Biomechanisch bestehen strukturelle Unterschiede zwischen Pseudoparalyse (aktive Abduktion in der Skapulabene unter 45°) und Pseudoparese (aktive Abduktion in der Skapulabene zwischen 45 und 90°). Im Fall einer posterosuperioren Rotatorenmanschettenmassenruptur ist die Integrität des unteren Subskapularrisssehnanteils der stärkste prädiktive Faktor für die aktive Elevation des Humerus. Patienten mit einer Pseudoparalyse haben häufig eine Rupturausdehnung in die untere Hälfte der Subskapularissehne sowie einen höheren Grad der fettigen Infiltration der Subskapularissmuskulatur. Die therapeutischen Optionen sind abhängig vom Zeitpunkt und der Reparierbarkeit der Ruptur. Die Rekonstruktion einer akuten und rekonstruierbaren Rotatorenmanschettenruptur kann zuverlässig die aktive Beweglichkeit wiederherstellen. In chronischen und irreparablen Fällen variieren die therapeutischen Optionen von konservativ, partieller Rotatorenmanschettenrekonstruktion, superiorer Kapselrekonstruktion, zu Sehnentransfer und schließlich inverser Schulterprothese, wobei Letztere die zuverlässigste Behandlungsoption insbesondere bei älteren Menschen darstellt.

Schlussfolgerung: Die konsistenteste Definition für eine Pseudoparalyse der Schulter beinhaltet eine massive Rotatorenmanschettenruptur, die zu einer eingeschränkten aktiven (<45° Schulterelevation) bei freier passiver Schultergelenkbeweglichkeit – ohne neurologische Ursache für eine Paralyse – führt. Die Integrität der Subskapularissehne ist der wichtigste strukturelle Unterscheidungspunkt zwischen einer pseudoparalytischen und pseudoparetischen (aktive Schulterelevation zwischen 45 und 90°) Schulter. Die Entscheidungsfindung für die chirurgischen Therapieoptionen richtet sich mehr nach der Rekonstruktionsmöglichkeit einer Sehnennruptur und dem Alter des Patienten als nach der Differenzierung zwischen Pseudoparalyse und -parese.

Schlüsselwörter
Rotatorenmanschettenverletzungen · Arthroskopie · Sehnentransfer · Schulterprothese · Klinische Entscheidungsfindung

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