Revision Repair for the Failed Rotator Cuff

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10.1 Introduction

The surgical management of rotator cuff tears (RCT) has risen consistently with continuous evolvement of open and arthroscopic techniques. Over the past decade, the incidence of arthroscopic RCT repairs has increased by almost 600%, whereas the use of open techniques only increased by 34% [1–3]. However, despite high satisfactory rates being achieved with both procedures, current literature still reports a high rate of re-tears ranging between 13% and 80%, mostly depending on the technique used as well as the initial tear size, muscle atrophy, fatty infiltration, and tendon retraction [4, 5]. Additionally, almost 25% of re-tears are observed within the first 2 years after surgery, [6] however, 50% of these patients are still expected to have satisfactory outcomes [7, 8].

When approaching revision RCT, the exact etiology of failed cuff surgery has to be determined. Patients presenting with functional impairment and persistent pain following rotator cuff repair remain a challenge for physicians, as these symptoms may be caused by extrinsic and/or intrinsic factors. However, structural failure does not always result in clinical failure and many patients with partial healing of the repaired cuff will be much improved after surgery, despite remaining residual defects.

Additionally, prognostic and risk factors associated with successful and unsuccessful outcomes after reconstruction of RCTs are poorly understood. Consequently, efforts have recently been focused on identifying subgroups of patients that may benefit from undergoing revision rotator cuff surgery [9].

10.2 Clinical Examination

A detailed physical examination is critical for a correct assessment of re-injury. As the patient often presents with ongoing shoulder pain, weakness, and functional deficits, the focus should be placed on location, intensity, and quality of pain. Extrinsic and intrinsic factors leading to pain, tingling, numbness, or burning sensations need to be carefully evaluated and may indicate a differential diagnosis such as a stiff shoulder, neuropathy, vasculopathy, or joint infection. Additionally, concomitant intra-articular lesions, which have been left unaddressed during primary surgery, have to be excluded.

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When approaching an RC re-tear, the physician needs to evaluate, whether there was a time after the initial intervention when the patient was pain-free or if a new history of trauma might be responsible for the re-tearing condition. Patient compliance and duration of physical therapy and rehabilitation play an important role during preoperative evaluation.

Following the history of the patient, physicians should focus on a thorough physical examination. It is critical to perform a complete physical examination including examination of the glenohumeral joint, sternoclavicular joint, cervical spine, and ipsilateral upper extremity along with a complete neurovascular exam, in order to rule out concomitant injuries. If the inspection reveals ecchymosis or any cardinal symptoms of an inflammatory reaction, a postoperative infection has to be excluded. A detailed neurovascular examination of the upper extremity can hereby exclude any possible brachial plexus lesions or more rare vasculopathies such as thoracic outlet syndrome. Further, the shoulder girdle should be evaluated for the presence of muscle atrophy. Active and passive range of motion (ROM), as well as scapulothoracic motion, need to be assessed. The presence of any scapular dyskinesia such as scapular winging or scapula alata is of great importance, as it may cause chronic shoulder dysfunction and/or pain.

10.3 Radiographic Examination

In addition to a thorough clinical exam, a detailed radiological evaluation is required. Besides, imaging prior to primary surgery should be further evaluated regarding initial tear size, muscle atrophy, fatty infiltration, tendon retraction, and concomitant intra-articular pathologies. Plain AP, y-view, and axillary radiographs might help in determining the extent of the rotator cuff pathology with the main focus on superior humeral head migration, bony disorders, and anchor misplacement or migration (Fig. 10.1) [10].

MRI scans may be useful for detecting concomitant injuries of the glenohumeral joint as well as determining the extent of the re-tear and quality of the involved tendons [11] although postoperative MRI is difficult to interpret, as only 10% of reconstructed tendons generate a normal MRI signal (Fig. 10.2) [10, 12]. Tissue remodeling and fibrous tissue may produce an intermediate signal within the tendon and can persist for
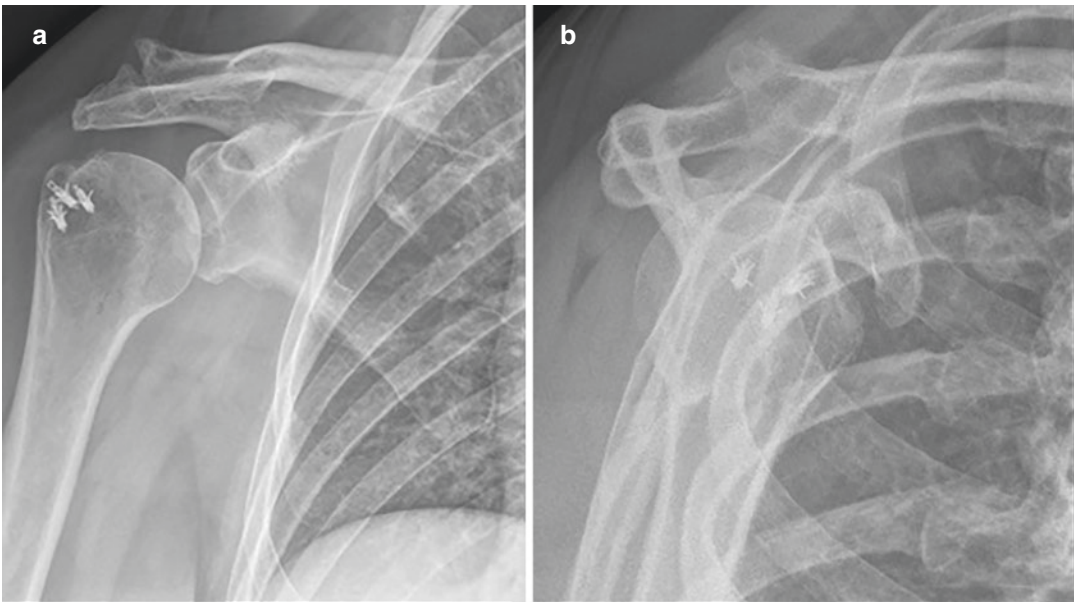

Fig. 10.1 Figure displaying (**a**) a.p. radiographs and y-view (**b**) of a patient with failed primary rotator cuff repair
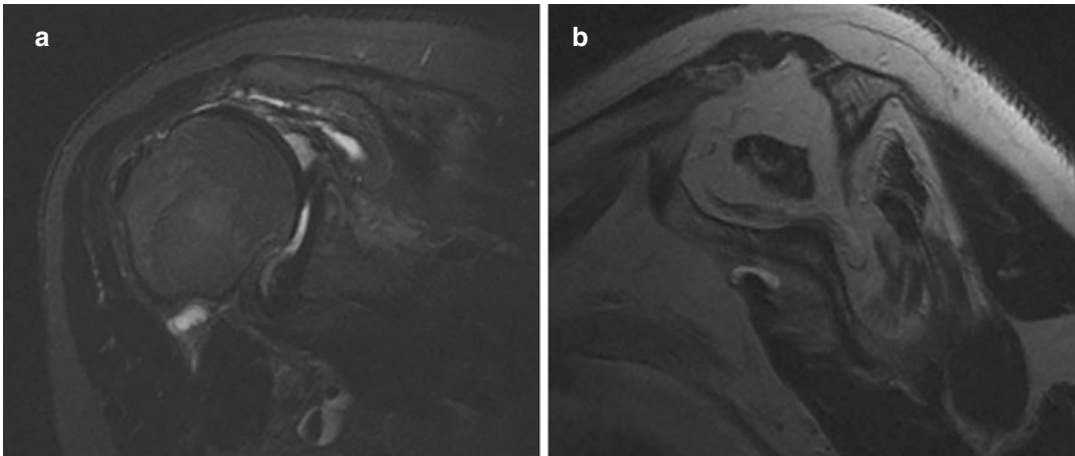
Fig. 10.2 (**a**) MRI showing a retracted torn supraspinatus tendon with (**b**) severe atrophy of the muscle belly

6 months following repair [10, 12, 13]. Additionally, fluid leakage into the subacromial space (after opening the rotator cuff interval) or (metal) artifacts may be observed [10]. Thus, intra-articular contrast might be helpful to evaluate the cuff with increased sensitivity [14].

Currently, there remains controversy if initial tendon and muscle quality is a determinant factor in tendon healing after rotator cuff repair [10, 15, 16]. When repairing the supraspinatus, Park et al. did not find any significant relationship between preoperative tissue quality (fatty infiltration) and postoperative tendon healing [15]. On the contrary, they observed that any fatty infiltration of the infraspinatus or subscapularis had a highly significant relationship affecting postoperative tissue healing [15].

Of great importance in current MRI diagnostic is the preoperative bone quality, especially the bone mineral density of the greater tuberosity. In a systematic review, Lädermann and colleagues found an increase in studies reporting on impaired bone quality within the greater tuberosity in chronic, retracted RCTs [10, 15, 17]. Further, bone quality might also be deficient due to anchor removal, cyst formation, or consequent osteolysis after the use of bioabsorbable anchors [10, 18].

If MRI is contraindicated or diagnostic assessment restricted due to technical restrictions (as mentioned above), ultrasound or CT arthrogram might be helpful, with current literature reporting high sensitivity in the diagnostic of RCT [19–21].

10.4   Indications

The indications for revision rotator cuff surgery are similar to those for primary repair. However, the surgeon should help managing patients' expectations and raise awareness for factors that can and cannot be changed with undergoing revision rotator cuff surgery.

In case of an acute traumatic re-tear in a physiologically young patient, revision surgery should be recommended [22]. In the setting of a chronic re-tear, the patient should be advised to undergo a trial of nonoperative treatment with the focus on restoring range of motion as well as strengthening of the remaining rotator cuff, shoulder girdle, and periscapular musculature. If conservative management has been unsuccessful, surgery can be considered along with patient-related factors (age, comorbidities, functional impairment, size of initial RCT) and the state of the remaining cuff [22].

In contrast, patients with irreparable rotator cuff tears, severe atrophy, or fatty infiltrations should not be considered for revision rotator cuff surgery [22].

10.5 Technical Aspects of Revision Rotator Cuff Reconstruction

Revision rotator cuff reconstruction can be performed using open, mini-open, or all-arthroscopic techniques, depending on the indication and the surgeon's preference. After induction of general anesthesia, the patient is positioned either in beach-chair position or in lateral decubitus position. If surgeons face inappropriately placed arthroscopic portals, care should be taken to replace a new portal in the anatomically necessary positions. The arm is placed in a movable arm holding device or a balanced suspension. Landmarks should be marked.

The surgical procedure starts with a diagnostic arthroscopy of the glenohumeral joint using a standard posterior portal. Concomitant intra-articular pathologies are evaluated and addressed first if necessary. Detailed examination of the long head of the biceps tendon (LHBT), the superior labrum, and the remaining rotator cuff should be performed. If still present, the LHBT should undergo either tenotomy or tenodesis. Acromioplasty should be considered, but care has to be taken to avoid acromial over-resection.

Careful handling of the remaining rotator cuff is of great importance, as retorn rotator cuff tissue is often of poor quality (Fig. 10.3). Further iatrogenic tissue damage has to be avoided. If

necessary, any scar tissue or adhesions should be removed carefully. A circumferential debridement might be necessary if the patient presented with a restricted range of motion due to a stiff shoulder pathology before surgery. Retained sutures, misplaced or dislocated anchors should be carefully removed (Fig. 10.4). If metal hardware was used, hardware removal may create large bone defects, therefore, should be considered to be left in place. Large and massive tears often require extensive dissection and mobilization of the rotator cuff margins to allow a tension-free repair to the original footprint (Fig. 10.5). If the rotator cuff is considered irreparable due to retraction, conversion to other techniques might be necessary. If the remaining cuff is deemed reparable, careful preparation of the greater or/ and lesser tuberosity is performed (Fig. 10.6). The decision to use single-row or double-row fixation mostly depends on the tissue quality and tension on the repair. However, double-row or transosseous reconstructions should be favored over single-row reconstruction. Primary subscapularis tears can be reconstructed using single-row repairs. When using new anchors in or around previously used anchor tracks, oversized anchors should be considered to improve anchor stability within the bone [23]. If bone defects prevent the use of any anchors, transosseous techniques need to be considered. If anatomic repair is not possible, margin convergence is an alternative option.
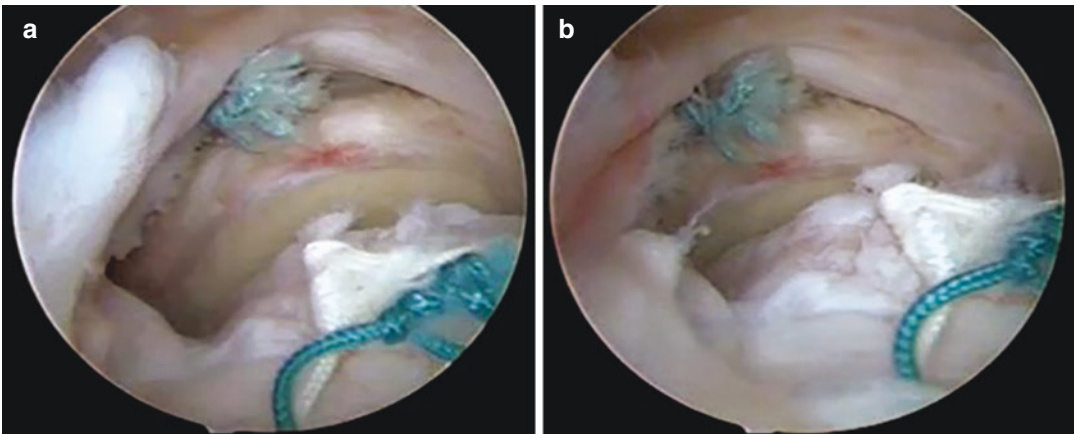

Fig. 10.3 Figure displaying poor tissue quality (**a** and **b**) in a chronic, torn supraspinatus tendon
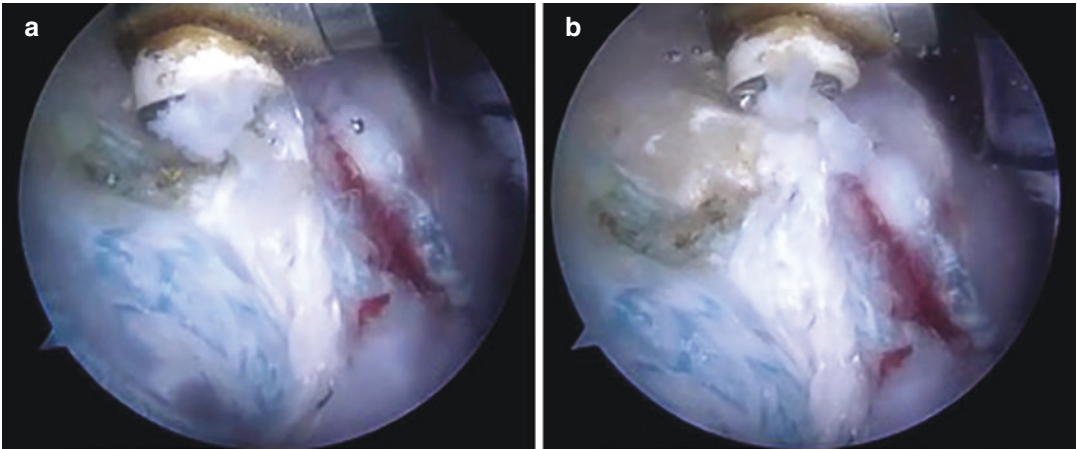
Fig. 10.4 (**a**) Figure displaying retained suture, (**b**) which should be carefully removed
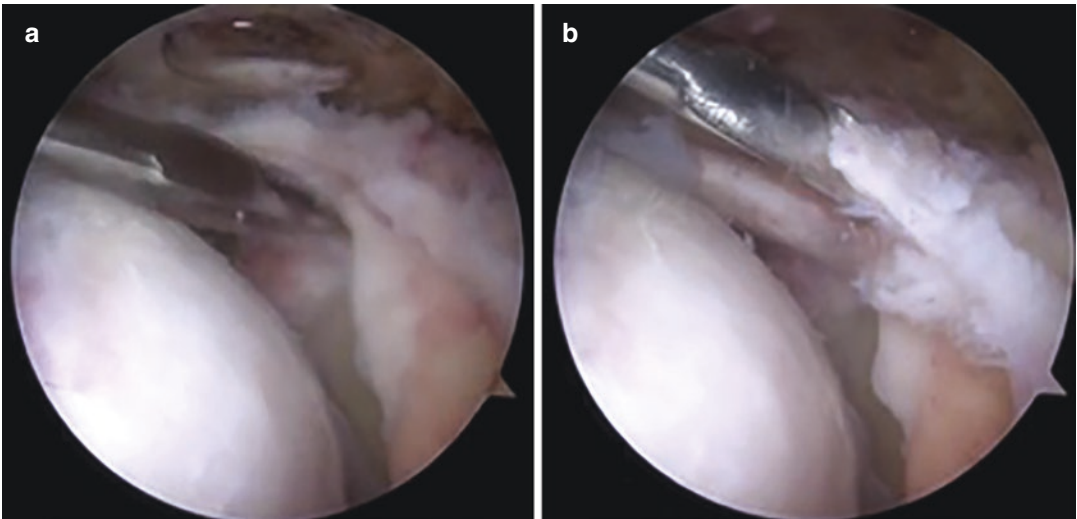

Fig. 10.5 (**a**) Figure showing a far retracted supraspinatus tendon, (**b**) deemed irreparable

10.6   Subscapularis Repair

Four portals are routinely used for subscapularis repair: a standard posterior viewing portal, an anterior portal used for anchor placement and suture passage, an anterolateral portal (just anterior to the biceps tendon) used for subscapularis mobilization and preparation of the lesser tuberosity and a second accessory anterolateral portal placed just posterior to the biceps tendon for the placement of traction sutures.

Arthroscopic repair of the subscapularis should be performed immediately after identifi-

cation of the tear as shoulder swelling can limit visualization and compromise the ability to perform an effective repair. In the revision situation, chronic subscapularis tears can be retracted medially and scarred to the inner deltoid fascia and MGHL, making identification difficult. In retracted subscapularis tears, the superior glenohumeral ligament and the coracohumeral ligament might be torn off the humerus at the upper border of the lesser tuberosity and remains attached to the superolateral portion of the tendon, forming the "comma sign" just above the superolateral corner the subscapularis [24]. This
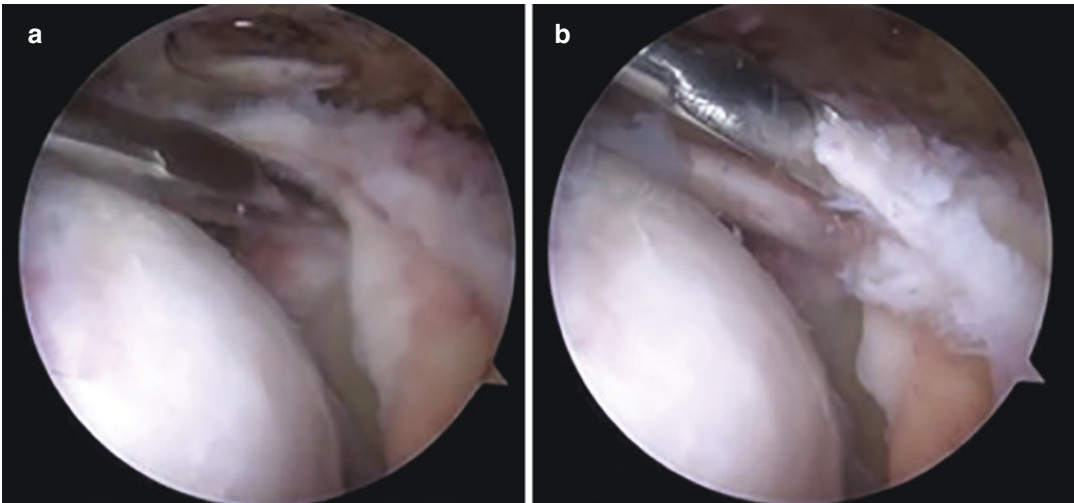
Fig. 10.6 (**a** and **b**) Debridement of the greater tuberosity should be carefully performed

"comma sign" can be used as a marker for the tendon. A tendon grasper can now be used to pull the medially retracted tendon laterally to place traction sutures along the upper lateral border of the subscapularis tendon.

Subsequently, mobilization is performed using electrocautery while traction is maintained through the accessory anterolateral portal. Care has to be taken to avoid dissection along the inferior border of the tendon to minimize the risk of neurologic or vascular injury. By preserving the lateral margin of the rotator interval, the continuity between the subscapularis and the posterosuperior rotator cuff can be preserved, allowing for later margin convergence, if necessary. After adequate mobilization, the subscapularis tendon is repaired using single or double-row fixation.

10.7 Supraspinatus and Infraspinatus Repair

The remaining cuff is now thoroughly evaluated through the lateral portal. As adhesions between the acromion, deltoid, and rotator cuff may occur, a dissection has to be performed using electrocautery or a shaver. In some cases, the anterior and posterior borders of the rotator cuff margins might be scarred to the deltoid fascia, and therefore have to be removed carefully. By placing the arthroscope into the lateral portal, dissection can

be started at the medial border of the posterosuperior cuff. Bursectomy and debridement are critical, in order to prevent swelling of the surrounding tissue and optimize visualization. Dissection is continued until all adhesions between deltoid, acromion, and cuff are resected and tension-free mobilization of the cuff is guaranteed. However, care is taken to avoid damage to deltoid fibers or any muscular tissue of the remaining cuff. Using an additional superior-medial (Neviaser portal) or a posterior infraspinous portal may allow to pierce the retracted rotator cuff tendon more medially when compared to using conventional portals [25]. Additionally, a curved suture passer (Banana-lasso, Arthrex Inc., Naples, FL, USA) may be used as it can be easily pushed through the skin, thus avoiding a skin incision. Care has to be taken to avoid any damage to the suprascapular nerve, which may be located 1-cm from the supraglenoid tubercle [26].

Depending on the remaining tendon tissue and the type of rotator cuff tear (Crescent shape; U-shaped; L-shaped), repair can be performed using margin convergence (in U-shaped or L-shaped tears) or directly to the bone (in crescent-shaped tears) in a single- or double-row construct. If anatomic repair is not possible, many authors recommend performing a partial repair by repairing as much tendon to tuberosity as possible [27, 28]. One may consider a medial-

ization of the remaining rotator cuff when the tendon's mobility is insufficient to cover the anatomic footprint, [29, 30] although, there remains a lack of data, especially in revision cases. Regardless of the technique used, reestablishing the force couple is of great importance.

10.8   Advantages of Arthroscopic Techniques

Generally, arthroscopic approaches offer several advantages compared to open revision repairs. Arthroscopy allows for a complete evaluation of the glenohumeral joint and subacromial space, which is important for diagnosis and treatment of concomitant pathology. Additionally, arthroscopic techniques minimally disrupt the deltoid. To this, correct classification, evaluation of the re-tear, and complete rotator cuff can be performed by using arthroscopy. Finally, postoperative stiffness can be reduced by using this less invasive approach.

10.9   Outcomes

Efforts to draw revealing conclusions from existing studies are limited by small sample sizes, differences regarding surgical technique, heterogeneity of tear types, and methods of quantifying the outcome [9]. Compared to primary arthroscopic rotator cuff repair, outcomes following revision surgery are generally reported to be less satisfactory [9, 31–33]. The first published series of revision rotator cuff repair surgery dates back to the early 1980s and involved open revision, however, without the use of any validated shoulder score [34, 35]. In 2004, Lo and colleagues published the first study of patients undergoing arthroscopic revision surgery and noted significant improvements in UCLA scores and active motion elevation, with overall good to excellent results in 64% of procedures [24, 36]. Since then, most of the results published are reporting similar, comparable promising results in terms of functional and clinical outcomes [2, 10, 32, 37–40]. However, these results are tempered by high complication (12%) and reoperation rates (5%) [2].

Similar, Willinger et al. investigated on clinical and radiological outcomes after revision RCR [36]. Of interest, they found that over 50% of patients showed a re-tear on postoperative MRI, however, tendon integrity was not correlated with better clinical outcomes after revision RCR at final follow-up. To this, almost equal strength could be restored for external rotation but not for abduction and internal rotation when compared to the intact contralateral side.

When stratifying outcomes by type of surgery, mean postoperative range of motion is greater with arthroscopic repair than open repair (forward flexion: 146° vs. 125°; external rotation: 51° vs. 42°) [2]. However, in 2019 Brochin et al. showed similar improvement from preoperative to postoperative range of motion for both techniques in a systematic review [2]. Mean VAS pain score were better with arthroscopic repair, contrary to the ASES score, with no significant differences between both techniques. Surprisingly, complication rates (16% vs 8%) and reoperation rates (7% vs. 2%) were higher for arthroscopic techniques than open revisions [2].

10.10   Prognostic and Risk Factors

Prognostic and risk factors associated with successful and unsuccessful results after reconstruction of the rotator cuff, especially revision rotator cuff repair, are poorly understood [10]. However, several patient-related risk factors are known to have a negative association with worse outcomes: Female sex, [37–39] surgery on the dominant arm [39], poor preoperative range of motion, [10, 38, 39, 41] high preoperative decreased clinical outcomes scores, [2] acromiohumeral distance (<7 mm) [32], and any presence of osteoarthritis [32]. Additionally, poor tendon quality has been shown to result in worse postoperative clinical outcomes [24, 35]. Patients with pseudoparalysis and glenohumeral arthritis often do poor after revision surgery and may better be treated with arthroplasty.

The influence of age on revision rotator cuff surgery continues to be controversial [40]. Lädermann et al. failed to demonstrate a significant correlation between age and functional outcomes, [38] contrary to Keener et al. who showed

age-related differences in repair integrity, with worse outcomes in patients aged 59 years (compared to patients aged 51 years) [33]. Chuang et al. also found worse outcomes in patients older than 70 years of age [39]. However, with a mean increase in Constant Score of 23.9 for patients over the age of 65 years and 24.5 for patients younger than 65 years, this could still imply that patients over 65 years can be considered for revision rotator cuff surgery [9, 39].

From a biomechanical point of view, non-restoration of a balanced force couple or suspension bridge system might be one of the main reasons along with the initial tear size and tissue quality for clinical failure [10, 42–44].

10.11 Summary

As the rate of primary RCR increases, the number of failures and subsequent revisions is likely to increase. Arthroscopic revision rotator cuff repair can be technically demanding, and the complication including failure rates are high. Compared to primary arthroscopic rotator cuff repair, outcomes following revision surgery are generally reported to be less satisfactory but remain high. Several patient-related risk factors are known to have a negative association with worse outcomes; however, prognostic and risk factors associated with unsuccessful results after reconstruction of the rotator cuff are poorly understood. The aim of shoulder surgeons should be to avoid unsatisfactory results and help in managing patients' expectations.

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