9 Clinical Outcome vs. Structural Integrity: What Really Matters?

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9.1 Introduction

Symptomatic rotator cuff (RC) tears are a very common musculoskeletal disorder that can cause severe disability, weakness, and persistent pain [1]. Therefore, surgical repair, with the transition from open to mini-open and to fully arthroscopic approaches, became one of the most increasingly commonly performed procedures [2–4]. In recent decades, authors have reported an overall increase of 238% [3], and importantly, a significant shift towards arthroscopic procedures with a 600% increase [2].

However, the repair of massive rotator cuff tears (MRCT) remains a surgical challenge with unpredictable outcomes due to the substantial fatty infiltration, tendon retraction, and tendon tissue degeneration [5–8]. In 2004 Galatz et al. reported 94% re-tear rates after arthroscopic repair of large and massive rotator cuff tears. Additionally, the authors found that the initial pain relief and the ability to perform daily activities were not constant. Their results deteriorated significantly in 2 years postoperatively [9]. Since then, rotator cuff surgery has evolved, where techniques have progressed from single-row [SR] suture anchor repairs, to double-row [DR], and finally to transosseous-equivalent speed bridge [SB] techniques. Additionally, several alternative surgical methods have been proposed to solve the challenging problem of massive repairable tears such as patch augmented repair, interval slide techniques, and the use of biological factors [10].

However, despite advances in surgical technique, are we really performing “a better operation” for the patient? The purpose of this chapter is to examine the evidence whether these newer methods have in fact improved the healing rate for MRCT and whether this correlates with clinical and functional outcomes. Finally, we will discuss whether or not a healed MRCT is actually a prognostic factor of a good final result.

9.2 Factors Affecting Rotator Cuff Integrity After Rotator Cuff Repair

Currently, reported re-tear rates following rotator cuff repair (RCR) vary between 13% and 68% [11]. Many authors have attempted to analyze the influence of several different factors on the final anatomical results [10, 12–15]. These

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factors could be categorized into two groups: (a) patient-related nonmodifiable factors and (b) surgeon-related modifiable factors [10].

9.2.1 Patient-Related Nonmodifiable Factors Affecting Rotator Cuff Healing

These factors are critically important and the surgeon must carefully evaluate them before any decision-making.

9.2.1.1 Age

Increasing patient age has been associated with lower rates of tendon healing after RCR in multiple studies [10, 16, 17]. The authors reported that due to aging, there is a biological limitation at the repair site that appears to be the most important factor influencing tendon healing, even after maximizing repair biomechanical strength with a double-row construct.

However, the most recent studies have shown that age over 70 or 75 years old is not a contraindication to proceed with arthroscopic rotator cuff repair, even in cases of large or massive lesions [18, 19]. Probably, the detrimental effect of increasing age on tendon healing after rotator cuff repair may be due to other factors affecting tendon healing rather than the age itself. Therefore, age may be a surrogate for other anatomical factors like decreased bone mineral density, fatty infiltration, and tendon retraction, which correlate with impaired healing after rotator cuff repair [10].

9.2.1.2 Tear Size and Location

As previously mentioned, repaired large and massive tears are prone to increased rates of anatomical failures [9, 10, 12]. Massive rotator cuff tears represent approximately 20% of all RCTs that require surgery and account for 80% of the cases with postoperative structural failure [20]. However, in the international literature, the failure rates of MRCTs are reported to be between 17.6% and 94%. One reason for this large discrepancy could simply be the lack of a universal definition for a "massive rotator cuff tear." By using the term "massive rotator cuff tear," the surgeon should take into account not only a tear diameter ≥5 cm or a complete tear of two or more tendons, but also other factors such as tendon retraction, muscle atrophy, arthritis, and intraoperative tendon mobilization [21].

Once an MRCT is identified, it should be further classified into subgroups according to the location of the tear, as this helps to determine the likelihood for a successful repair. For this reason, either the classification of Gerber et al. [22] or Collin et al. [23] can be used. Recent studies have shown that postero-superior tears have the highest postoperative failure rate followed by antero-posterior subtypes of MRCTs [20, 24, 25].

9.2.1.3 Fatty Infiltration and Atrophy

It is reported that Goutallier grade 2 or higher degrees of fatty infiltration are significantly associated with poorer healing after repair [10]. This is also supported by several studies [5, 12, 26, 27] where the fatty infiltration of both the supraspinatus and infraspinatus can predict the final tendon integrity. A new meta-analysis showed that an increase in supraspinatus or infraspinatus fatty infiltration by one grade increases the risk of re-tear by approximately 2.5 times [13].

However, we should comment that the current body of literature is sometimes confusing and the final multivariate analysis performed by some authors shows that fatty infiltration may not be a risk factor for re-tear [28], nor is a negative prognostic factor for bad functional outcome even in postoperative cases with intact tendon [29]. Furthermore, some authors propose that only decreased preoperative active external rotation rather than atrophy is a risk factor for postoperative re-tear in the postero-superior and antero-posterior tear groups [25]. One could conclude that the pathoanatomy of MRCTs is multifactorial.

9.2.1.4 Muscle-Tendon Unit Retraction and Tissue Quality

The Patte classification is usually used for the evaluation of the RC tendon retraction, and it assesses the degree of tendon retraction in the coronal plane on MRI. According to this classification, RCTs are divided into three groups: (1) Full-thickness tear with little tendon retraction, (2) tendon retraction to the level of the humeral head, and (3) tendon retraction to the level of the glenoid [30]. Lädermann et al. have further defined an MRCT as requiring at least one of the two torn tendons to be retracted beyond the top of the humeral head [21].

Tendon retraction has been directly correlated with the tear size, tear chronicity, and muscle fatty infiltration [10, 31]. Furthermore, it has been reported to be an independent prognostic factor of re-tear [12, 32, 33].

9.2.1.5 Other Patient-Related Factors

Several other patient-related factors have been reported to affect rotator cuff tendon healing.

- *Smoking*

  Smoking can increase the risk for rotator cuff tears, can influence the size of the tear, and also compromise healing [10].
- *Hypercholesterolemia and Diabetes*

  Total cholesterol, triglycerides, and low-density lipoprotein cholesterol concentrations are increased in patients with rotator cuff tears and may also affect the healing rates [10]. Similarly the body fat (expressed as body mass index) [34] and the sustained hyperglycemia increase the possibility of anatomic failure of a repaired cuff [35].
- *Osteoporosis*

  In older patients and especially in women, the surgeon should account for not only diminished bone mineral density, but also possible vitamin D deficiency, which may have a negative effect on rotator cuff tendon healing following surgical repair [10].

9.2.2 Surgeon-Related Modifiable Factors Affecting Rotator Cuff Healing

9.2.2.1 Single-Row, Double-Row, or Suture Bridge Techniques

After understanding the importance of different technical factors like the orientation and the depth of anchors, the type and the strength of the knots used, the rotator cuff surgical trends have gradually passed from the classic open transosseous [TO] repairs to single-row [SR] suture anchor repairs, to double-row [DR] suture anchor repairs, and finally to transosseous-equivalent suture bridge [SB] techniques [10]. Double-row and speed bridge transosseous-equivalent techniques seem to produce a better biomechanical environment that theoretically could improve healing rates and superior functional outcomes.

The initial reports with SR techniques showed healing rates from 71% to 78%. However, large or massive tears with antero-superior, and principally, postero-superior lesions showed up to 50% tear recurrence [16, 36]. Furthermore, Barth et al. reported their anatomical and functional outcomes in 212 patients operated with the classic DR technique. The authors used the postoperative RC integrity classification as described by Sugaya and found an overall 13% recurrence rates. However, large and massive tears were also more prone to anatomical failure (25.5%), but with significantly better results compared to previous SR studies [12]. Duquin et al. after including 1252 patients from 23 studies concluded that the re-tear rates are significantly lower for DR techniques. In detail, they reported failures for DR of 7% for small (<1 cm), 8% for medium (1–3 cm), 25% for large (3–5 cm), and 43% for massive tears (>5 cm). Respectively, the values for the SR were 18% for small, 31% for medium, 44% for large, and 65% for massive tears [37]. The introduction of the SB technique had initially given encouraging results with Frank et al. [38] reporting 88% healing rates in 25 patients [100% success in massive tears (3/3 patients)]. Later Neyton et al. evaluated the arthroscopic SB repair for only small- to medium-sized supraspinatus tears and reported 10.3% recurrence (one case rupture of musculotendinous junction, 0.9%) [39]. Furthermore, Kim et al. stated that the overall anatomical failure rate for SB was 15%, and more specifically 12%, 21%, and 22% for medium, large, and massive tears, respectively [40].

Newer reports have shown equivalent outcomes between double-row and single-row repairs in small and medium lesions. However, in large and massive tears DR or TOE fixation may provide a functional advantage over SR [10, 25, 41].

9.2.2.2 Interval Slide Techniques for Massive Immobile Rotator Cuff Tears

In cases of massive, contracted, and immobile rotator cuff tears, Lo and Burkhart in 2004 proposed the interval slide technique. This can be either anterior, by incising the posterior part of the coracohumeral ligament (release of the supraspinatus from the rotator interval), or posterior by releasing the interval between the supraspinatus and infraspinatus tendons [42]. Initially, the authors reported no complications and significant improvement in the active range of motion and muscle strength [42]. However, despite the functional improvement, Berdusco et al. demonstrated that the healing rates did not exceed 45% [43]. Finally, according to Kim et al., the aggressive interval slide techniques with complete tendon repair have a 91% re-tear rate, which is not superior to partial repair [44].

9.2.2.3 Biologics (More Details Regarding the Biologics Are Provided in Chaps. 5, 6, and 7)

- *Patch Augmentation for Large and Massive Rotator Cuff Tears*

  Due to the significant rates of rotator cuff failures, especially in large and massive tears, several patch augmentation materials have been developed. Their purpose is either to enhance mechanically the strength of the repair and or provide a better biologic healing environment. Additionally, the mechanical support could be obtained either by augmentation of the repair either by interposition or bridging of the patch between tendon and bone.

  The current literature shows that regardless of the type of material (xenografts, allografts, and autografts), the interposing or bridging patches that span the defect from the retracted and stiff tendon stump to the greater tuberosity show superior healing rates than augmentation patches (75–90% successful rates vs. 50–60% respectively) [45–47]. This may be explained by the fact that in chronic massive tears, the relative tendon to muscle ratio of the musclotendinous unit is severely altered, resulting in significant loss of the muscle force [48].

- *Platelet Rich Plasma (PRP)*

  Despite the promising advantages and the results of animal model studies, great controversy exists regarding the effectiveness of the PRP when clinically applied during rotator cuff repair [10]. Interestingly, regarding their intraoperative clinical use during rotator cuff surgery, there is an abundance of review and meta-analysis articles, with 64 published to date. All authors concluded that the use of PRP during rotator cuff surgery results in no differences in the overall re-tear rates and in functional outcomes compared with patients treated without the application of any biological factor, except probably the small- and medium-sized tears [49, 50].

The most important prognostic factors affecting rotator cuff integrity after rotator cuff repair are shown in Table 9.1, as presented in the meta-analysis of Saccomanno et al. [14] and McElvany et al. [13].

Table 9.1 The most important prognostic factors affecting rotator cuff healing presented by Saccomanno et al. and McElvany et al.

	Saccomanno et al. [14]	McElvany et al. [13]
Re-tear risk factors	Older age	Older Age (per 10 years)
	Severe fatty infiltration	SSP fatty infiltration
	Larger tear size	ISP fatty infiltration
	Multiple tendons involved	Global fatty degenerative index
	Poor tendon quality	Tear size >3 cm
	Tendon delamination	Traditional double-row technique (no suture bridge)
	Single-row technique	Single-row technique
	ACJ procedures	Delay of active ROM and strengthening
	LHB procedures	
	Lower bone mineral density	
	Smaller AHD	
	Preoperative tendon length <15 mm	

9.3 What Is the Clinical Effect of a Rotator Cuff Re-tear in Cases with a Massive Lesion?

Despite surgical evolution and a better preoperative diagnostic approach, structural failures of MRCTs after arthroscopic repair remain high [10, 14]. This raises several important questions that will be discussed in turn:

(a) *What is the clinical effect of a rotator cuff re-tear?*
(b) *Is it worth repairing a massive rotator cuff tear when 20–90% of repairs will re-tear anyway?*
(c) *What are the prognostic factors that influence the outcome of MRCT repair most?*

9.3.1 What Is the Clinical Effect of a Rotator Cuff Re-tear?

Due to the heterogeneity in their study design, the different surgical techniques used, the type of the tears included, and the different imaging and functional evaluations utilized, the conclusions regarding the clinical effect of a postoperative rotator cuff re-tear are often confusing. For example, numerous studies have shown that both objective and subjective results are significantly superior in cases with confirmed healed tendon [12, 51–55]. However, others report that the presence of a postoperative tendon defect is not always correlated with an inferior outcome [53, 56]. However, evaluation of the published articles reveals that the functional evaluation of the patients is most often performed using the ASES, UCLA, and Constant scores. The ASES score is a validated outcome measure in patients with shoulder pathology, including rotator cuff tears. However, the minimal clinically important difference in the ASES score has to be in the range of 6.4–12.00 points, which is quite large [56]. The UCLA score was originally designed to measure outcomes after shoulder arthroplasty, and heavily weights pain relief, passive shoulder motion, and patient satisfaction. Therefore the use of the UCLA as an outcome measure is less reliable in terms of distinguishing the difference between patients with or without rotator cuff re-tear [56].

In the majority of published studies, the patients with a healed tendon had greater strength in forward flexion (by approximately 2.5 kg) and marginally improved strength in external rotation. Furthermore, the Constant score is largely influenced by strength, which accounts for worse Constant scores in cases with RC repair failure [56]. This is also in accordance with the findings of Kim et al., who showed poorer outcomes after RC re-tear in patients of younger age and lower education level and laborers [57]. Also, we know that worse clinical outcomes are found not in small and partial tears, but mainly in large recurrent defects (>4 cm) [58, 59].

From the aforementioned studies it is understood that re-tear may not significantly affect the final functional scores nor patient satisfaction. However, surgeons should rather focus on the postoperative strength of the operated shoulder, which is detrimentally affected by an anatomical failure, and correlate this with the occupational demands of the patient [7, 11].

9.3.2 Is It Worth Repairing a Massive Rotator Cuff Tear When 20–90% of Repairs will Re-tear Anyway? (Table 9.2)

As mentioned, the landmark article by Galatz et al. demonstrated a 94% re-tear rate of massive tear repairs at 1 year postoperatively in 18 patients, but patients had a high degree of satisfaction, most achieved overhead arm function, and the American Shoulder and Elbow Surgeons (ASES) score was >80 in two-thirds of the patients.

In 2000, Gerber et al. reported 44% failure rates (12/27 patients) 2 years postoperatively in patients with MRCTs treated with open repair. The authors also reported that patients with a re-tear showed significant improvement in the shoulder compared with the preoperative state, but they showed less improvement than those with a successful repair who had excellent results

Table 9.2 Table showing the clinical and structural outcomes after massive rotator cuff tear repair

	Patients	Surgical technique	Re-tear results	Follow up	Constant		VAS		ASES		UCLA		Strength	Subjective shoulder value (SSV)
Park et al. (2016) [24]	92 patients I: 42 subscapularis (SSC) Intact S: 22 ≤ ½ SSC tear L: 28 > ½ SSC tear	SR for SSC DR for SSP + ISS	Overall re-tear: 27% (25/92) I: 21% (9/42)[a] S: 18% (4/22)[a] L: 43% (12/28)[a]	24 months	L tears postoperative Intact 66.4 Failed 64.4[a]		L tears postoperative Intact 1.1 Failed 3.8p		L tears Postoperative Intact 90.6 Failed 58.5p					
Heuberer et al. (2016) [60]	68 patients 23 DB 22 PR 23 CR	SB/SR/CR	CR re-tear (29%) PR re-tear (53%)	45 months	Postoperative DB: 65.8 ± 14.7 PR: 67.5 ± 9.9 CR: 80.3 ± 8.9[b]									
Jung et al. (2017) [19]	64 patients	Open	Re-tear: 26% (12/46)	24–60 months	Preoperative 44 ± 18	Postoperative 76 ± 7	Preoperative 6.4 ± 2.2	Postoperative 2.3 ± 1.1	Preoperative 42 ± 16	Postoperative 84 ± 8			Elevation strength from 51% to 78% Ex. rotation strength from 59% to 81%	
Ohzono et al. [29]	55 patients	Arthroscopic rotator cuff repair	Overall re-tear: 25.6% (19/74)	30 ± 12 months			Rest 26.3 Motion 59.8 Night 52.3 Postoperatively				Preoperative 18.1 ± 4.4	Postoperative 29.8 ± 4.5	Elevation 66.7[c] Abduction 65.5[c] Int rotation 67.5[c] Ext rotation 74.3[c]	
Shimokobe et al. [25]	102 patients 59 antero-superior tear (AS) 21 postero-superior tear (PS) 22 antero-posterior tear (APE)	SB/SR/DR	Overall re-tear 25.5% (26/102) AS: 10/59 (16.9%) PS: 9 (42.9%)[d] APE: 7 (31.8%)	>12 months			Stat. significant improvement than preoperative				Preoperative AS: 18.2 ± 5 PS: 17 ± 4.7 APE: 15.9 ± 4	Postoperative 28.3 ± 7.2 29.4 ± 3.8 28.3 ± 5.9	Stat. significant improvement than preoperative	
Agout et al. (2018) [26]	511 patients 289 isolated SS tears 92 anterior extension (A) 94 posterior extension (P) 36 antero-posterior (AP)	Open (254) Arthroscopic (257) SR/DR/TRANSOSSEOUS	SS: 40/289 (19%) A: 19/92 (25%) P: 24/94 (32%) AP: 8/36 (31%)	10 years	Preoperative A: 59.3 ± 16.2 P: 54 ± 14.9 AP: 51.2 ± 18.3	Postoperative 77.4 ± 14.1 78.4 ± 12.2 78.5 ± 8.6								Postoperative A: 84.5 ± 15.9 P: 83.8 ± 15.8 AP: 82.5 ± 15.3

Godenèche et al. [61]	73 patients 50 CR 23 PR	SB/SR	PR: 11/23 (47.8%) CR: 10/50 (20%)	29–55 months	Preoperative PR: 32.2 ± 9.1 CR: 30.8 ± 8.7	Postoperative PR: 75.3 ± 13.9 CR: 79.7 ± 12							Postoperative PR: 11/23 (47.8%) CR: 10/50 (20%)	Postoperative PR: 70.2 ± 23.7 CR: 79.2 ± 20.2
Kim et al. [62]	73 patients	Arthroscopic	Re-tear (R): 39/73 (53%) Healed (H): 34/73 (47%)	2 years			H: 1 ± 1 R: 2.1 ± 1.1		H: 90.8 ± 5.8 R: 76.6 ± 14.2		H: 31.0 ± 2.9 R: 24.9 ± 5.8			H: 90.2 ± 6.7 R: 77.4 ± 14.5
Ok et al. [20][e]	104 patients 34 antero-superior tear (A) 54 postero-superior tear (P) 16 antero-posterior tear (AP)	SB	Overall 45/104 (43.3%) A: 8/34 (23.5%) P: 28/54 (51.9%) AP: 9/16 (56.3%)	2 years	Preoperative 56.9 ± 15.4	Postoperative 74.3 ± 10.5	Preoperative 5.0 ± 2.73	Postoperative 2.4 ± 1.31	Preoperative 52.3 ± 11.4	Postoperative 79.4 ± 11.4	Preoperative 19.1 ± 8.31	Postoperative 27.1 ± 8.46		
Collin et al. [5]	130 patients	Open (64%) Arthroscopic (47%) SR/ Transosseous	Overall 34%	10 years	Preoperative 53.1 ± 15.9	Postperative 78.5 ± 11.3								Postoperative 83.4 ± 15.7
Henry et al. (2015) [63]	954 patients	Open/ Arthroscopic SR/DR	Re-tear 79%	33–52 months	Preoperative 49 Postoperative 74		Preoperative 5.9 Postoperative 1.7		Preoperative 40 Postoperative 84		Preoperative 13.5 Postoperative 29.6			
Lee et al. (2017) [64]	122 patients I: 45 intact SSC P: <1/3 tear of SSC C: >1/3 tear of SSC	SR for SSC SR/SB for SSP, ISP	Overall re-tear 37/122 (31.1%) I: 10/45 (22.2%) P: 7/35 (20%) C: 20/45 (47.6)p	39.5 months	Preoperative I: 48 ± 11.6 P: 45 ± 15.6 C: 44.3 ± 13	Postoperative 82 ± 11.8 82 ± 13.5 82.5 ± 12.8	Preoperative I: 4.6 ± 1.8 P: 4.9 ± 1.2 C: 5.1 ± 1.3	Postoperative 1.8 ± 1 1.9 ± 1.3 1.9 ± 1.2	Preoperative I: 45.5 ± 15 P: 43.5 ± 16 C: 42.7 ± 14	Postoperative 85.7 ± 12.5 81.7 ± 13.4 82.7 ± 14.7				
Papadopoulos et al. [58]	27 shoulders	Mini open SR	Overall re-tear 14/27 (51.9) <2 mm than initial 12/14 (small) >2 mm than initial 2/14 (large)	36–60 months	Postoperative Intact 85 Small 77.1 Large 67.5						Postoperative Intact 32.23 Small 29.8 Large 25.5			
Zumstein et al. [65]	23 patients	Open transosseous technique	Re-tear 13/23 (57%) 9.9 years Re-tear 10/27 (37%) 3.1 years[a]	9.9 years	Intact 81 Failed 64p								Abduction strength Intact 5.5 Failed 2.6p	

[a]not statistically significant
[b]Statistical significance between PR (partial repair)/DB (debridement)/CR (complete repair)
[c]Measured as the percentage of unaffected side
[d]Statistical significance higher than AS and APE
[e]Functional outcomes between groups were not significantly different

[22]. Eight years later the same authors presented the results of the same case series of 23 patients. Twenty-two of the 23 patients remained very satisfied or satisfied with the result. The subjective shoulder value and the Constant score were slightly improved compared with results from 2000 (82% vs. 80% and 85 vs. 83, respectively). However, the re-tear rate (57% vs. 44%) and the re-tear size were increased. Patients with a failed repair had a worse result than those with an intact reconstruction but still better than their preoperative conditions [65].

Papadopoulos et al., using mini-open repair, reported 52% failure rates 3 years postoperatively, but with good overall Constant and UCLA scores. Only large (>5 cm) defects were correlated with significantly worse clinical outcomes [58].

Collin et al. in a recent multicenter study with 10 years follow up of postero-superior MRCTs reported an overall prevalence of re-tears of 34%. Final Constant scores were significantly associated with cuff integrity, but even in cases with Sugaya type 5 re-tears, the mean score was 75, which is 20 points higher than the mean preoperative value. Also, their multivariate analysis revealed that the functional outcomes were only associated with preoperative infraspinatus retraction. Finally, the anterior extension of the tear and the involvement of the subscapularis did not have any negative effect on the Constant score or re-tear rates [5].

In antero-superior MRCTs, the percentage of structural failure also remains high. Kim et al. reported that after 2 years follow up there were 53% re-tears. Again the functional outcomes were significantly worse in patients with re-tears and even worse when the subscapularis was torn. Again, within both groups (healed or not), all scores and the range of motion improved significantly compared with preoperative values [62].

Rotator cuff surgery has also been studied in patients older than 75 years with MRCTs. Jung et al. reported on 64 patients with results of 26% re-tears but 80% patient satisfaction. The most important finding of this study was that beyond improvements in ASES and Constant scores, these elderly patients showed significant functional independence during their daily activities (Katz index and Functional independence measurement motor) [19].

Ozhono et al. reported that tendon integrity after repair of MRCTs is not the panacea for an excellent postoperative outcome. In their case series, they found that preoperative fatty degeneration of the infraspinatus and or subscapularis with Goutallier stage 2 or higher was significantly associated with worse outcome in patients who had intact tendons after arthroscopic repair [29].

Finally, Godenèche et al. in their study tried to answer the question whether we should reconstruct an MRCT even when it is partially repairable. The authors found 20% re-tears in patients with complete repair and approximately 50% in those with partial repair. However, the Constant score was only slightly higher for completely reparable tears (81.5) than for partially reparable tears (79). The authors reported that even two tendon repairs can produce "equivalent" improvement, patient satisfaction, and autonomy [61].

9.3.3 What Are the Prognostic Factors that Influence the Outcome of MRCT Repair Most?

Review of the literature focused on MRCT repair shows that possible prognostic factors associated with the outcomes of the procedure include the following:

- The recognition of *a reparable MRCT* is of great importance. An MRCT is described as a tear with a diameter of 5 cm or more, and or as a complete tear of two or more tendons, with at least one of the two tendons retracted beyond the top of the humeral head. It is important to exclude arthritis and the cuff arthropathy should be Hamada stage 2 or less.
- The location of MRCT seems to be very important. The classifications proposed by Gerber et al. [22] or by Collin et al. [23] are very useful for the clinician during decision making. The *postero-superior and antero-posterior tears* are prone to worse outcomes in terms of postoperative tendon integrity, reduced acromiohumeral distance, and functional results [20]. Additionally when over half of the subscapularis tendon is involved in

a postero-superior tear some authors propose other treatment options [24].

- Advanced preoperative fatty infiltration and atrophy. The preoperative fatty infiltration of the infraspinatus and or subscapularis with Goutallier stage 2 or higher are associated with worse postoperative outcomes even in patients with intact tendons [29].
- The pre-operative infraspinatus retraction may have a significant association with the 10-year Constant-Murley score [5].
- The decreased preoperative active external rotation in patients with postero-superior tears [25].
- The size of the postoperative tendon re-tear is significantly correlated with worse outcomes [9, 58].
- Older age is not always a contraindication of an MRCT repair [19].
- The onset of the tear is also important with traumatic tears showing better and more predictable outcomes [61].
- Zumstein et al. proposed that the wide lateral extension of the acromion is a risk factor of re-tear in MRCTs [65]. Recently, Taniguchi et al. described a new scale for measuring humeral head translation. The T-scale is the perpendicular distance from the head center to the coracoacromial line. The authors support that a negative T-scale value is a useful prognostic factor for considering reverse shoulder arthroplasty in patients with MRCTs [66].

9.4 Conclusions

Before any decision making, the recognition of a repairable MRCT and its location is of great importance. Despite the high failure rates after MRCT repair, in most cases the patients' functional outcomes are significantly better than their preoperative condition. However, surgeons should focus on the postoperative strength of the operated shoulder, which is still reduced in cases of anatomical failure and consider this along with the patients' occupational demands. Older (fatty infiltration and tear location) and newer (T-scale) prognostic factors should be preoperatively systematically evaluated before considering all possible treatment modalities, from arthroscopic repair to reverse shoulder arthroplasty.

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