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ORIGINAL PAPER

Massive rotator cuff tears: definition and treatment

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Abstract
Purpose The aim of this review is to summarise tear pattern classification and management options for massive rotator cuff tears (MRCT), as well as to propose a treatment paradigm for patients with a MRCT.
Method Data from 70 significant papers were reviewed in order to define the character of reparability and the possibility of alternative techniques in the management of MRCT.
Results Massive rotator cuff tears (MRCT) include a wide panoply of lesions in terms of tear pattern, functional impairment, and reparability. Pre-operative evaluation is critical to successful treatment. With the advancement of medical technology, arthroscopy has become a frequently used method of treatment, even in cases of pseudoparalytic shoulders. Tendon transfer is limited to young patients with an irreparable MRCT and loss of active rotation. Arthroplasty can be considered for the treatment of a MRCT with associated arthritis.
Conclusion There is insufficient evidence to establish an evidence-based treatment algorithm for MRCTs. Treatment is based on patient factors and associated pathology, and includes personal experience and data from case series.

Keywords Shoulder function · Massive rotator cuff repair · Cuff tear arthropathy · Scores · Tendon transfer · Arthroscopy · Pseudoparalysis · Reverse shoulder arthroplasty · Outcome

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Introduction

Massive rotator cuff tears (MRCT) comprise approximately 20 % of all cuff tears and 80 % of recurrent tears [1, 2]. This condition can be treated with various approaches, according to clinical factors, characteristics of the tear and biological factors [3]. Advances during the last 15 years of arthroscopic and prosthetic techniques, and better understanding of pathoanatomy have opened new frontiers in management of this condition, such that some of the previous definitions and treatment options are no longer valid.

Few articles have been published about the proper management of MRCT [4–11]. This article provides a comprehensive review of current concepts pertaining to MRCT, including a contemporary definition and classification of this lesion, a review of pertinent biomechanical changes induced by this condition, and clinical, radiological and electromyographic (EMG) implications. Lastly, this article presents the authors' preferred options and their treatment algorithm to provide the best functional outcome.

Definition and classification

Massive rotator cuff tear

Historically a massive rotator cuff tear has been described as a tear with a diameter of 5 cm or more as described by Cofield [12] or as a complete tear of two or more tendons as described by Gerber [13] (Figs. 1, 2 and 3). The former in particular is usually applied at the time of surgery. In an attempt to provide a pre-operative MRI-based classification, Davidson et al. defined a massive tear as one with a coronal length and sagittal width greater than or equal to 2 cm [14]. Unfortunately, these systems are vulnerable to error due to variation in patient size and arm position at the time of measurement. It is more appropriate to define the size of a tear in terms of the amount of tendon that has been detached from the tuberosities. While the Gerber definition helps account for variability in size [13], there are exceptions to the complete two-tendons requirement and this classification does not distinguish different patterns or predict function. Additionally, the authors of the present review believe that this definition is outdated due to skills developed with arthroscopy. For example, in using the term "massive" there is a connotation of difficulty and irreparability. While challenging, most MRCT are reparable and other factors like the tendon retraction, atrophy, arthritis, and mobilisation must be taken into account. Thus, we believe that in addition to the number of tendons involved, at least one of the two tendons must be retracted beyond the top of the humeral head (Patte [15] 3 for the supraspinatus in the coronal plane; Fig. 4). Such classification also takes advantage of three-dimensional information on tear pattern, providing guidance on treatment technique [14].

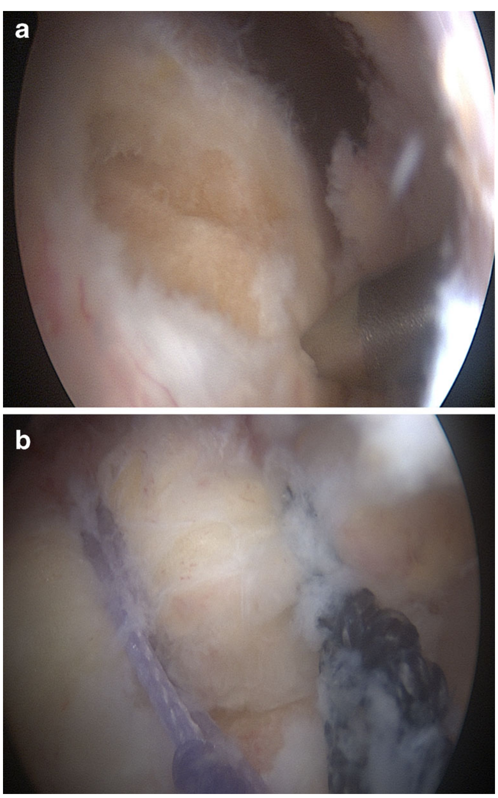

Fig. 1 Small right rotator cuff tear posterior view before (**a**) and lateral view after (**b**) arthroscopic repair

Once a MRCT is identified, it can be further classified according to Collin et al. [16]. In this classification, the rotator cuff is divided into five components: supraspinatus, superior subscapularis, inferior subscapularis, infraspinatus, and teres minor (Fig. 5). Rotator cuff tear patterns can then be classified into 5 types: 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. 6) [16]. This classification not only subclassifies massive tears but has also been linked to function, particularly the maintenance of active elevation [16].

Irreparable rotator cuff tears

The definition of an irreparable rotator cuff varies widely. At one extreme some surgeons argue that all rotator cuff tears are reparable. Others consider tears with a chronic acromiohumeral distance (AHD) less than 7 mm [17] or atrophy greater than grade 2 [18] irreparable. While we believe most rotator cuff tears can be repaired, we acknowledge that some lesions are not reparable or should not be repaired and several preoperative factors should be considered before attempting repair. Furthermore, with advances in anchors, suture strength, techniques of release and repair with load-sharing rip-stop fixation [19], interval slides [20], etc., the definition of irreparable continues to evolve.

The most important prognostic factor is nonfunctional muscle bellies (grade 3 or 4 fatty infiltration) [21]. But, there is confusion regarding this classification. Goutallier et al. classified muscle quality by the amount of fatty infiltration in the rotator cuff muscle as identified on CT in the axial plane, with a thorough analysis of the whole muscle belly [21]. With the advent of magnetic resonance imaging (MRI), however, the classification was extrapolated to the most lateral parasagittal image on which the scapular spine was in contact with the scapular body (Y view) [22]. The latter is related to musclotendinous retraction. As a result, a normal muscle can be interpreted as completely fatty infiltrated if such MRI criteria are used (Fig. 7), and conversely, supposed fatty infiltrated muscle can appear normal postoperatively, making surgeons believe fatty infiltration has been reversed. Fatty degeneration is irreversible even with repair and leads to reduced function of the rotator cuff musculature [23]. If associated with preoperative supraspinatus tendon length of less than 15 mm, MRCTs with Goutallier stages 2 to 3 MRCT fail to completely

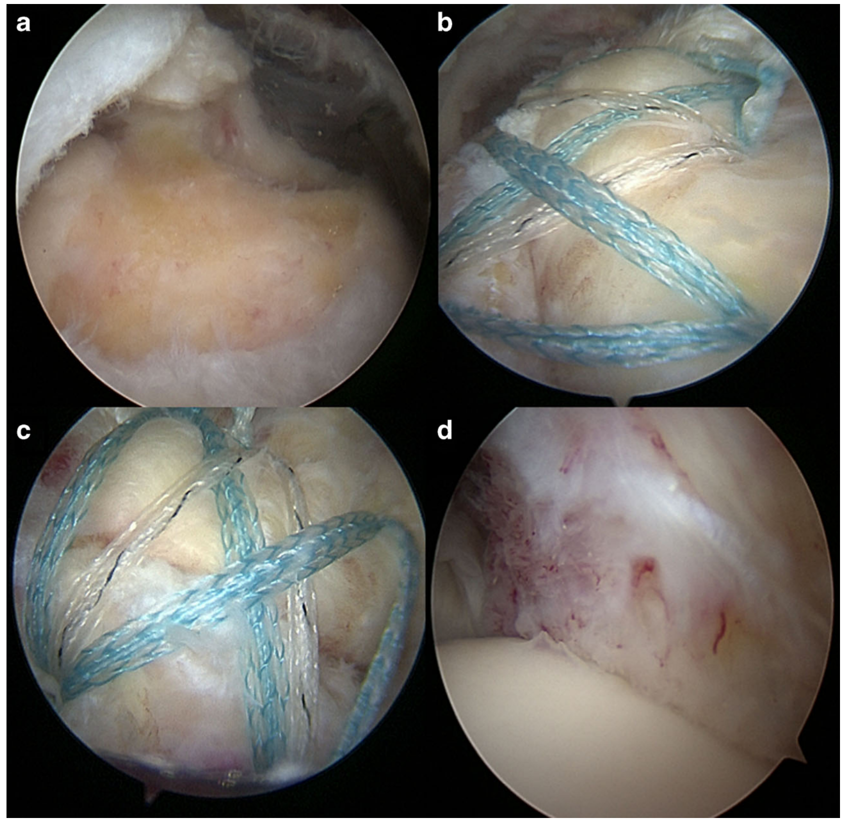

Fig. 2 **a** Large tear of a right rotator cuff. Anterior (**b**) and lateral (**c**) views of the repair. **d** Intra-articular view confirming a perfect reduction of the tendon on the medial footprint

heal in up to 92 % of cases [24]. Yet, some authors have reported improvement in function outcome (irrespective of healing) with an arthroscopic repair in patients with grade 3 or even grade 4 atrophy [25].

The tangent sign [26] is an indicator of advanced fatty infiltration [27] and has been reported to be a predictor of whether a rotator cuff tear will be reparable [28]. On the other hand, in a recent prospective analysis we found that a complete repair could be achieved in over 90 % of patients with this sign (unpublished data). Acetabularization of the acromion and femoralization of the humeral head are pre-operative factors reflecting significant chronic static instability and are a contraindication for repair.

Pseudoparalytic shoulder

Pseudoparalysis is defined as an inability to actively elevate the arm beyond 90° with full passive forward flexion. It is also

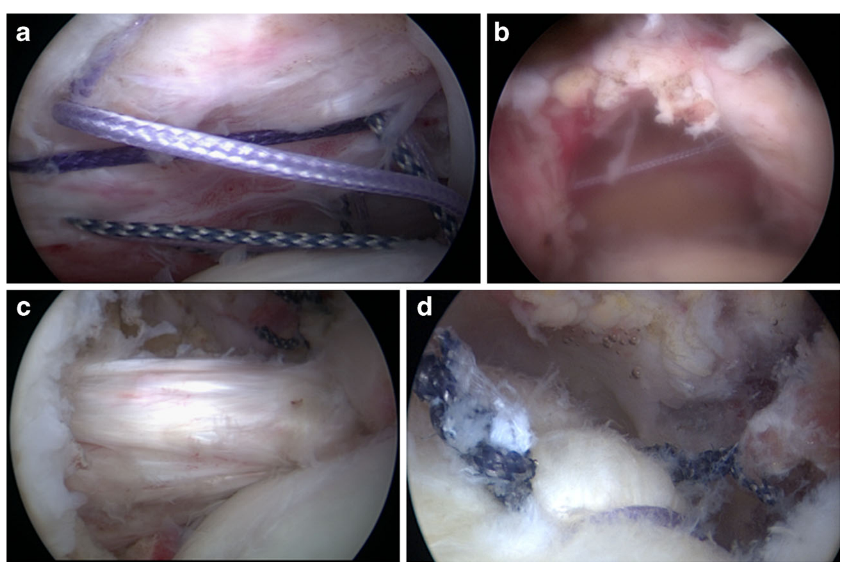

Fig. 3 Massive rotator cuff tear of a right shoulder. **a** Intra-articular view which confirms a complete lesion of the subscapularis. **b** The lateral view demonstrates a complete tear of supra- and infraspinatus tendons. Note the purple suture under the tendon used for a rip-stop configuration repair. Intra-articular (**c**) and subacromial (**d**) posterior views that confirm complete repair of the subscapularis and postero-superior rotator cuff, respectively

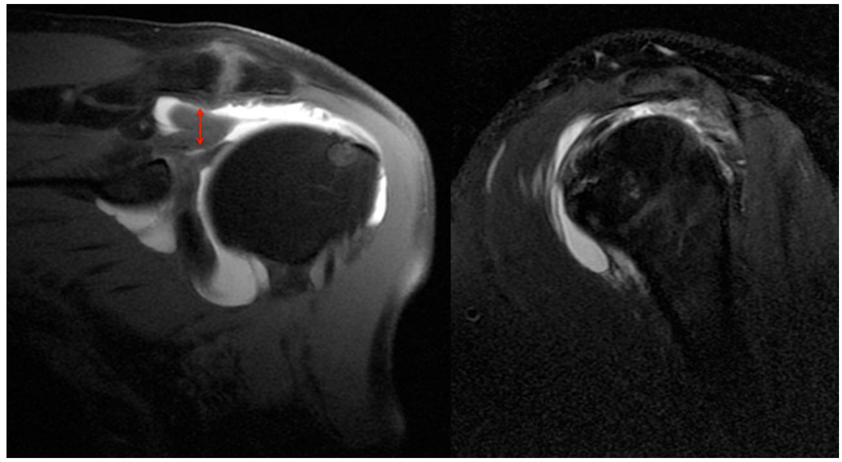

Fig. 4 Left massive rotator cuff tear (MRCT) in a 71-year-old patient. The coronal DP T1 FAT SAT view revealed a Patte 3 retraction and a thick (15 mm) tendon (*red arrow*), evoking a Fosbury flop lesion [72]. The supraspinatus and infraspinatus are both completely detached on the sagittal DP FAT SAT view

important to note that this is functional limitation and not pain inhibition; this can be distinguished by the inability to hold the arm at 90° and/or an evaluation of motion after a subacromial injection. Anatomically, pseudoparalysis requires the disruption of at least one rotator cable attachment. Recently it has been demonstrated that dysfunction of the entire subscapularis and supraspinatus (Collin B) or three rotator cuff muscles are risk factors for pseudoparalysis [16]. Primary arthroscopic repair can lead to reversal of pre-operative pseudoparalysis in 90 % of patients, but in only 43 % of revision surgeries [29].

Biomechanics

A primary function of the rotator cuff is to work synergistically with the deltoid to maintain a balanced force couple about the glenohumeral joint. A force couple is a pair of forces that act on an object and tend to cause it to rotate. For any object to be in equilibrium, the forces must create moments about a center of rotation that are equal in magnitude and opposite in direction. Coronal and transverse plane force couples exist between the subscapularis anteriorly and infraspinatus and teres minor posteriorly. The rotator cuff force across the glenoid provides concavity compression, which creates a stable fulcrum and allows the periscapular muscles to move the humerus around the glenoid.

The rotator cable is a thickening of the rotator cuff that has been likened to a suspension bridge in which force is distributed through cables that are supported by pillars (the anterior and posterior attachments). The anterior rotator cable attachment bifurcates to attach to bone just anterior and posterior to the proximal aspect of the bicipital groove. The posterior attachment comprises the inferior 50 % of the infraspinatus. With small central tears the cable attachments often stay intact and forces are transmitted along the rotator cable. The rotator cable also explains why patients with most rotator cuff tears can maintain active forward flexion, and also why even after only a partial rotator cuff repair, good functional results can be

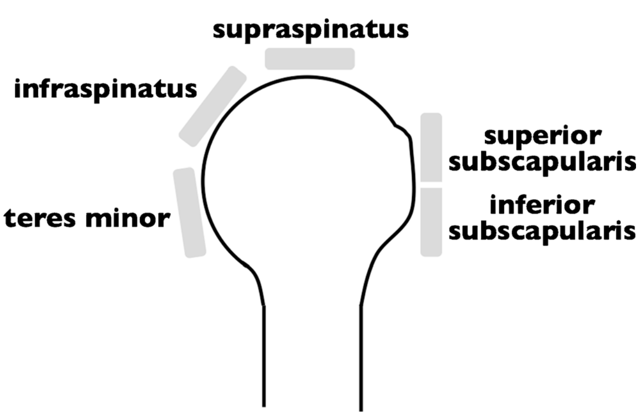

Fig. 5 The rotator cuff is divided into five components: supraspinatus, superior subscapularis, inferior subscapularis, infraspinatus, and teres minor

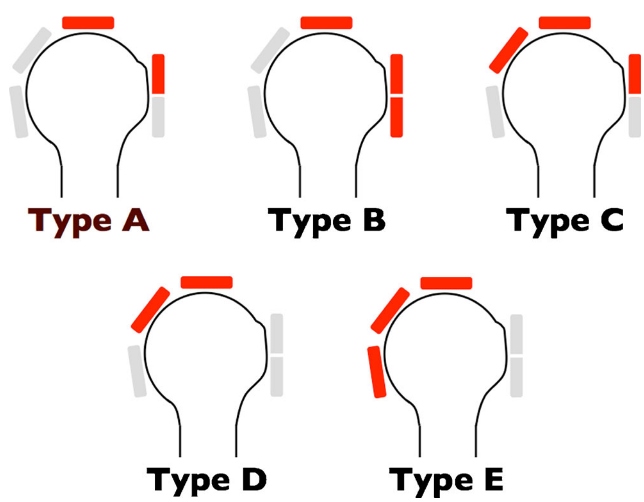

Fig. 6 Rotator cuff tears classified by the involved components: type A, supraspinatus and superior subscapularis tears; type B, supraspinatus and entire subscapularis tears; type C, supraspinatus, superior subscapularis, and infraspinatus tears; type D, supraspinatus and infraspinatus tears; and type E, supraspinatus, infraspinatus, and teres minor tears

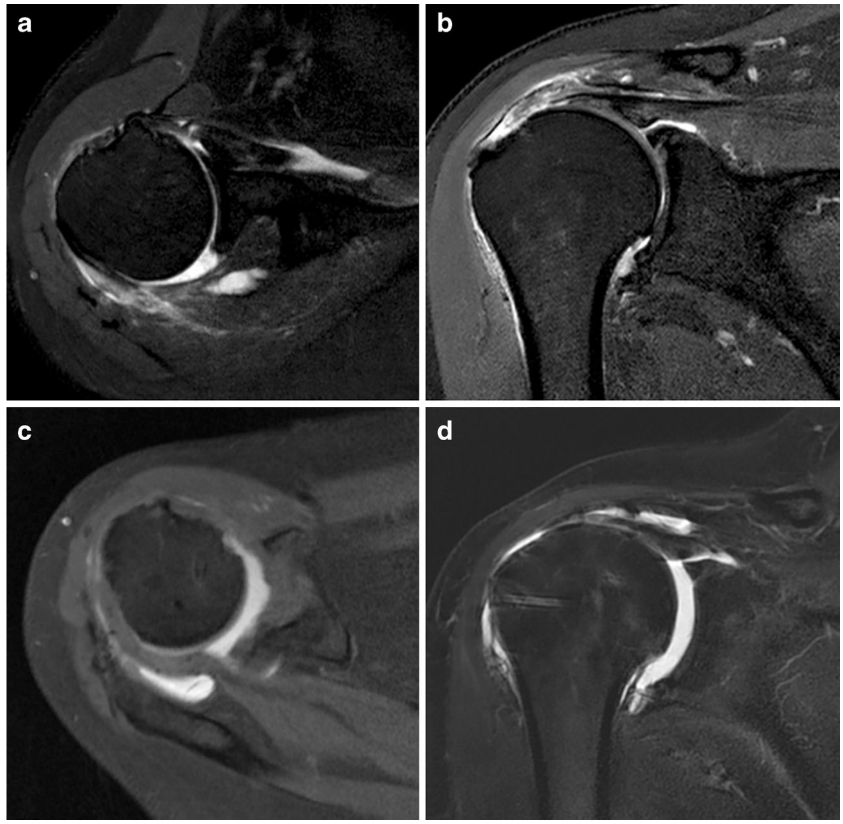

Fig. 7 Sixty-nine-year-old patient known for an open right rotator cuff repair 15 years ago. He sustained a fall and developed immediate pain and pseudoparalysis of the right shoulder. **a** The axial T2 view reveals a rupture of the subscapularis with medial dislocation of the long head of the biceps. **b** The coronal T2 view shows a complete rupture of the postero-superior rotator cuff with a Patte 2 retraction. The patient experienced pain two months after surgery during an anodyne movement. Axial T1 and coronal T2 images demonstrated a re-tear of the postero-superior lesion only (**c** and **d**, respectively)

achieved [30]. However, in the setting of MRCT with rotator cable disruption and non-compensation by other humeral head stabilizers (i.e., pectoralis major and latissimus dorsi), the moments created by the opposing muscular forces are insufficient to maintain equilibrium in the coronal plane, resulting in altered kinematics, instability, and ultimately in pseudoparalysis.

Physical examination

Functional deficits often correlate with the location of the tear. Type A disruption typically causes a decrease in internal rotation strength with positive Belly press and Bear Hug tests. Superior rotator cuff insufficiency, present in all types of massive tears, is usually associated with a positive Jobe manoeuver and decreased strength in the external resistance of the elbow at the side. Posterosuperior (type D) MRCTs may have a positive external rotation lag sign. Posterosuperior MRCT with an extension to the teres minor (type E) may have an external rotation lag sign of greater than 40°, Patte and drop [31]. Moreover, patients of the latter group often exhibit a positive hornblower sign which is the inability to maintain external rotation with the arm abducted 90°; symptomatic patients typically report an inability to bring the hand to mouth without abduction of the affected shoulder.

Imaging

Imaging studies play a critical role in both the diagnosis and the selection of the correct treatment for MRCT. The analysis should always begin with plain radiographic views. A true anteroposterior X-ray with the arm in neutral rotation, and the patient relaxed is obtained to evaluate the shape of the acromion and greater tuberosity, the critical shoulder angle, and the AHD. Lateral Y-view is used to analyse the presence of a spur; the shape of the acromion on this view is less accurate to detect full-thickness rotator cuff tear [32]. An axillary lateral view can exclude static anterior subluxation. If pathology of the acromio-clavicular joint is suspected, a Zanca view is additionally acquired.

Following X-ray evaluation, advanced imaging modalities are obtained to confirm and plan treatment. Ultrasonography is an excellent cost-effective screening tool in the office but does not allow evaluation of intra-articular pathology or easy evaluation of muscle quality. MRI accurately estimates tear pattern, fatty infiltration, and retraction, and is thus obtained to plan arthroscopic repair or tendon transfer. The muscle bellies are assessed, if available, on T1-weighted axial, coronal, and sagittal views with cuts sufficiently medial to allow proper assessment regardless of retraction. Finally, computed tomography (CT) scans are used if MRI is contraindicated or if joint replacement is planned, particularly in the setting of glenoid deformity.

Suprascapular nerve neuropathy and MRCT

Recently there has been growing interest in the relationship between suprascapular neuropathy and MRCTs. Theoretically, medial retraction of posterosuperior rotator cuff tears can place excessive traction on the suprascapular nerve [33]. However, clinical diagnosis is beset with uncertainties as the potential symptoms of suprascapular nerve neuropathy, namely, pain, weakness, and atrophy, are inseparable from those of MRCT. There is actually no support for routine suprascapular nerve release when MRCT repair is performed for several reasons. First, it is clearly demonstrated that repair of MRCT without release leads to satisfactory results. Moreover, the prevalence of suprascapular nerve neuropathy in case of MRCT in a recent prospective study was low (2 %) [34].

Treatment options

It should be remembered that nonoperative treatment is successful in many cases. When surgery is indicated, the primary aim is restoration of force couples and anatomic or partial repair of the rotator cuff to its footprint. However, a number of factors (refusal of the patient, biologic factors, characteristics of the tear, etc.) can make these goals difficult, impossible, or unwanted to achieve. Fatty infiltration, rotator cuff retraction, and poor tendon compliance are common in patients with MRCT. In these situations, other approaches have been advocated, with varying degrees of success [35]. These include physical therapy [36, 37], subacromial decompression and palliative biceps tenotomy (subacromial debridement) [38], muscle transfer [39], and reverse shoulder arthroplasty [40]. However, there are no randomized controlled trials comparing these various options and recommendations are mainly based on retrospective case series and the surgeon's own experiences.

Conservative treatment

Many patients with MRCT respond favourably to nonsurgical treatment. Nevertheless, patients must be aware that despite clinical improvement, future treatment may be impacted by progression of glenohumeral osteoarthritis and fatty infiltration as well as narrowing of the AHD. In a series of 19 patients with MRCTs treated nonoperatively the average Constant score was 83 % at a mean follow-up of 48 months. However, 50 % of "reparable" tears became "irreparable" during this period [37].

The mainstay of nonoperative treatment includes nonsteroidal anti-inflammatory drugs, subacromial corticosteroid injections, and physical therapy. The protocol of rehabilitation focused habitually on global deltoid reconditioning and periscapular strengthening. Although certain authors proposed that re-education of the anterior deltoid muscle to compensate for a deficient rotator cuff is the cornerstone, we attach more importance to solicitation of stabilizing muscles of the glenohumeral joint with an approach based on exercises in high position. In this position, the deltoid, which acts synergistically with the remaining rotator muscles, has no upward component and participates in the articular coaptation [36].

In general, nonoperative management is attempted for six months before considering surgery. Younger patients (<60 years of age), however, may be immediate candidates for surgery based on the high risk for progression with conservative treatment. If after six months, symptoms have not improved, the chances of success with further nonoperative treatment decreases and operative treatment may be considered for older patients. It is unclear if it is exercise alone or exercise in combination with other interventions during the recovery process that offers the greatest benefit. In a recent prospective cohort of 45 patients suffering from pseudoparalysis with a radiographically confirmed MRCT, Collin and al. found after a follow-up of 48 months that the mean Constant score improved from 43 to 56 points and the mean forward flexion improved from 76° to more than 160° after completion of the program [36]. They also demonstrated that effectiveness of physical therapy is related to the size and location of the lesion; if the tear involved the posterosuperior rotator cuff (B type), or only two tendons or less, most patients regained active anterior elevation that persisted for 48 months [36]. The anterior rotator cuff is the key of anterior active elevation as only 20 % of patients with MRCTs, but an intact subscapularis, develop pseudoparalysis [16].

Operative treatment

For older patients surgery is considered when nonoperative treatment fails. Additionally, we often consider surgery as first line treatment in young patients because there is a high rate of progression with conservative treatment and for tears involving the anterior rotator cable since this area is most important to maintenance of forward elevation as previously noted.

A primary or revision approach, either open or arthroscopic, should be discussed if the rotator cuff is still reparable [41, 42]. If the tear is irreparable a variety of other options have been proposed. These include debridement with or without a biceps tenotomy/tenodesis [38] or acromioplasty/tuberoplasty [43, 44], partial rotator cuff repair [45], tendon transfers [39], graft or biodegradable spacer interposition [46], superior capsule reconstruction [47] and arthroplasty [48]. Although they are consistently proposed in review articles as part of a treatment algorithm, we feel that simple subacromial debridement, isolated tuberoplasty, deltoid flap and hemiarthroplasties have very limited and primarily historical roles because the results of the procedures have been disappointing over time. On the other hand, recent innovative methods, such as trapezius transfer to improve external rotation, superior capsular reconstruction, and insertion of a biodegradable spacer, are in their early stages and will consequently not be discussed in this review article.

Arthroscopic rotator cuff repair

Our approach is to repair all of the rotator cuff that can reasonably be brought back to the tuberosities without excessive tension, and to address all potential causes of persistent pain or factors threatening the repair. The goal of a repair, even if partial, is to restore force couples [45] and to re-establish the "suspension bridge" [49]. In this theory, complete closure of the defect is less important than restoration of a stable fulcrum for normal shoulder kinematics. Although shoulder strength may not improve after this intervention, function is usually enhanced because of relief from pain caused by mechanical impingement. Additionally, although complete healing of massive tears is not always achievable, we believe that partial healing of the cuff may prevent secondary extension of the tear.

Repair techniques have been previously thoroughly described [50]. Mobilization techniques vary based on the type of lesion [14] and surgeons' preferences. Margin convergence, interval slides [20] and reinforcement by biological and synthetic grafts [51] have all been suggested but it is not clear when each becomes beneficial.

The acromion and biceps

Complete anterior acromioplasty is not advisable in the setting of a massive tear as it may lead to postoperative anterosuperior migration of the humeral head. The acromio-humeral arch is probably a component of human evolution used to compensate the deficiency of the superior rotator cuff [52]. However, the lateral acromion might be responsible for more impingement than the anterior part [53] and may increase stress on the repaired rotator cuff [54]. Consequently, we recommend adding a lateral acromioplasty to any postero-superior rotator cuff repair if the critical shoulder angle is above 35° [55, 56]. This is done in an arthroscopic fashion, but bevelling the undersurface of the acromion with care taken to not disrupt the deltoid insertion.

We almost consistently performed a tenotomy or tenodesis of the long head of the biceps in the setting of a massive rotator cuff tear. There is evidence suggesting that the long head of the biceps tendon may be a source of pain and contributes to the discomfort associated with symptomatic MRCT [38]. In a large series, Walch et al. observed an increase in the Constant score from 48.4 preoperatively to 67.6 after arthroscopic biceps tenotomy. At last follow-up, 87 % of patients were satisfied or very satisfied with the result. However, the acromiohumeral interval decreased by a mean of 1.3 mm during the follow-up period.

There is one exception with B type MRCTs; the tenotomy is not recommended as it could aggravate the situation.

Repair techniques

Unfortunately, even if reinsertion of the tendon on the bone is achievable, it is often difficult to reliably achieve long-term healing with a structurally intact repair [57]. In the setting of a massive tear, a double-row repair improves long-term functional outcome [41, 58, 59]. However, this should not be performed at the expense of over-tensioning as application of a double-row repair to a tendon with poor tendon length and excursion may lead to medial failure [24]. On the other hand, poor-quality tendon can be managed with load-sharing ripstop fixation construct [19]. This technique has demonstrated superior fixation strength in cadaveric studies. However, no clinical studies have been reported on healing following this repair.

Augmentation

Graft augmentation may improve healing in massive rotator cuff tears [60] but add significant cost and time to the procedure. The choice of graft is influenced by several factors including mechanical properties, host response and potential for ingrowth. Scaffolds provide mechanical support and have biological properties that may favourably influence cell proliferation and differentiation, hopefully improving tendon-to-bone healing. Currently, scaffolds derived from dermis, small intestinal submucosa, skin, fascia lata, and pericardium have been processed and marketed for augmentation in the repair of massive tears. We prefer biological grafts, when compared to synthetic grafts, due to the unknown host response to synthetic grafts. An important factor in the longevity and strength of a graft is the amount of ingrowth.

Results

We have previously reported our results following arthroscopic repair of MRCTs [29, 42]. For primary repair, improvements were observed in forward flexion (132° vs 168°), pain (6.3 vs 1.3), UCLA score [61] (15.7 vs 30.7), and American Shoulder and Elbow Surgeons score [62] (41.7 vs 85.7) ($P<0.001$). A good or excellent outcome was obtained in 78 % of cases. Similar results were noticed after repair of type A, B and C MRCT [63]. After revision of MRCT repair [42], mean active forward elevation improved by 15°, from 136.0°

±51.9° (range, 30–180°) at baseline to 151.4°±41.5° (range, 30–180°) at final follow-up ($P=0.019$). The mean pain score improved by 3.1 points, from 5.0±2.4 points at baseline to 1.9 ±2.3 points at final follow-up ($P<0.001$). The mean ASES score improved from 45.7±17.8 at baseline to 75.5±20.3 at final follow-up ($P<0.001$). The mean UCLA score also improved, from 16.7±4.9 at baseline to 26.4±6.9 at final follow-up ($P<0.001$). According to the UCLA score, functional results were excellent in 15 % of cases, good in 35 %, fair in 25 %, and poor in 25 %. Seventy-nine percent of the patients were satisfied, and 32 patients (60 %) returned to their previous activities [42].

Allograft for bony and tendinous insufficiency of the rotator cuff in young patients with pseudoparalysis

Older patients with pseudoparalysis combined with bony and tendinous insufficiency of the rotator cuff can be easily managed with reverse shoulder arthroplasty. However, there are currently few satisfying options for young patients. A fresh frozen allograft (i.e., calcaneum and Achilles tendon) has effectively been used to address this difficult problem (Fig. 8).

Tendon transfer

In younger and active patients with an irreparable MRCT, tendon transfer may be an option. This palliative surgery can improve rotation. However, this is not a viable option in the setting of pseudoparalysis, as no tendon transfers are able to restore active motion in elevation and abduction.

Anterior rotator cuff insufficiency

Currently, the most commonly used transfer for irreparable A, B and C type MRCT is the pectoralis major transfer [64, 65]. The direction of pull of the pectoralis major tendon can help restore internal rotation and the transverse force couple in the setting of subscapularis deficiency without static anterosuperior migration of the humeral head. Pain can be improved, but functional restoration is often disappointing [65]. Pectoralis minor tendon transfer has also been described, but does not improve strength and cannot be recommended.

Posterior rotator cuff insufficiency

Currently, the most commonly used transfer for an irreparable type D or E MRCT is latissimus dorsi transfer [39, 66, 67]. The ideal candidate is a patient who has maintained active

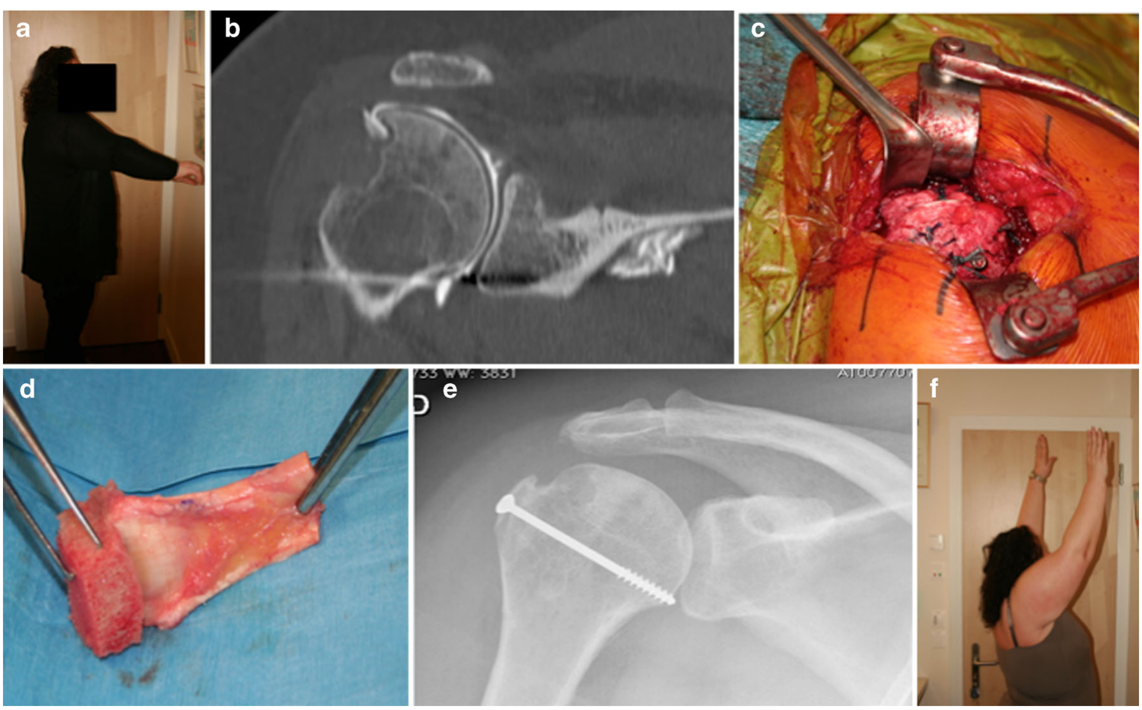

Fig. 8 **a** Example of a 44-year-old woman who sustained a fracture of the greater tuberosity following a right glenohumeral dislocation. An open reduction and stabilization of the greater tuberosity with a "Hawkins" tension band was performed in another institution. The patient presented persistent pain and pseudoparalysis. **b** The CT scan evaluation demonstrated a massive humeral head bone loss. **c** and **d** A fresh frozen allograft of calcaneum and Achilles tendon was used to compensate for this deficiency. **e** and **f** At the five-month follow-up, the patient was pain free, had complete range of motion, a SANE score of 95 and radiologically an integrated allograft and competent rotator cuff

anterior elevation, but lacks control of the arm in space in external rotation (simple weakness in external rotation is not a sufficient indication for surgery), and who also has an intact subscapularis and no glenohumeral arthritis. Results are disappointing in patients with subscapularis insufficiency [39]. In addition, results have been disappointing in the setting of preoperative teres minor tears or atrophy [39]. Gerber et al. [39] reported long-term results at a mean of 147 months. The mean SSV in 46 shoulders increased from 29 % preoperatively to 70 %, the relative Constant score improved from 56 % to 80 %, and the pain score improved from 7 to 13 points ($P<0.0001$ for all). However, there is no proof that latissimus dorsi transfer gives better long-term results than a simple partial rotator cuff repair. Effectively, 60 % of type E MRCTs do not lose control of the arm in external rotation [31]. Consequently and despite large series recently published, indications for this type of surgery are rare.

Reverse shoulder arthroplasty

A hemiarthroplasty or an anatomical total shoulder arthroplasty is contraindicated in the absence of a functional rotator cuff because loss of a balanced coronal force couple, leading to either limited goal prosthesis or to glenoid component loosening, respectively. Reverse shoulder arthroplasty has recently emerged as a treatment for MRCT [48]. While primarily used in the setting of glenohumeral arthritis Hamada 4–5, its implantation might be discussed in certain cases of glenohumeral arthritis Hamada 1–3 [68], particularly in older patients or those with chronic pseudoparalysis (as opposed to acute pseudoparalysis which responds well to arthroscopic treatment).

The reverse ball-and-socket relationship of the prosthesis restores stability to the glenohumeral joint. The glenosphere position medializes and lowers the glenohumeral center of rotation, thereby increasing the lever arm of the deltoid muscle. Deltoid tension, produced by the lowered centre of rotation, increases muscle fibre recruitment of the anterior and posterior deltoid that compensates for a deficient rotator cuff. While initial results were associated with a substantial rate of clinical and radiological complications [69], tremendous efforts have been made to better understand biomechanics of the prosthesis and to lower prevalence of various complications including scapular notching, learning curve effect [70], lengthening of the arm [71], surgical approach, etc. These have all led to improvement in outcomes and decreased complications. While RSA is technically easier than arthroscopic repair, we usually do not recommend reverse shoulder arthroplasty as the first line of treatment for massive rotator cuff tears with minimal arthritis. Indications for MRCTs remain limited in our hands to (1) tears with advanced atrophy and with chronic pseudoparalysis, (2) type B irreparable MRCT, (3) adaptive changes of the proximal humerus (classic rotator cuff arthropathy) and (4) failure of revision rotator cuff repair [29].

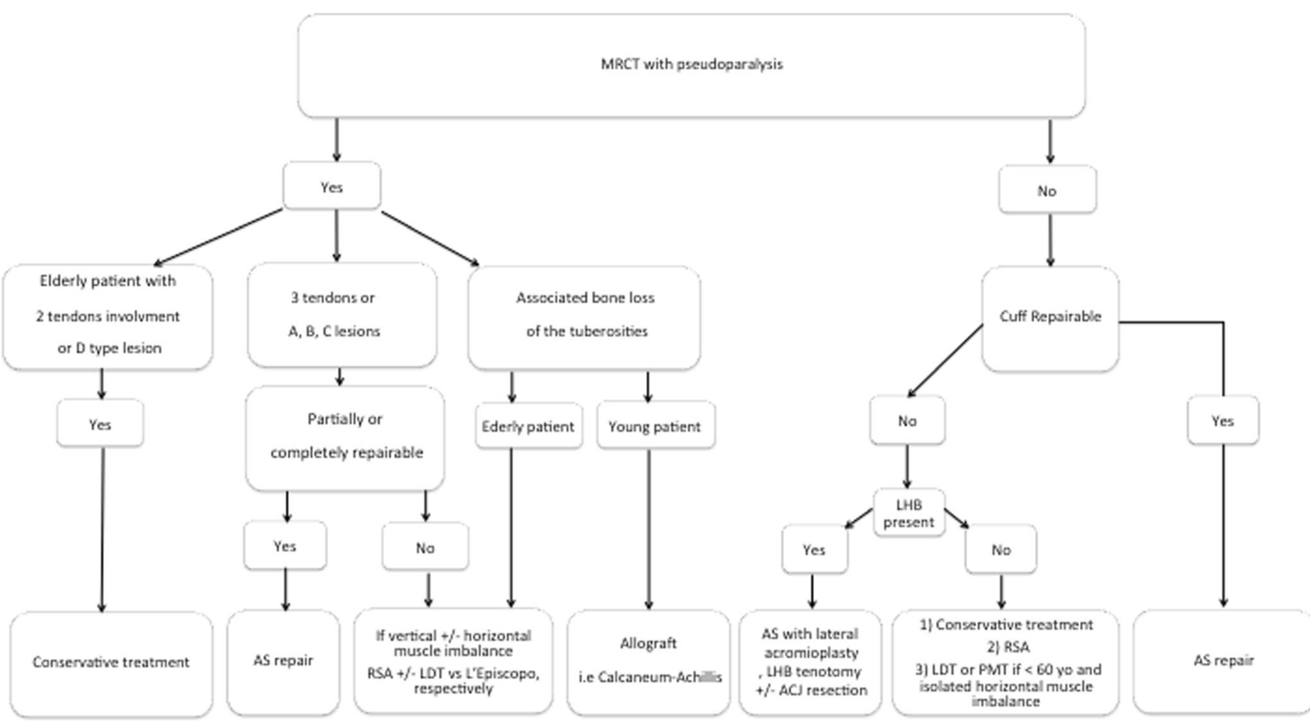

Fig. 9 Treatment paradigm proposed by the authors for patients with massive rotator cuff tears (MRCT). *ACJ* acromio-clavicular joint, *AS* arthroscopy, *LDT* latissimus dorsi transfer, *LHB* long head of the biceps, *MRCT* massive rotator cuff tear, *PMT* pectoralis major transfert, *RSA* reverse shoulder arthroplasty

Author's preferred paradigm treatment for MRCT

Unfortunately, the scientific literature does not contain enough data to allow establishment of an evidence-based treatment algorithm. Treatment is based on patient factors and associated pathology as previously discussed and therefore includes personal experience and scientific data. The following criteria have proven helpful in the assessment of the key parameters in the decision-making process for MRCT in our experience and are offered for consideration. In general, for patients that have a complete or a partially reparable MRCT that resists conservative treatment, whatever the age, we offer a primary cuff repair. If the tear is only partially reparable, the goal is to transform a B or C type into an A type, and an E type in a D type. Associated procedures are systematically performed in order to relieve all potential sources of pain. For patients under the age of 65 that have a loss of control in space of external and internal rotation, we consider tendon transfer if there is no glenohumeral arthritis. For pseudoparalysis, the first line of treatment is conservative in elderly patients with two-tendon involvement or a type D lesion [36]. In the setting of young patients (<65 years) or type A, B, C and E lesions (3 tendons or anterior involvement), we recommend an attempt at an arthroscopic approach. It is important to remember that arthroscopic treatment does not compromise subsequent RSA if this is needed; particularly in young patients, we believe it is better to attempt an arthroscopic repair than to proceed directly to RSA. On the basis of the aforementioned elements, we use a treatment paradigm for all patients with MRCT (Fig. 9).

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Ethical committee approval NA

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