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Review article

Failed rotator cuff repair

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ABSTRACT

After rotator cuff repair, few patients require revision surgery, and failure to heal does not always translate into clinical failure, although healing is associated with better outcomes. Failure of rotator cuff repair is perceived differently by the patient, by the surgeon, and in terms of social and occupational abilities. The work-up of failed cuff repair differs little from the standard work-up of cuff tears. Information must be obtained about the circumstances of the first repair procedure, a possible diagnostic inadequacy and/or technical error, and early or delayed trauma such as an aggressive rehabilitation programme. Most cuff retears do not require surgery, given their good clinical tolerance and stable outcomes over time. Repeat cuff repair, when indicated by pain and/or functional impairment, can improve pain and function. The quality of the tissues and time from initial to repeat surgery will influence the outcomes. The ideal candidate for repeat repair is a male, younger than 70 years of age, who is not seeking compensation, shows more than 90° of forwards elevation, and in whom the first repair consisted only in tendon suturing or reattachment. In addition to patient-related factors, the local conditions are of paramount importance in the decision to perform repeat surgery, notably repeat suturing. The most favourable scenario is a small retear with good-quality muscles and tendons and no osteoarthritis. When these criteria are not all present, several options deserve consideration as potentially capable of relieving the pain and, to a lesser extent, the functional impairments. They include the implantation of material (autograft, allograft, or substitute), a muscle transfer procedure, or reverse shoulder arthroplasty. However, the outcomes are poorer than when these options are used as the primary procedure. Prevention is the best treatment of cuff repair failure and involves careful patient selection and a routine analysis of the treatments that may be required by concomitant lesions. Biceps tenotomy should be considered on a case-by-case basis. Smoking cessation should be strongly encouraged and any metabolic disorders associated with repair failure should be brought under control.

1. Introduction

Rotator cuff repair is increasingly performed, due to the ageing of the population, advances in imaging techniques and arthroscopic surgery, and growing demand from patients. Based on its good clinical outcomes and low morbidity, arthroscopic surgery now tends to be offered to patients with limited symptoms, with the goal of preventing tear progression and muscle deterioration. However, the tear fails to heal in about 20% of cases. The healing rate depends chiefly on the initial size of the tear [1,2]. Regarding the causes of repair failure, six main questions continue to generate controversy:

- how is cuff repair failure defined and how common is it?
- what work-up is needed in patients with cuff repair failure?
- which patients are candidates to re-operation?
- which surgical techniques are available and what are their outcomes?
- how can repair failure be prevented?
- can a treatment algorithm be developed?

2. How is cuff repair failure defined and how common is it?

Cuff repair failure is perceived differently by patients, surgeons, and in terms of social and occupational activities, as the goals vary across these three perspectives. These goals must be clearly defined before surgery.

Repair failure is usually defined as a need for further surgery in the short- or medium-term. In the retrospective SoFCOT study [3] of 511 patients who underwent repair surgery for an isolated supraspinatus tear in 2003, 35 (7%) patients required revision surgery within 10 years (repeat repair, $n = 17$; arthroplasty, $n = 7$; and other procedures, $n = 11$).

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1877-0568/

Cuff et al. [4] defined failed cuff repair as an American Shoulder and Elbow Surgeons (ASES) score lower than 70 or a range of forwards elevation below 90°. In contrast, pseudoparalysis or a structural defect in the cuff were used by Gasbarro et al. [5] to define repair failure. Thus, an insufficient improvement or worsening compared to the preoperative manifestations could also be viewed as indicating repair failure.

2.1. Failure for the patient: clinical failure

2.1.1. Persistent pain

Persistent pain is the main cause of failure as perceived by the patient. An aetiological evaluation must be performed to look for an abnormality left untreated during the first procedure, such as acromio-clavicular osteoarthritis, a tear in another tendon (biceps, subscapularis, infraspinatus), gleno-humeral cartilage wear or, more rarely, suprascapular neuropathy [6]. However, such abnormalities rarely lead to revision surgery, as failure to heal is the main cause of persistent pain.

2.1.2. Postoperative stiffness

Stiffness has become a less common cause of failure since the advent of arthroscopy and rapid mobilisation. Primary surgery is best performed on a shoulder that has regained its mobility. Postoperative stiffness should lead to investigations for cutibacterium acnes infection and adhesive capsulitis.

Patients are usually willing to prolong the duration of their rehabilitation therapy. Arthroscopic release is only exceptionally required after cuff repair [7] but can produce benefits if the cuff has healed properly.

2.1.3. Loss of strength

Many patients complain of loss of strength after cuff repair surgery. Common causes include failure to heal; muscle degeneration, often identified before the index procedure by magnetic resonance imaging (MRI) or computed tomography (CT)-arthrography; and an eccentric humeral head position.

Baseline objective strength measurement using a dynamometer before the first procedure is therefore useful as a point of reference to document postoperative loss of strength.

Loss of strength only very rarely warrants repeat surgery, as the outcome in this situation is unreliable. Nevertheless, strength is a major endpoint for patients who work in manual jobs, notably heavy manual laborers.

2.1.4. Pseudoparalysis

Pseudoparalysis is often due to a structural defect in the cuff with anterior-superior displacement of the humeral head, usually due to an antero-superior tear. Most patients require repeat surgery, which may consist in reverse shoulder arthroplasty (RSA).

2.1.5. Poor cosmesis

Rupture of the long head of biceps tendon with retraction of the muscle belly produces an unsightly lump on the arm (Popeye sign). This complication should be prevented by tenodesis or self-locking tenotomy removing the superior labrum [8] (Fig. 1).

2.1.6. Cracking sounds, friction

With postero-superior tears, the humeral head lodges under the acromion and may cause cracking sounds, sometimes with pain. This symptom does not warrant repeat surgery, and this should be explained to the patient.

2.2. Failure for the surgeon

2.2.1. Failure to heal

The healing failure rate varies widely across studies [9–11]. It depends both on the postoperative imaging technique and on the classification used (Table 1). Barth et al. [12] found retears in 9.1% of shoulders after 3 months, 3.4% after 6 months, and 2.8% at last follow-up.

Retears usually develop at the junction between the tendon and the bone [13]. A careful assessment of the MRI scan is needed to determine the surface area of the retear, its location (at the enthesis or in the body of the tendon at the first row of sutures), and the thickness and length of residual tendon [14].

2.2.2. Symptom exacerbation after surgery

At the time of surgery, some patients have mild pain, good range of motion, and normal strength. In this situation, a very detailed pre-operative work-up must be performed. The pain and functional impairment should be documented, motion ranges measured using a goniometer, and strength measured using a dynamometer. Other valuable tools for evaluating the outcome comparatively with the pre-operative status include quality-of-life (QOL) scores such as the abbreviated form of the Disabilities of the Arm, Shoulder, and Hand score (QuickDASH) and the Shoulder Pain and Disability Index (SPADI) (Fig. 1) and functional scores (Constant score, American Shoulder and Elbow Surgeons [ASES] shoulder score, and Activities of Daily Living requiring active External Rotation [ADLER] score) (Fig. 2). At least one of these scores should be determined routinely.

In some patients, the symptoms worsen after surgery, as established by comparing the preoperative and postoperative clinical evaluations. However, the worsening does not correlate reliably with the healing status, and patients with worsened symptoms may have healed tears [15].

2.2.3. Factors associated with failure to heal

Several risk factors for failure to heal have been identified:

- the main factors are the size of the tear [5,16], presence of muscle wasting [5,17], and presence of fatty degeneration with a Goutallier index ≥ 3 [6] (Fig. 3), notably of the infraspinatus and subscapularis muscles. Maqdes et al. reported that healing of antero-superior tears correlated with the severity of fatty degeneration of the subscapularis muscle [18]. In a study by Park et al. [19], fatty degeneration of the supraspinatus muscle was not a major risk factor.
- older age [16] and a number of comorbidities (smoking [19], diabetes [20], hypercholesterolemia [21], alcohol abuse, obesity, and hypertension) also have deleterious effects on the healing process.
- other risk factors include symptom duration [22], thinning of the cuff, and specific gene expression patterns [23].

Nevertheless, a nuanced approach to the risk factor profile is needed:

- older age should not be viewed as a contraindication to surgical repair. Thus, a study reported at the 2013 French Arthroscopy Society showed better outcomes of rotator cuff repair compared to bursectomy and acromioplasty in patients older than 70 years [24]. Thus, the healing rate for distal and intermediate tears was 89% [25];
- the influence of infraspinatus delamination [26] and of a subscapularis tear [27] remains debated. An infraspinatus tear longer than 1 cm has also been identified as a risk factor for failure to heal [5].

Shoulder Pain and Disability Index

Please place a mark on the line that best represents your experience during the last week attributable to your shoulder problem.

Pain scale

How severe is your pain?

Circle the number that best describes your pain where: **0** = no pain and **10** = the worst pain imaginable.

At its worst?	0	1	2	3	4	5	6	7	8	9	10
When lying on the involved side?	0	1	2	3	4	5	6	7	8	9	10
Reaching for something on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Touching the back of your neck?	0	1	2	3	4	5	6	7	8	9	10
Pushing with the involved arm?	0	1	2	3	4	5	6	7	8	9	10

Total pain score _____ /50 x 100 = _____ %

(Note: If a person does not answer all questions divide by the total possible score, eg. if 1 question missed divide by 40)

Disability scale

How much difficulty do you have?

Circle the number that best describes your experience where: **0** = no difficulty and **10** = so difficult it requires help

Washing your hair?	0	1	2	3	4	5	6	7	8	9	10
Washing your back?	0	1	2	3	4	5	6	7	8	9	10
Putting on an undershirt or jumper?	0	1	2	3	4	5	6	7	8	9	10
Putting on a shirt that buttons down the front?	0	1	2	3	4	5	6	7	8	9	10
Putting on your pants?	0	1	2	3	4	5	6	7	8	9	10
Placing an object on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Carrying a heavy object of 10 pounds (4.5 kilograms)	0	1	2	3	4	5	6	7	8	9	10
Removing something from your back pocket?	0	1	2	3	4	5	6	7	8	9	10

Total disability score: _____/ 80 x 100 =_____ %

(Note: If a person does not answer all questions divide by the total possible score, eg. if 1 question missed divide by 70)

Total Spadi score: _____ 130 x 100 = _____ %

(Note: If a person does not answer all questions divide by the total possible score, eg if 1 question missed divide by 120)

Minimum Detectable Change (90% confidence) = 13 points
(Change less than this may be attributable to measurement error)

Source: Roach et al. (1991). Development of a shoulder pain and disability index.

Fig. 1. Shoulder Pain and Disability Index (SPADI).

Table 1
Healing rates after arthroscopic cuff repair.

Author	Barth	Neyton	Boileau	Charousset	Kim	Lafosse	Meyer
Number of cases	206	107	65	167	132	105	31
Study design	Prospective	Retrospec-tive	Retrospec-tive	Retrospec-tive	Prospective	Prospective	Retrospective
Imaging technique	Ultrasound	MRI	CT-arthrography	CT-arthrography	MRI	CT-arthrography	MRI-arthrography
Healing rate (%)	84.7	89.7	71	41	82	88.5	12
Classification							
Follow-up (months)	35.5	16.1	29	19	12.7	>24	49.4
Risk factors for retear	Size Fatty degeneration	Smoking	Older age Delamination of the infra-scapularis Subscapularis tear	Longer symptom duration	Tension Fatty degeneration of the infraspinatus muscle		

The surgical technique plays a central role. Strong fixation must be achieved, but no suturing or anchoring method has been proven superior over the others. The surgeon must adapt the surgical technique to the local conditions, notably the shape and direction of the tear and the flexibility of its borders. The immobilisation and rehabilitation methods must also be adapted [28]. Nonsteroidal anti-inflammatory drug therapy is very effective in relieving the postoperative pain but may adversely affect tendon healing [29].

Thus, some factors can be controlled by the surgeon, such as the quality of the repair, whereas others are more difficult to

ADLER score

Are you able to

Comb your hair
Shave or put on make-up
Brush your teeth
Dress, i.e., put on a sweater or coat without assistance
Fill a glass from a full bottle, when seated
Drink (bring a glass up to your lips)
Eat soup with a spoon (filling the spoon completely)
Give a handshake or open a door
Use a telephone (holding it near your ear)
Write a letter (or sign a document or use a keyboard or play the piano)

Each activity confers three points: the score can range from 0 to 30.

Fig. 2. Activities of Daily Living requiring External Rotation (ADLER) score.

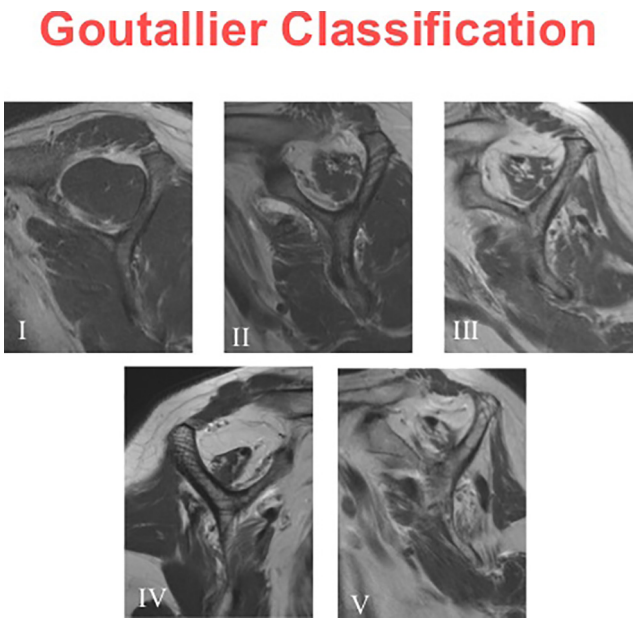

Fig. 3. Goutallier classification of fatty degeneration of the shoulder muscles (Equivalence IRM).

correct, notably those related to the patient (smoking, diabetes, hypercholesterolemia, poor patient adherence). These factors are of special importance during the intermediate period (21 to 45 days after surgery), when tissue healing replaces the effect of the sutures.

2.3. Failure in terms of social, occupational, and recreational activities

A cuff repair procedure that does not allow the patient to return to previous social, occupational, and recreational activities is considered a failure.

2.3.1. Prolonged recovery process

Rotator cuff tear is among the recognised occupational disorders (table 57 in France) and can occur as a work-related injury. The management and recovery process may be prolonged, with sick leave durations longer than 18 months.

2.3.2. Inability to return to work and sports

Return to work may prove impossible, despite workplace adjustments. Nové-Josserand et al. [30] reported that 41.5% of patients were unable to return to work. Thus, many patients must retrain for another job, retire, or be put on disability.

Collin et al. [31] found that one-fifth of patients had not returned to their previous occupation 6 months after surgery. Factors associated with failure to resume work were female gender, heavy manual work, and persistent bursitis detected by follow-up sonography.

2.4. Infection

Infection is a rare cause of failure and may require one or more further surgical procedures, which should be performed arthroscopically when possible. Infection may result in failed cuff healing and stiffness. The most common micro-organisms are *cutibacterium acnes*, *staphylococcus epidermidis*, and *staphylococcus aureus*. Infection remains a rare event, with an incidence of 0.3% to 1.9%. Risk factors include male gender, older age, and longer operative time. Prophylactic therapy with a single preoperative dose of antibiotic decreases the risk of infection [32].

In sum:

- the definitions and causes of failed cuff repair vary;
- failure may be defined based on patient perceptions, the structural result of the repair, or the functional outcomes;
- the main risk factors for repair failure are a larger initial tear and worse fatty degeneration of the muscles;
- failure consists chiefly in retear with persistent pain and/or loss of strength 6 months after the repair procedure.

3. What work-up is needed in patients with cuff repair failure?

3.1. Medical history-taking

Details should be recorded about social and occupational activities, previous health conditions, initial symptoms, and the goal of the first repair procedure (e.g., pain relief or strength recovery). The imaging studies performed before the initial procedure and the surgical report should be analysed. Points of special interest are suture tension, whether a watertight construct was achieved, and the extent of footprint coverage. This last factor, however, does not seem to influence the outcome [33].

The characteristics of the postoperative course should be specified (immobilisation, rehabilitation, postoperative trauma). The dominant arm should be recorded, as well as any functional impairment of the contralateral shoulder.

The patient should then be asked about the persistent complaints, notably pain, difficulties with movements required for daily activities or at work, recreational activities, and discomfort at night. The expectations of the patient should be determined with great accuracy. The time since the first repair procedure is also a major factor, since a long interval is a risk factor for failure to heal.

3.2. Physical evaluation

3.2.1. Acromio-clavicular joint

Osteoarthritis of the acromio-clavicular joint should be looked for by direct palpation and by performing Paxinos' test (Fig. 4) and Jacob's test (Fig. 5). Pain location at the upper part of the shoulder, a positive local injection test, and the imaging study findings can support the results of these three clinical signs.

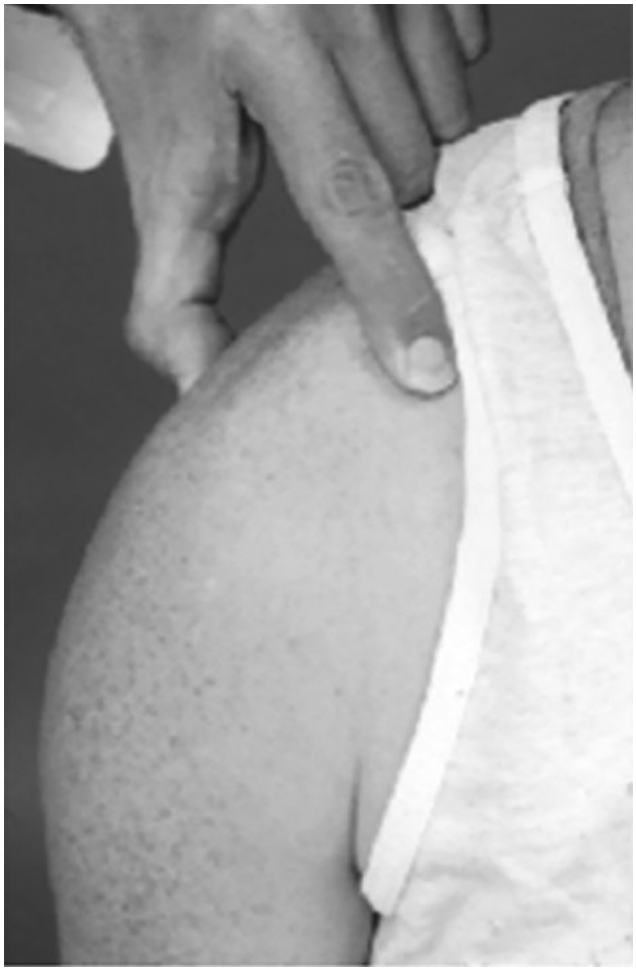

Fig. 4. Paxinos' test.

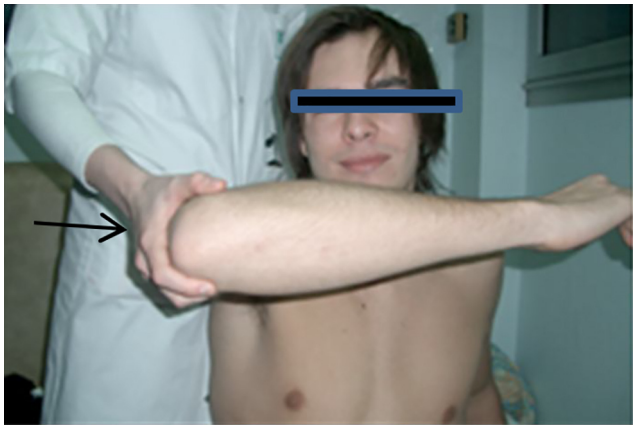

Fig. 5. Jacob's test.

3.2.2. Other tendons

Lesions of tendons that were not involved in the repair can be suspected clinically or detected during the first visit by sonography if the surgeon is trained in this imaging technique.

3.2.3. Mobility

Either a goniometer or a smartphone application should be used to measure range of motion.

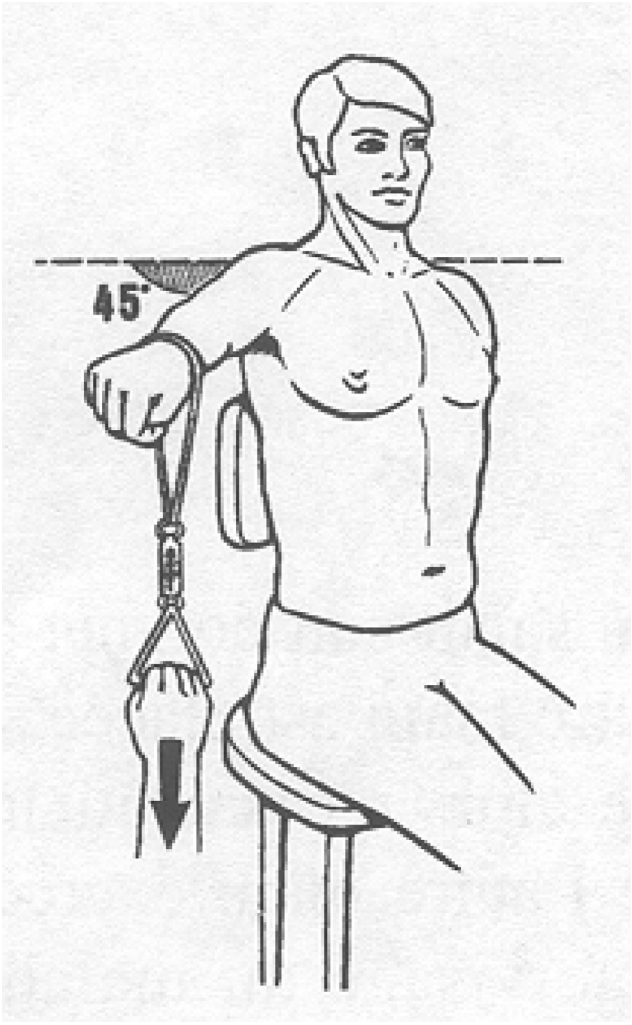

Fig. 6. Strength measurement using a dynamometer.

3.2.3.1. Stiffness. Stiffness is best assessed by recording the passive range of motion due solely to the gleno-humeral joint, by immobilising the tip of the scapula between the thumb and forefinger. Passive mobility is evaluated in all planes, including external rotation with the elbow by the side (ER1).

3.2.3.2. Pseudoparalysis. Pseudoparalysis is variably defined in the literature. One definition is active forwards elevation of less than 90° in the absence of shoulder stiffness, trauma, and acute inflammation [34].

3.2.4. Strength

Strength is a major objective parameter. Strength should be measured using a dynamometer under the conditions defined in Constant's score (Fig. 6).

3.2.5. Neurological examination

If the patient complains of shooting posterior pain, suprascapularis neuropathy should be considered. The provocative manoeuvre combines retropulsion of the shoulder with rotation and inclination of the neck towards the contralateral side, to stretch the nerve. An electromyogram and a local injection near the nerve under ultrasonography guidance are also useful.

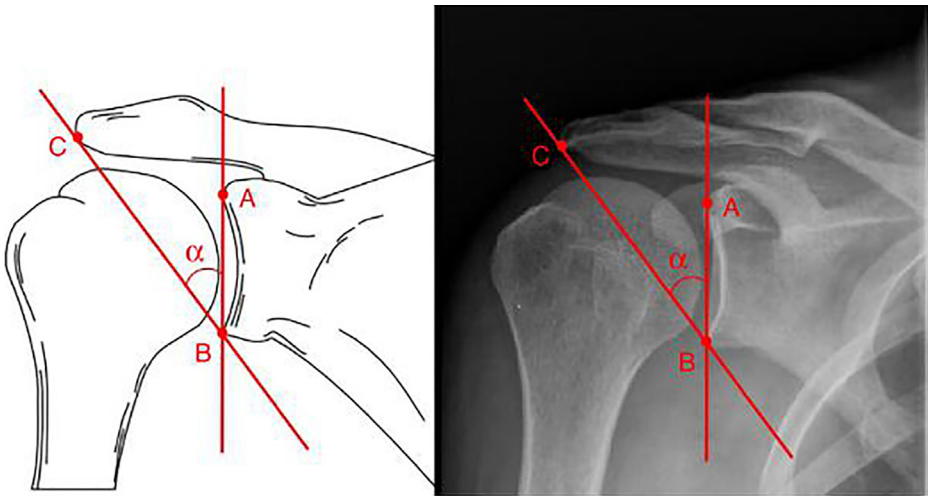

Fig. 7. The critical shoulder angle (CSA).

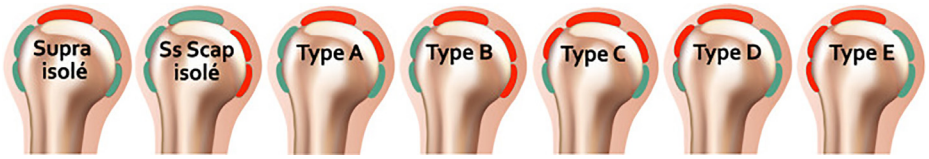

Fig. 8. Collin's classification.

3.3. Imaging studies

3.3.1. Radiographs

Radiographs are indispensable to assess centring of the humeral head in the coronal plane (acromio-humeral interval and Gothic arch on the antero-posterior view), the shape of the acromion (overhanging, tilted), calcification of the acromio-clavicular ligament, and signs of incipient gleno-humeral osteoarthritis. Garcia et al. reported that a high value of the critical shoulder angle, formed by the lateral border of the acromion and the vertical line through the superior and inferior margins of the glenoid (Fig. 7), was associated with an increased retear risk [35].

3.3.2. Sonography

One advantage of sonography is that dynamic imaging can be performed. Sensitivity is 80% and specificity 98% versus MRI for retear detection [36]. Sonography is an effortless means of monitoring the healing process over the first 6 months, which is the intermediate period during which the repair is relatively fragile.

3.3.3. Magnetic resonance imaging (MRI)

MRI is the most informative investigation for assessing the condition of the tendons, muscles, and cartilage (on T1-weighted sequences).

The classification developed by Sugaya et al. is the most widely used [37]. An analysis of the tendons and muscles allows classification of the patient according to Collin (Fig. 8): the risk of pseudoparalysis is greatest in types B (80%) and C (45%) [38]. The images should be examined for evidence of a retear within the muscle or at the musculo-tendinous junction.

Bipolar rotator cuff insufficiency, in which the tear is combined with absence of the greater tuberosity, and Fosbury flop tears characterised by reversal of the tendon stump are exceedingly rare [15].

3.3.4. CT-arthrography, MRI-arthrography

With CT-arthrography, the injection of a contrast medium provides details on the condition of the cartilage and can detect small fissures, tendon delamination, and widening of the suture holes.

In sum:

- the work-up in a patient with failed cuff repair differs little from the standard work-up. However, the patient must be asked about the circumstances of the first repair procedure (inadequate diagnosis? inadequate surgical technique?) and about any early or delayed trauma, which may have consisted in an aggressive rehabilitation programme;
- imaging studies including an MRI scan or CT-arthrography must be obtained before any decision about revision surgery;
- once the work-up is complete, and depending on the patient's wishes and local conditions, revision surgery can be considered.

4. Which patients are candidates to revision surgery?

4.1. Motivation, functional demands, and patient expectations

The patient's motivation for re-operation, functional demands, and expectations should be analysed. Re-operation often seeks to achieve a limited goal, which is chiefly to relieve the pain.

The ideal patient for re-operation is a male younger than 70 years of age, who is not seeking compensation, has more than 90° of forwards elevation [39], and has had a single previous repair procedure.

In addition to the patient's health status, the local conditions play a central role in the decision to perform a repeat repair procedure.

Table 2
Outcomes of repeat suturing.

Author	Lo	Keener	Piasecki	Lädermann	Parnes	Chuang	Shamsudin	Valencia
Study design	Retr.	Retr.	Retr.	Retr.	Retr.	Retr.	Retr.	Retr.
Number of cases	14	21	54	74	94	32	50	51
Massive tear	79%	NR	7%	72%	54%	59%	NR	49%
Postoperative range of forwards elevation (°)	153	146	136	152	NR	156	NR	
Post-operative ASES	NR	74	67	77	NR	87	NR	
Factors of good prognosis								Small size Elevation > 90°
Failure to heal (%)	NR	52	NR	NR	10.6	NR	40	
Revision (%)	0	0	11.1	8.1	9.6	NR	12	

Retr.: retrospective; NR: not reported.

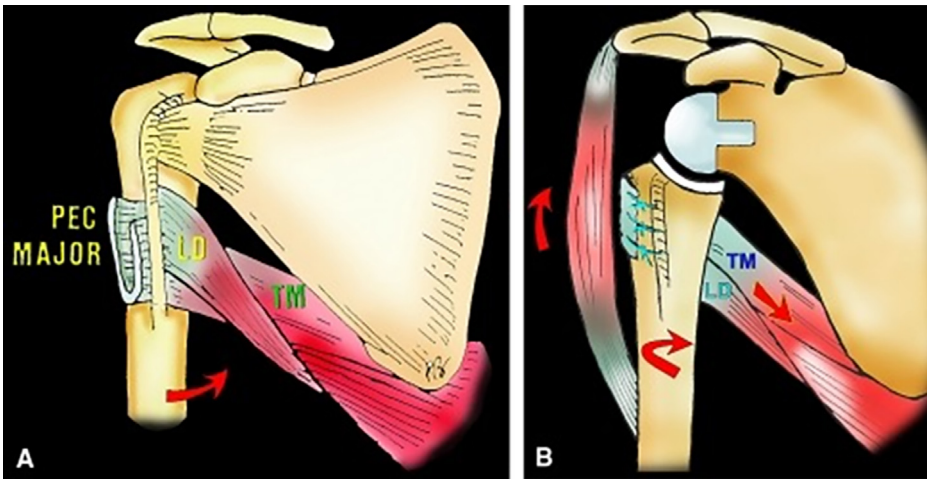

Fig. 9. Latissimus dorsi transfer as described by L'Episcopo.

4.2. Local conditions

4.2.1. Muscles

A careful assessment of the muscles on the sagittal T1-weighted MRI views is of paramount importance. The MRI scan must include slices medial to the coracoid process.

4.2.2. Tendons

If the motor (e.g., the muscles) appears functional, then the belt (e.g., the tendons) should be evaluated. In addition to retraction, there may be structural defects [14]. MRI provides information on the length and thickness of the tendons, as well as on their degree of degeneration (intermediate-intensity signal).

4.2.3. Cartilage

The presence of a cartilaginous lesion does not support a repeat surgical procedure, particularly on the tendons.

4.2.4. Bone

Osteopenia of the greater tuberosity should be taken into account [40]. The decreased bone density seen in chronic tears does not seem to influence the healing rate. Anchors are more stable when inserted near the cartilage and located at the lower part of the vertical portion of the greater tuberosity, where the bone is strongest.

Cysts may develop around absorbable anchors. A large defect in the greater tuberosity, which may be of traumatic origin, is a less common challenge to a repeat surgical procedure.

4.2.5. Centring of the humeral head

An eccentric humeral head position is extremely difficult to correct by repeat repair surgery. It is a relative contra-indication to repeat repair and may, depending on the course, warrant RSA. In this specific scenario, humeral head centring should be assessed on both antero-posterior and lateral views.

4.3. Time to re-operation

Given the risk of progressive deterioration of the local conditions, the re-operation should not be postponed in the presence of shoulder pain or functional impairment, notably in young, physically active patients. The fact that retears develop early further supports this attitude.

In sum:

- the ideal conditions for re-operation are a small retear, with good-quality muscles and tendons and no evidence of gleno-humeral osteoarthritis.

5. Which surgical techniques are available and what are their outcomes?

5.1. Palliative procedures

5.1.1. Arthroscopic capsular release

Arthroscopic capsular release can be considered in patients with persistent stiffness despite optimal rehabilitation therapy, provided tendon healing has been achieved.

5.1.2. Arthroscopic debridement

5.1.2.1. Biceps tenotomy. Biceps tenotomy is probably the least aggressive procedure. However, the biceps tendon is rarely involved in revision surgery and is usually managed during the initial repair.

5.1.2.2. Acromioplasty. Insufficient acromioplasty has been suggested as warranting revision surgery. However, whether acromioplasty performed during the initial repair procedure provides benefits remains actively debated [41].

5.1.2.3. Tuberoplasty. When the greater tuberosity is irregular or congenitally prominent, re-shaping does not carry any risk of destabilisation.

5.1.3. Superior capsule reconstruction; absorbable sub-acromial spacer

Reconstruction of the superior capsule using a substitute [42] and implantation of an absorbable subacromial spacer (inflated balloon that undergoes resorption over time) [43] require further evaluation of their efficacy when used for revision surgery.

5.2. Curative procedures

5.2.1. Partial or total direct repeat repair

Repeat suturing of the torn tendons to restore a watertight cuff is the most widely performed re-operation in motivated patients who have favourable local conditions. Nevertheless, the outcomes are less good than those of primary repair (Table 2).

An alternative is partial suturing with the goal of obtaining a cuff that is functional, although not watertight, by restoring the anterior and posterior rotator cables according to the theory put forward by Burkhart [44]. An interesting option for revision procedures consists in side-to-side suturing of the infraspinatus and subscapularis tendons (V-Y suture or margin convergence [45]).

5.2.2. Tendon transfers

Several tendon transfer procedures have been described for the treatment of massive cuff tears, which may be accompanied with loss of external rotation. The best known is the latissimus dorsi transfer [46]. Valenti et al. [47] reported that the patient satisfaction rate with this procedure was 50% after revision surgery compared to 84% after primary repair.

Transfer of the pectoralis major has been suggested for sub-scapularis tears. However, the latissimus dorsi transfer has superseded this procedure, as it is more logical in terms of the direction of the force vectors along the torn tendon and transfer.

To restore external rotation, Elhassan et al. [48] suggested using the inferior trapezius. However, an elegant and minimally aggressive option consists in the latissimus dorsi transfer technique developed by L'Episcopo (Fig. 9).

No studies have specifically evaluated these procedures when used for revision surgery. Contraindications to *latissimus dorsi* transfer consist in involvement of the lower portion of the subscapularis, eccentric humeral head position, Hamada grade 4 or 5 gleno-humeral osteoarthritis, pseudoparalysis and, according to some authors, a tear in the teres minor tendon.

5.2.3. Patch graft repair

In patients with tendon defects, reconstruction with a biological material (autograft, allograft, substitute) is controversial (Fig. 10). Promising results have been obtained in several studies [49–51].

In patients undergoing primary surgery for irreparable massive cuff tears, Mori et al. [52] reported retear rates of 8.3% after fascia-lata patch grafting compared to 41.7% after partial repair.

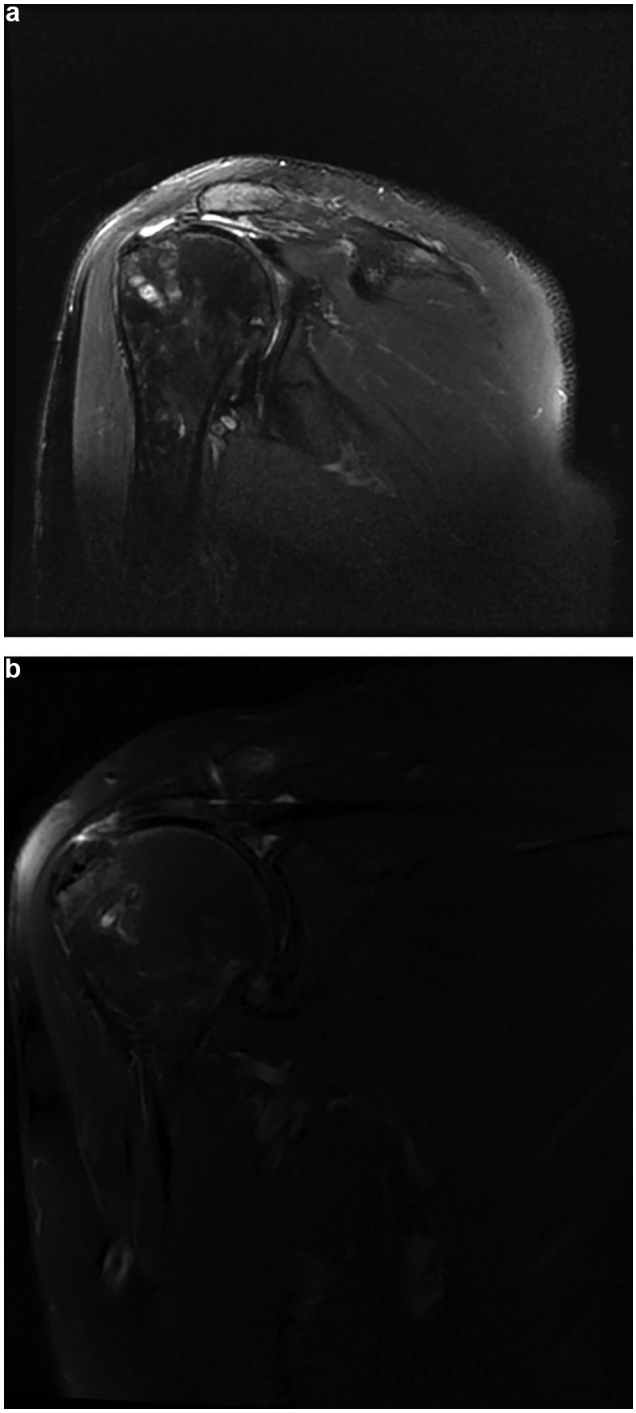

Fig. 10. a and b. Magnetic resonance imaging views after autografting at the triceps brachii.

5.2.4. Adjuvants: platelet-rich plasma, stem cells

Adjuvants such as platelet-rich plasma and stem cells have been proven effective in vitro. Although they may hold promise when used during repeat suturing adjuvants, their efficacy in primary cuff repair surgery remains unproven [1].

5.3. Reverse shoulder arthroplasty (RSA)

RSA is without doubt the procedure that provides the most predictable outcomes, particularly when the humeral head is not centred. However, when performed because of shoulder pain, there

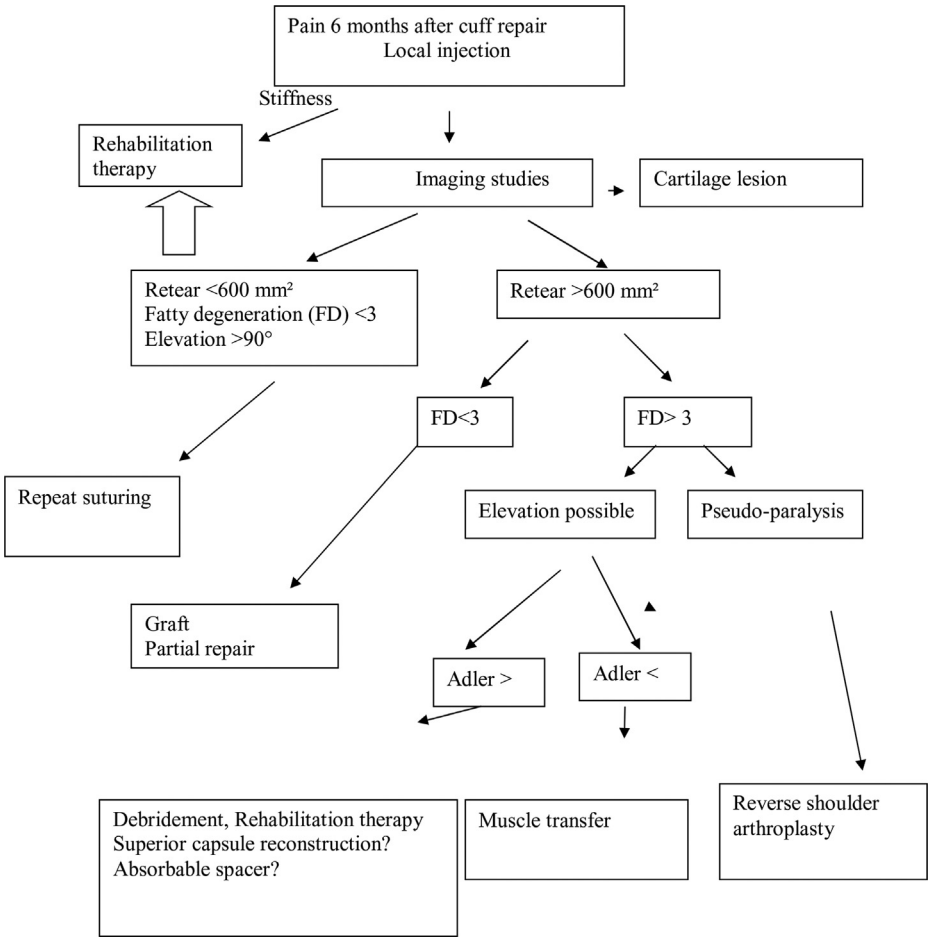

Fig. 11. Algorithm.

is a risk of motion range limitation [53]. RSA is chiefly reserved for patients with an eccentric humeral head position or age above 70 years.

In young patients, RSA has a high complication rate. Thus, the overall complication rate in patients younger than 60 years studied by Gerber et al. [54] was 39%.

In sum:

- repeat suturing of small retears and RSA for extensive retears have been proven effective;
- studies of repeat procedures are scarce and included small numbers of patients;
- in the absence of postoperative trauma, it may seem reasonable to perform a different procedure from the failed one, provided the initial indication was appropriate and technical criteria required for repeat surgery are met;
- the various procedures provide poorer outcomes when used to treat failed cuff repair compared to primary cuff repair [53].

6. How can repair failure be prevented?

6.1. Preventing failure to heal

To avoid failure to heal, criteria such as those defined by Zingg et al. [55] should be applied to determine whether the tear can be repaired. The repair should be free of tension [56] and the stiches should preserve blood flow [57]. Separate sutures should be used to prevent widening of the suture holes.

The rehabilitation programme should be tailored according to the size of the tear and severity of degenerative tendon changes [12]. Smoking cessation is indispensable before any cuff repair procedure, and a cholesterol-lowering treatment may be in order [58].

6.2. Preventing failures due to absence of treatment of concomitant lesions

The need for treatments to correct concomitant abnormalities during the cuff repair procedure should be discussed routinely. Examples include distal clavicle resection, trimming or re-attachment of the upper portion of the subscapularis, and layered repair of infraspinatus tendon delamination.

In thin but muscular patients, biceps tenodesis should be performed to prevent downwards displacement of the biceps brachii muscle.

Shoulder stiffness should be treated by rehabilitation before the repair procedure.

6.3. Preventing failure to achieve social, occupational, and recreational goals

The patient should be given detailed information, notably about sick leave duration (9 months at the most for a work-related injury in France) and the possibility that workplace adjustments or job retraining may be required.

Oddly enough, the rate of return to recreational sports is higher [59].

In sum:

The prevention of cuff repair failure relies chiefly on appropriate patient selection for the primary repair procedure.

Concomitant abnormalities should be treated also.

7. Can a treatment algorithm be developed?

In patients who have persistent pain 6 months after cuff repair surgery despite receiving rehabilitation therapy and, if appropriate, a local injection, an imaging work-up should be obtained.

Repeat suturing can be considered of the following criteria are met: retear smaller than 4 cm in the coronal plane or 3 cm in the sagittal plane [60], fatty degeneration index below 3, and forwards elevation above 90°.

If the retear is larger than 4 cm in the coronal plane or 3 cm in the sagittal plane and the fatty degeneration index is below 3, either patch grafting or a partial repair should be performed.

Patients with massive tears and a fatty degeneration index of 3 or more can be offered a muscle transfer procedure or, in the event of pseudo-paralysis, RSA (Fig. 11).

Non-operative treatment (rehabilitation and local injections) should be considered in patients with manageable pain and limited physical activities [61]. If the retear is limited and smaller than the initial tear, good clinical outcomes can be achieved [62]. Jost et al. [63] reported that the outcomes of non-operated retears remained stable after a mean follow-up of 7.6 years.

8. Conclusion

The management of retears after failed cuff repair procedures is complex and should take both the pain and the functional impairments into account, most notably in younger patients who are still working.

Repeat suturing is an option in patients with small retears, good-quality muscles, and more than 90° of forwards elevation.

Reconstruction techniques that use a reinforcement prosthesis, matrix, or graft are being evaluated.

Muscle transfer procedures can produce improvements, provided their contra-indications are taken into account.

RSA is chiefly indicated in older patients with an eccentric humeral head position.

In most patients with failed tendon healing, no further surgery is performed. In the event of repeat surgery, all the available techniques produce poorer outcomes than when used for primary surgery.

Disclosure of interest

The author declares that he has no competing interest.

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