4 Re-rupture or Non-healing? Factors Determining an Unsuccessful Repair

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4.1 Introduction

There is a need to understand the reasons why a high proportion of rotator cuff repairs fail to heal. Several studies have noted that increasing age is a significant factor for diminished rotator cuff healing, while biomechanical studies have suggested that the reasons for this may be an inferior healing environment in older patients.

Rotator cuff tears may cause significant pain and loss of function. Patient outcomes are reported in outcome scores, including strength, pain, and active range of motion. Healing of the tendon after surgical repair is thought to improve functional outcomes and is the reason why patients with persistent symptoms are commonly offered surgical treatment. Even though rotator cuff repair results in improved clinical outcome, several studies report failure of healing in up to 94% of patients [1]. An explanation of this discrepancy is that the success of a repair is commonly based on patient-related outcomes and not on the healing of the tendon. The outcome is often irrespective of healing; however, there is a tendency that outcome scores that include strength and active range of motion provide better results with tendon healing, whereas those scores that evaluate subjective patient outcomes fail to show a difference between patients with healed tendons and those with discontinuity of the rotator cuff tendon [2].

Healing indicates a continuous layer of tissue from the rotator cuff muscle belly to the insertion on the greater tuberosity. The healing process is divided into three overlapping stages: inflammation (1 week), repair (week 1–4), and remodeling (after 3 weeks) [3].

To assess healing structural and qualitative assessment of the rotator cuff can be done with either MRI or ultrasound. Most often repair integrity is determined by MRI, according to the classification described by Sugaya et al. [4]. This classification distinguishes five repair categories with the use of oblique coronal, oblique sagittal, and transverse T2-weighted images. Type I indicates a repaired rotator cuff that has sufficient thickness with homogeneously low intensity on each image; type II, sufficient thickness with a partial high-intensity area; type III, insufficient thickness without discontinuity; type IV, the presence of a minor discontinuity in more than one slice of each image, suggestive of a small tear; and type V, the presence of a major discontinuity on each image, suggestive of a large tear (Fig. 4.1).

The term re-rupture is used throughout the literature when rotator cuff healing is assessed, but most studies do not specifically document healing before recurrent tears. Reported healing rates from rotator cuff repairs in general range from 6 to 100% [1], in other words a huge variation.

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N. Sampaio Gomes et al. (eds.), *Massive and Irreparable Rotator Cuff Tears*,
https://doi.org/10.1007/978-3-662-61162-3_4

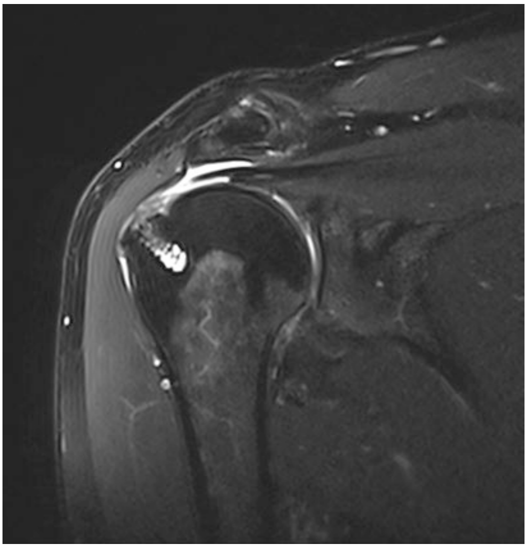

Fig. 4.1 Re-rupture after rotator cuff repair, Sugaya 5

Agout et al. published healing rates of 68–81% 10 years after rotator cuff repair, depending on the initial type of tear [5]. Tears with posterior extension have a higher retear rate, while the risk of arthritis is higher in tears with anterosuperior extension.

Isolated supraspinatus tears show the best results, with a lower failure rate than the other types.

The factors associated with healing are multifactorial in nature. Interpretation of scientific studies is confounded by variations in the definition of healing, the time point at which healing is assessed and the imaging modality and method used to assess healing.

A randomized trial of open vs. arthroscopic repair (UKUFF trial) revealed that 40% of repairs fail within 12 months irrespective of the surgical technique used and that a failed repair adversely affected patient outcomes [6].

The factors that are most consistently reported to influence healing are patient age and tear size. Other commonly cited factors include fatty infiltration, muscle atrophy [7], muscle tendon retraction, workers compensation, compliance with rehabilitation, smoking, manual workers, injections, type of repair, use of orthobiologics [8], and hypercholesterolemia.

4.2 Patients' Age

Patients with well-healed repair tend to be younger [9]. Age is found to be an independent predictor for a structurally intact rotator cuff repair. Gumina et al. [10] reported that the mean age of patients with a healed repair was 3.0 years younger than those who had a recurrent tear.

Diebold et al. [11] studied a cohort of 1600 patients normally distributed in terms of age, with a mean age of 59 years and a range from 15 to 91 years. The 212 patients (13%) who had a retear at 6 months were also normally distributed in terms of age, with a mean age of 65 years and a range from 15 to 88 years. They found that the re-rupture rate in patients below 50 years of age was 5%. This increased to 10% in patients aged 50–59 years, 15% in those aged 60–69 years, 25% in those aged 70–79 years, and 34% in those aged above 80 years. Multiple logistic regression analysis showed that the patient age was an independent factor strongly associated with re-ruptures.

Older age should not be viewed as a contraindication to surgical repair. A study from the French Arthroscopy Society in 2013 showed better outcomes of rotator cuff repair compared to bursectomy and acromioplasty in patients older than 70 years [12].

4.3 Tear Size

The healing rate depends chiefly on the initial size of the tear [6, 13]. Tear size measurements are often made in the anterior posterior direction according to the footprint defect. Medial-lateral dimensions are retraction measurements from the leading edge of the tear to the lateral edge of the footprint [14]. Small and medium tears are more likely to heal than large and massive tears. Park et al. found the failure rate to be significantly higher in patients with a tear of more then 2 cm in size anterior to posterior (34.2%) compared with patients with a tear of less then 2 cm (10.6%) [14]. Rodeo et al. concluded that at 12 weeks post-repair, 71% of small tears healed compared with 82% of medium tears, and 56% of large tears [15].

The influence of infraspinatus delamination and of a subscapularis tear remains debatable [16, 17]. An infraspinatus tear longer than 1 cm has also been identified as a risk factor for failure to heal [18].

Agout et al. reported 10-year results of 511 patients in 2014. The healing rate was from 68 to 81% depending on the initial type of tear. Tears with posterior extension had a higher retear rate, while the risk of arthritis was higher in tears with anterosuperior extension. Isolated supraspinatus tears showed the best results, with a lower failure rate than the other types. However, surgical repair gave good functional results in the long term whatever the type of tear was, in spite of a 10% complication rate and a 12% revision rate.

Shimokobe et al. [19] found that the re-rupture rate was significantly higher in a group with posterosuperior tears compared to two groups with anterosuperior tears or anterioposterior-extending tears ($P = 0.02$). In this study of 102 patients multivariate analysis showed that decreased preoperative active external rotation range was a unique risk factor for postoperative re-rupture in both the posterosuperior and the anteriorposterior-extended groups.

4.4 Fatty Infiltration

To assess the degree of fatty infiltration the T1-weighted oblique sagittal sequences are frequently used and graded based on Goutallier's classification scheme [20]. Previous studies have found that this staging system can be appropriately applied to MRI [21]. The scan is evaluated in the sagittal plane at the level where the scapular spine and body form a Y shape (Fig 4.2).

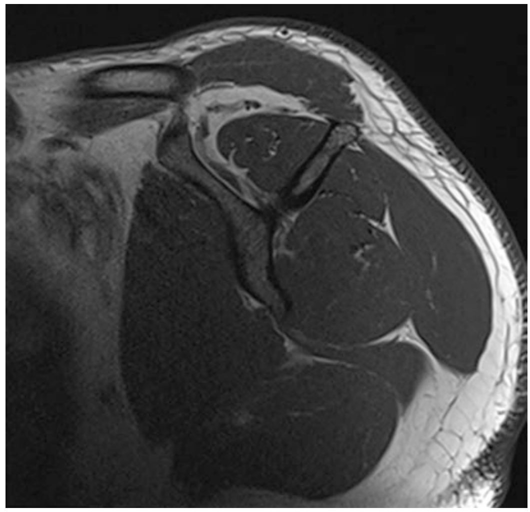

Fig. 4.2 Fatty infiltration is evaluated in the sagittal plane at the level where the scapular spine and body form a Y shape

In 2016 Gasbarro et al. analyzed risk factors to predict structural failure after arthroscopic cuff repair [18]. The material consisted of 30 failures compared to 60 controls. The presence of supraspinatus fatty infiltration grade 2 or above was significantly more common in the failure group. Fatty infiltration in any rotator cuff muscle was present upon MRI in 30% of the failures vs. 25% of the controls. There was no difference in the average number of muscles being affected. Conditional logistic regression confirmed supraspinatus fatty infiltration and supraspinatus tear size as risk factors for failure.

4.4.1 Muscle Atrophy and Muscle Tendon Retraction

In the muscle, there is significant migration of inflammatory cells within the first few days of a tear and the muscle fibers undergo apoptosis [22]. In the ensuing weeks to months, this early response leads to muscular retraction, degeneration, and atrophy. The progressive loss of muscle volume is due to the loss of sarcomeres, which causes an enlargement of the inter- and intramyofibrillar spaces. If the muscle remains unloaded and retracted, the myogenic precursor cells may be reprogrammed into the adipogenic pathway, with mature adipocytes infiltrating the free inter- and intramyofibrillar spaces. This phenomenon is termed fatty infiltration [23].

4.5 Compliance with Rehabilitation

A number of rehabilitation protocols have been described for use following rotator cuff repair. While some surgeons recommend early, aggressive rehabilitation programs, others recommend a more conservative rehabilitation program. Early aggressive rehabilitation protocols may result in a slightly higher incidence of retear compared with more conservative protocols.

Slower, less aggressive rehabilitation programs have demonstrated improved healing with no negative effect on the final range of motion and are therefore recommended after repair of most full-thickness tears [24].

4.6 Smoking

Galatz et al. [25] demonstrated that nicotine impairs biomechanical as well as histological properties after rotator cuff tendon repair in a rat model. In a clinical study, a dose- and time-dependent relationship between smoking and the presence of rotator cuff tears was noted [26]. This data suggests that abstinence or at least a decrease in nicotine use might help to improve healing after rotator cuff repair and smoking cessation should be strongly encouraged.

4.7 Manual Workers

Return to work may prove impossible, despite workplace adjustments. Collin et al. found that one-fifth of patients had not returned to their previous occupation 6 months after rotator cuff repair. The factors associated with failure to resume work were female gender, heavy manual work, and persistent bursitis detected by follow-up sonography [27]. They were unable to show a difference in Constant scores between a group returning to work and the other group not returning to normal activities at 6 months after the univariate analysis. Lack of healing was not correlated with the group not returning to normal activities. This finding corroborates with previous studies [28] and confirms that lack of healing does not necessarily result in clinical failure, except in labour intensive workers who represent a high-risk group for poor outcome among patients with failure [29].

Despite studies that suggest that tendon healing can affect the final outcome [30], the lack of tendon healing is not associated with the inability to return to work or activity, at least at 6 months postoperatively.

4.8 Injections/Medication

Nonsteroidal anti-inflammatory drug therapy is very effective in relieving the postoperative pain but may adversely affect tendon healing in rats [31].

There is some basic research evidence that the application of NSAIDs postoperatively may alter rotator cuff healing [32]. The common practice of administering NSAIDs should therefore be reconsidered during the first 6 postoperative weeks. After this period of time, NSAIDs do not seem to have an influence on healing and there is evidence that they positively influence the remodeling of the collagen matrix during that time [33].

4.9 Type of Repair

The surgical technique might play a role. During the past decade, several innovative arthroscopic techniques have been introduced for rotator cuff reconstructions. Strong fixation can 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 double-row repair has been shown to increase the biomechanical properties relative to simple suture single-row as well as trans osseous rotator cuff repairs.

In a metaanalysis by Brown et al. there were no significant differences in re-rupture rates for modified Mason Allen sutures compared to simple sutures in single row repairs of tears measuring less than 3 cm [34]. For single row repairs of tears measuring more than 3 cm there was no significant difference in mattress sutures compared to simple sutures. The rates of re-rupture did not differ between the single row and double row for tears measuring less than 3 cm or 3 cm and more. These findings suggest that suture technique may not affect re-rupture rates after rotator cuff repair.

Hein et al. did a systematic review where their imaging diagnosed re-rupture rate was stratified by preoperative tear size at a minimum of 1 year follow-up, and re-ruptures were diagnosed by either MRI, ultrasound, or arthrogram. Both double row and suture bridge had significantly lower re-rupture rates than single row repair for all sizes. There was no significant difference between double row and suture bridge. To date, no level I study has shown whether the suture bridge technique yields superior healing rates compared with conventional double row.

This study only investigated the incidence of postoperative re-ruptures as diagnosed by clinical imaging, and as such, no conclusions regarding clinical outcomes as a function of repair technique could be made.

Asymptomatic retears in the intermediate term may progress to larger, symptomatic tears requiring revision, and massive retears are inherently difficult to revise. Therefore future studies are necessary to track the long-term re-rupture rates of rotator cuff repair techniques to determine how re-ruptures affect long-term clinical outcomes.

Despite the apparent benefits of newer constructs, double-row rotator cuff repairs lead to increased surgical time and higher implant costs compared to single-row repairs, and therefore, there is still a debate about the ideal repair construct.

4.10 Orthobiologics

In the past two decades, orthopaedic research has focused on biologically augmenting the rotator cuff reconstruction, and therefore improving healing at the tendon-bone interface as well as trying to stop muscular degeneration or even accomplish regeneration of the rotator cuff muscle. This biological augmentation has included applying different platelet concentrates containing growth factors, mesenchymal stem cells, scaffolds, and a combination of the above. The biology of rotator cuff tears and repairs has gained more interest as growth factors might positively influence tendon to bone ingrowth and, therefore, might positively influence the re-rupture rate.

The additional augmentation with platelet-rich plasma did not reveal any significant differences in the healing rate compared to conventional rotator cuff repair. No definitive evidence supports the use of platelet rich plasma or mesenchymal stem cells (MSC) regarding improvement of healing rates and clinical outcomes [24].

In a rabbit model hyalorunic acid (HA) accelerated tendon-to-bone healing in the rotator cuff repair model, enhancing the biomechanical strength and increasing chondroid formation and tendon maturity at the tendon-bone interface. Based on the data of in vitro experiments, HA activated MSCs may play a crucial role in the acceleration of tendon-to-bone healing [35].

Bone marrow vents are a cheap possibility to stimulate the interface between tendon and bone. There are some articles publishing good clinical and radiological results after rotator cuff repair with bone marrow vents; however, as long as there are no control groups, it is impossible to conclude that this really enhances the healing [36].

4.11 Hypercholesterolemia and Diabetes Mellitus

There seems to be a relationship between an individual's lipid levels and tendon pathologies [37]. Therefore the question arises if high serum cholesterol levels should be treated before rotator cuff surgery.

Diabetes may have an impact on rotator cuff healing. Bedi et al. [38] reported that diabetes mellitus decreased the biomechanical properties in a rat model. Chen et al. [39] reported a higher rate of postoperative complications, namely infections and to a lesser extent also failures.

4.12 Discussion

The healing rate of rotator cuff repair went down from 94% in 2007 to 71% in 2015. The reason for this is likely to be multifactorial. One possibility is publication bias and an increased tendency to report not just clinical outcomes but also imaging of repair integrity after surgery. Some series reporting these outcomes of failed biologic healing are based on ultrasound evaluation and others are based on MRI.

There has been a dramatic increase in the incidence of rotator cuff repair surgery, reflecting a probable change in the selection criteria for surgery.

Park et al. [14] used a univariate analysis in their case-control study to conclude that both age and tear size were prognostic factors for healing. They also noted that the mean age of patients with healed repairs was 59 vs. 63 years in those with a failed repair and that tears greater than 2 cm in size healed less often than those less than 2 cm (66% vs. 89%). They did not adjust for age and tear size together.

Repair failure is usually defined as a need for further surgery in the short- or medium-term. In the retrospective SoFCOT study [5] 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, $n = 11$).

After a retear discovered at follow up there will be a new assessment whether to perform a revision surgery or not. In general the results of revision surgery are inferior to primary cases. Most of the cuff re-ruptures do not require surgery, given their good clinical tolerance and stable outcomes over time. Information must be obtained about the circumstances of the first repair procedure; a possible diagnostic inadequacy or technical error might be present. Trauma after repair might be due to an aggressive rehabilitation program. Revision cuff repair, when indicated by pain or functional impairment, can improve pain and function at midterm follow-up [40]; however, the clinical outcome scores were comparable in patients with an intact repair and those with failed rotator cuff healing after revision repair. Therefore, tendon integrity is not necessarily correlated with better clinical outcomes after revision rotator cuff repair at final follow-up.

4.13 Summary

Clinical decision-making should take into account the overriding importance of increasing age as a risk factor when considering the suitability of rotator cuff surgery for patients.

Non-operative treatment (rehabilitation and local injections) should be considered in patients with manageable pain and limited physical activities.

A rotator cuff re-rupture is a multifactorial process with no single preoperative or intraoperative factor being overwhelmingly predictive of it. Nevertheless, rotator cuff tear size shows stronger association with re-ruptures at 6 months after surgery than measures of tissue quality and concomitant shoulder injuries.

Knowledge about risk factors of re-ruptures or non-healing may help surgeons and patients to predict the success of arthroscopic rotator cuff repair, and this information is likely to assist preoperative counseling, preoperative planning, and selection of patients for surgery.

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