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SHOULDER

Clinical and anatomic results of rotator cuff repair at 10 years depend on tear type

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Abstract

Purpose Although good short-term and mid-term outcomes are reported for rotator cuff repair, few studies have investigated long-term outcome with clinical and MRI evaluation. The hypothesis was that 10 years following repair of rotator cuff tear, the clinical and anatomic results depend on the extension of the tear.

Methods The records of all 965 patients who underwent repair of rotator cuff tears in 2003 were retrieved. The patients were reviewed in 2014 for evaluation at a minimum follow-up of 10 years. A total of 511 patients were evaluated clinically, of whom 397 were also evaluated using MRI. There were 289 isolated supraspinatus tears (SS), 94 tears with posterior extension (P), 92 with anterior extension (A) and 36 with anteroposterior (AP) extension.

Results The Constant score had significantly improved from 53.8 ± 14.7 preoperatively to 77.7 ± 12.1 ($P<0.0001$) at 10 years, with no significant difference between the four groups. The rate of retear (Sugaya IV, V) was lower in the SS group (19%) and higher in the P (32%) and AP groups (31%). At review, infraspinatus fatty degeneration was significantly greater (Fuchs > 2) in the P ($P<0.001$) and AP ($P<0.001$) groups and subscapularis fatty degeneration was significantly greater (Fuchs > 2) in the A ($P<0.001$) and AP ($P<0.001$) groups. The rate of osteoarthritis (Samilson > 2) was significantly higher at 11% ($P=0.001$) in the A group. The failure rate was significantly lower ($P=0.044$) in the SS group (25%) than the massive rotator cuff tear groups (A, P and AP groups) (35%). Complications occurred in 51 shoulders (10%) and repeat surgery was required in 62 shoulders (12%), with no difference between the four groups.

Conclusions The long follow-up period of this study, large series of patients and MRI evaluation of tendon repair allowed us to demonstrate that 10 years following rotator cuff tear repair, between 68 and 81% of tendons had healed. These findings are of value in predicting response to surgical treatment. Tears with posterior extension had a higher risk of retear. However, surgical repair appeared to give a good functional outcome whatever the type of tear, despite the overall rate of complications and repeat surgery.

Level of evidence IV.

Keywords Long-term outcome · Magnetic resonance imaging (MRI) · Rotator cuff tear · Shoulder · Surgical repair

Abbreviations

A	Anterior extension
AP	Anteroposterior extension
P	Posterior extension
SS	Supraspinatus

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Introduction

Rotator cuff lesions account for 4.5 million consultations in the United States each year, of which 250,000 are repaired surgically [11, 20]. Their high frequency makes them a public health problem.

Treatment of tears restricted to the supraspinatus gives satisfactory functional and anatomic results [5, 19, 32] but tears extending to several tendons carry a higher risk of disappointing functional results and retears [12]. The results depend on a number of parameters: for example, the size of the initial tear is often the predominant factor but other factors are also influential, notably the patient's age, fatty degeneration of muscle, diabetes and tobacco use [3, 4, 16, 17, 22, 25, 26]. The few studies of long-term results generally report the patients' functional results and few provide anatomic results [1, 2, 6, 7, 10, 18, 28]. Only Zumstein et al. [33] and Vastamäki et al. [31] have reported the anatomic results of repair using MRI. Similarly, there has been no study of the relationship between initial type of tear and long-term results, when watertight repair had been possible.

The aim of this study was to describe the characteristics of the different types of rotator cuff tears and to report the clinical, radiological and anatomic results 10 years after surgical repair. Our hypothesis was that the long-term results were dependent on the type of tear. We considered that the 10-year follow-up period with MRI evaluation of tendon healing would result in improved clinical knowledge of long-term patient management.

Materials and methods

A retrospective study was performed of the records of all patients who underwent surgical repair of rotator cuff tears in 2003 by 15 surgeons at 15 centres. The study was carried out under the direction of the Société Française de Chirurgie Orthopédique et Traumatologique (SOFCOT). The inclusion criteria were adult patients with full-thickness rotator cuff tears, which received complete tendon repair, by either open or arthroscopic surgery. The exclusion criteria were partial-thickness tears, history of previous shoulder surgery, partial tendon repairs and isolated subscapularis tears. A total of 965 patients were identified and were asked to return in 2014 for clinical and radiographic evaluation at a minimum follow-up of 10 years. All patients gave their informed consent to participation in the study.

Of the original cohort of 965 patients, 392 could not be contacted. Sixty-two patients underwent repeat surgery: 26 for retears, 12 for conversion to shoulder arthroplasty, and 24 for other reasons (Fig. 1). These patients were excluded from clinical and MRI assessment but retears and shoulder arthroplasty were included in the analysis of failure. The final study cohort consisted of 511 patients (59% men), aged 56.4 ± 7.9 years (range 25–78) at the time of surgery, divided into four groups: isolated supraspinatus tears, tears with anterior extension (supraspinatus and subscapularis), tears with posterior extension (infraspinatus and supraspinatus) and tears with anteroposterior extension (infraspinatus, supraspinatus and subscapularis) (Table 1). Preoperative MRI or computed tomography (CT) arthrography was available for these 511 shoulders to determine initial tear pattern and the imaging findings were confirmed intra-operatively. The tear pattern was isolated supraspinatus in 289 shoulders (57%), anterior extension in 92 shoulders (18%), posterior extension in 94 shoulders (18%), and anteroposterior extension in 36 shoulders (7%) (Table 2).

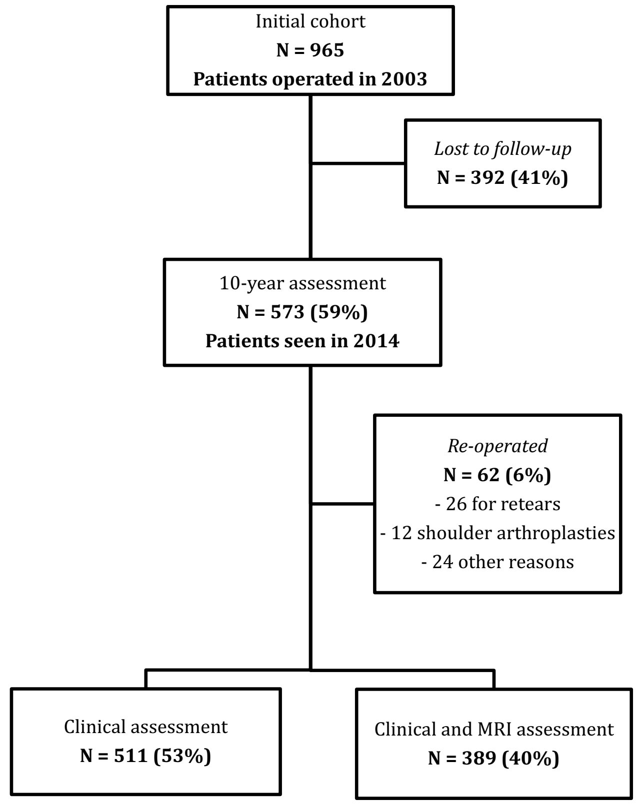

Fig. 1 Flowchart of the study

Five hundred eleven patients were examined clinically and evaluated using the Constant-Murley score [8], Subjective Shoulder Value (SSV) [12, 13], the Simple Shoulder Test (SST), and range of motion (ROM). Of the study cohort, 122 patients were unable to undergo radiography or declined. A total of 389 patients were evaluated by magnetic resonance imaging (MRI) and frontal and sagittal view X-ray in neutral rotation. In these patients, tendon healing was evaluated by MRI according to the Sugaya classification [30] (stages I, II and III, healing; stages IV and V, retear) and fatty infiltration according to the modified Goutallier classification [9, 14] (stages 0, 1 and 2, functional muscle; stages 3 and 4, non-functional muscle), while glenohumeral arthritis was graded radiographically according to the Samilson classification [27] (stage > 2, glenohumeral arthritis) and Hamada classification [15] (stage > 1, glenohumeral arthritis). The MRI protocol included (1) T2-weighted fat-suppression sequences (non-proton density weighted) in the oblique coronal, oblique sagittal, and transverse planes, including the entire scapula, to assess tendon healing, and (2) T1-weighted sequences in the transverse and sagittal planes to assess fatty infiltration and muscle condition.

Table 1 Patient demographics

	Isolated supraspinatus tears $N=289$ (56.6%)	Tears with anterior extension (supraspinatus and subscapularis) $N=92$ (18.0%)	Tears with posterior extension (infraspinatus and supraspinatus) $N=94$ (18.4%)	Tears with anteroposterior extension (infraspinatus, supraspinatus and subscapularis) $N=36$ (7.0%)	*P* value
Patient demographics					
Age, years (range)	56.5 ± 8.3 (31.6–77.2)	56.4 ± 6.8 (38.8–73.8)	55.6 ± 7.3 (38.3–78.7)	58.0 ± 8.3 (25.5–71.3)	n.s.
Men:women	146:143	69:23	61:33	27:9	< 0.0001
Dominant side	209 (73%)	76 (83%)	76 (81%)	26 (72%)	n.s
Smokers	38 (13%)	13 (14%)	10 (11%)	6 (17%)	n.s.
Previous trauma	78 (27%)	34 (40%)	41 (44%)	17 (47%)	0.001
Onset—Chronicity, years (range)	1.7 ± 1.9 (0.1–15.0)	2.2 ± 3.5 (0.1–24.0)	1.6 ± 2.7 (0.2–21.0)	2.4 ± 4.9 (0.1–27.0)	n.s.
Work-related accidents, *n* (%)	68 (24)	29 (32)	23 (24)	11 (31)	n.s.
Profession, *n* (%)					
Sedentary	85 (29)	18 (20)	26 (28)	9 (25)	
Light manual	92 (32)	37 (40)	21 (22)	8 (22)	
Heavy manual	75 (26)	26 (28)	33 (35)	12 (33)	n.s.
Repetitive	33 (11)	7 (8)	9 (10)	6 (17)	
Unknown	4 (1)	4 (4)	5 (5)	1 (3)	

Each MRI scan was interpreted by three central observers, a senior radiologist, a senior surgeon and a junior surgeon, and discrepancies in classification or grading were discussed until consensus was reached. To determine intra- and inter-observer agreement, each observer repeated their reading on 50 scans after an interval of 3 weeks. The k statistic test revealed good intra-observer agreement ($k = 0.71$) and moderate inter-observer agreement ($k = 0.56$) for the modified Goutallier classification of fatty infiltration, and good intra-observer agreement ($k=0.74$) and moderate inter-observer agreement ($k=0.68$) for the Sugaya classification of tendon healing.

Surgical techniques

Repair was open (anterosuperior approach) in 254 shoulders (50%) and arthroscopic in 257 shoulders (50%). Adjuvant acromioplasty was performed in 484 shoulders (95%), while biceps tenodesis was performed in 227 (44%) and tenotomy in 89 (17%) shoulders. Because of the retrospective and multi-centre design of the study, there was some heterogeneity in suture techniques, which included single-row, double-row and transosseous-equivalent techniques [21]. All repairs were complete at the end of the intervention.

Postoperative rehabilitation

Following surgery, the arm was supported in a sling against the body ($n=188$) or at 20° of abduction ($n=323$) for 5.7 ± 1.0 weeks (median 6; range 0–8). All centres followed the same rehabilitation protocol. Passive motion exercises were initiated on the first postoperative day, and when possible, hydrotherapy was initiated after skin healing. Active shoulder motion was allowed after 8.0 ± 6.5 weeks (median 6; range 0–50). Patients were not allowed to perform any strengthening exercises or strenuous work for 6 months after surgery. Light sports and more demanding activities were allowed after 6 months.

Ethical approval

This study received prior approval from the institutional review board of the Medical university of Strasbourg (IRB# 2013-A01788-37).

Statistical analysis

Statistical analyses were performed using R version 3.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were used to summarize the data. For non-Gaussian quantitative data, between-group differences were evaluated using Wilcoxon rank sum tests (Mann–Whitney *U* test). When three or more groups were compared, Kruskal–Wallis tests were used. Categorical data were analysed using Pearson Chi-square tests or Fisher's exact tests. Model assumptions were checked before the analyses were performed. *P* values < 0.05 were considered statistically significant.

Table 2 Preoperative clinical and radiographic assessment and intraoperative assessment (case note review)

	Isolated supraspinatus tears *N* = 289 (56.6%)	Tears with anterior extension (supraspinatus and subscapularis) *N* = 92 (18.0%)	Tears with posterior extension (infraspinatus and supraspinatus) *N* = 94 (18.4%)	Tears with anteroposterior extension (infraspinatus, supraspinatus and subscapularis) *N* = 36 (7.0%)	*P* value
Preoperative assessments					
Passive forward elevation (range)	166.7 ± 15.6 (90–180)	164.0 ± 25.3 (85–180)	162.1 ± 21.3 (90–180)	147.8 ± 33.2 (70–180)	0.003
Active forward elevation (range)	148.1 ± 31.3 (40–180)	156.9 ± 31.8 (30–180)	146.0 ± 32.4 (30–180)	138.1 ± 31.2 (70–180)	0.001
Pain (range)	5.4 ± 3.1 (0–15)	6.1 ± 3.1 (0–15)	5.7 ± 2.9 (0–15)	5.6 ± 3.2 (0–15)	n.s
Activity (range)	10.2 ± 3.1 (3–19)	11.2 ± 3.2 (2–18)	10.5 ± 3.8 (2–20)	10.3 ± 3.9 (2–20)	0.048
Mobility (range)	29.4 ± 7.8 (6–40)	31.7 ± 8.6 (6–40)	30.4 ± 7.9 (10–40)	27.5 ± 8.9 (8–40)	0.016
Strength (range)	6.8 ± 5.3 (0–24)	10.1 ± 6.5 (0–25)	7.1 ± 4.9 (0–20)	7.6 ± 6.4 (0–22)	0.001
Total Constant score (range)	51.8 ± 13.6 (19–87)	59.3 ± 16.2 (16–89)	54.0 ± 14.9 (16–83)	51.2 ± 18.3 (14–82)	0.001
Total weighted Constant score (range)	64.7 ± 17.0 (22–110)	70.6 ± 19.4 (18–104)	64.7 ± 18.6 (23–107)	60.4 ± 19.3 (16–91)	0.011
Preoperative radiographic assessments *n* (%)					
Acromial spur	156 (54)	34 (37)	42 (45)	18 (50)	0.035
Samilson > 2	0 (0)	0 (0)	1 (1)	0 (0)	n.s.
Hamada > 1	7 (2)	8 (9)	5 (5)	6 (17)	0.005
Intraoperative assessment					
Surgical technique					
Arthroscopy	175 (61)	35 (38)	37 (39)	10 (28)	< 0.0001
Open	114 (39)	57 (62)	57 (61)	26 (72)	
Acromioplasty	274 (95)	90 (98)	90 (96)	30 (83)	n.s.
LHB rupture	4 (1)	10 (11)	4 (4)	2 (6)	0.001
LHB dislocation or subluxation	31 (11)	53 (58)	9 (10)	23 (64)	< 0.0001
Adjuvant procedures on LHB *n* (%)					
None	127 (44)	17 (18)	20 (21)	5 (14)	< 0.0001
Tenodesis	92 (32)	62 (67)	48 (51)	25 (69)	
Tenotomy	58 (20)	8 (9)	18 (19)	5 (14)	
Unknown	12 (4)	5 (5)	8 (9)	1 (3)	

LHB long head of biceps

Results

Regarding demographic data (Table 1), the majority of patients whose tear extended posteriorly or anteriorly were men ($P < 0.0001$) and were more likely to have had a history of injury ($P = 0.001$) than in the group with isolated supraspinatus tears. There was no significant difference between groups for age (n.s.), dominant side (n.s.), tobacco use (n.s.), duration of symptoms (n.s.), work-related injury (n.s.) or occupation (n.s.).

Regarding preoperative clinical data (Table 2), the group of tears with anteroposterior extension had a passive forward elevation of 147.8° ± 33.2° (range 70°–180°) ($P = 0.003$) and active forward elevation of 138.1° ± 31.2° (range 70°–180°) ($P = 0.001$), which was significantly less than in the other groups. The group of tears with anterior extension had a significantly higher preoperative Constant score (59.3 ± 16.2; range 16–89) ($P = 0.001$) than the other groups. On preoperative imaging, the group with isolated supraspinatus tears had a significantly higher rate of acromial spurs (54%) ($P = 0.035$). The group of tears with anteroposterior extension had a significantly higher rate of preoperative arthritis (Hamada > 1; 17%) ($P = 0.005$). Peroperatively, arthroscopic surgery was significantly predominant in the isolated supraspinatus group (61%) ($P < 0.0001$). The long part of the biceps was more often torn (11%) ($P = 0.001$) and more often dislocated or subluxated when the lesion extended anteriorly (tears with anterior extension, 58% or tears with anteroposterior extension, 64%) ($P < 0.0001$). Regarding functional results (Table 3), the mean Constant

Table 3 Postoperative clinical outcomes according to tear pattern

	Isolated supraspinatus tears $N=289$ (56.6%)	Tears with anterior extension (supraspinatus and subscapularis) $N=92$ (18.0%)	Tears with posterior extension (infraspinatus and supraspinatus) $N=94$ (18.4%)	Tears with anteroposterior extension (infraspinatus, supraspinatus and subscapularis) $N=36$ (7.0%)	*P* value
Constant score					
Pain (range)	13.0 ± 3.0 (0–15)	12.2 ± 3.2 (3–15)	13.1 ± 2.7 (5–15)	13.1 ± 2.7 (7–15)	0.029
Activity (range)	17.9 ± 2.9 (5–20)	17.5 ± 3.2 (8–20)	17.9 ± 2.9 (9–20)	17.8 ± 3.0 (10–20)	n.s.
Mobility (range)	35.5 ± 5.8 (6–40)	35.0 ± 6.2 (10–40)	36.2 ± 5.3 (10–40)	35.6 ± 4.7 (20–40)	n.s.
Strength (range)	11.3 ± 5.9 (0–25)	12.8 ± 6.7 (0–25)	11.2 ± 6.1 (0–25)	11.3 ± 5.2 (4–22)	n.s.
Total Constant score (range)	77.8 ± 12.2 (37–100)	77.4 ± 14.1 (35–100)	78.4 ± 12.2 (36–98)	78.5 ± 8.6 (61–95)	n.s.
Total weighted Constant score (range)	104.5 ± 17.1 (55–145)	99.9 ± 18.4 (42–129)	103.4 ± 16.8 (57–134)	104.2 ± 12.1 (73–123)	n.s.
SSV (range)	84.9 ± 14.9 (20–100)	84.5 ± 15.9 (30–100)	83.8 ± 15.8 (30–100)	82.5 ± 15.3 (45–100)	n.s.
SST (range)	10.1 ± 2.2 (3–12)	9.9 ± 2.4 (3–12)	10.0 ± 2.2 (3–12)	10.2 ± 1.8 (5–12)	n.s.
Complications	30 (10%)	7 (8%)	11 (12%)	3 (8%)	n.s.
Re-operation for retears	35 (11%)	8 (8%)	15 (14%)	4 (10%)	n.s.

SSV subjective shoulder value, *SST* simple shoulder test

score of the whole study population was significantly better postoperatively (77.7 ± 12.7, range 35–100) than preoperatively (53.8 ± 14.7, range 14–87) ($P < 0.0001$). Postoperatively, the absolute Constant score, weighted Constant score, SSV score, SST score, complication rate and repeat surgery rate did not significantly differ between groups.

Regarding anatomic results (Table 4), retear rates (Sugaya 4 and 5) were higher if the tear extension was posterior (32%) or anteroposterior (31%) but the difference was not significant (n.s.). The group of tears with anterior extension had the highest rate of subscapularis lesions (11%) ($P = 0.002$) at 10 years. Both preoperatively and postoperatively, fatty degeneration > 2 of the supraspinatus ($P < 0.0001$) and the infraspinatus ($P < 0.0001$) was more common if the tear extended posteriorly, and fatty degeneration > 2 of the subscapularis ($P < 0.0001$) was more common if the tear extended anteriorly (Fig. 2). Arthritis was significantly more frequent in tears with anterior extension (Samilson > 2) at 11% ($P = 0.001$). If the entire subscapularis was involved, this rate was 22%. The failure rate (retears and repeat surgery for retear) was higher in the group with posterior extension (40%), but this difference was not significant (n.s.). The failure rate of the isolated supraspinatus group was significantly lower ($P = 0.044$) (25%) than that of all the other groups (anterior, posterior and anteroposterior extension tears) (35%).

Table 4 Anatomic results according to tear pattern

	Isolated supraspinatus tears $N=289$ (56.6%)	Tears with anterior extension (supraspinatus and subscapularis) $N=92$ (18.0%)	Tears with posterior extension (infraspinatus and supraspinatus) $N=94$ (18.4%)	Tears with anteroposterior extension (infraspinatus, supraspinatus and subscapularis) $N=36$ (7.0%)	*P* value
MRI assessment, *n* (%)	210 (73)	77 (84)	76 (81)	26 (72)	
Tendon healing, *n* (%)					
Retear (Sugaya IV, V)	40 (19)	19 (25)	24 (32)	8 (31)	n.s.
Subscapularis tear	5 (2)	10 (11)	2 (2)	1 (3)	0.002
Glenohumeral arthritis, *n* (%)					
Samilson > 2	24 (12)	25 (33)	12 (18)	8 (28)	0.001
Failure (retear and re-operation for retear), *n* (%)	61 (26)	25 (30)	35 (40)	9 (32)	n.s.

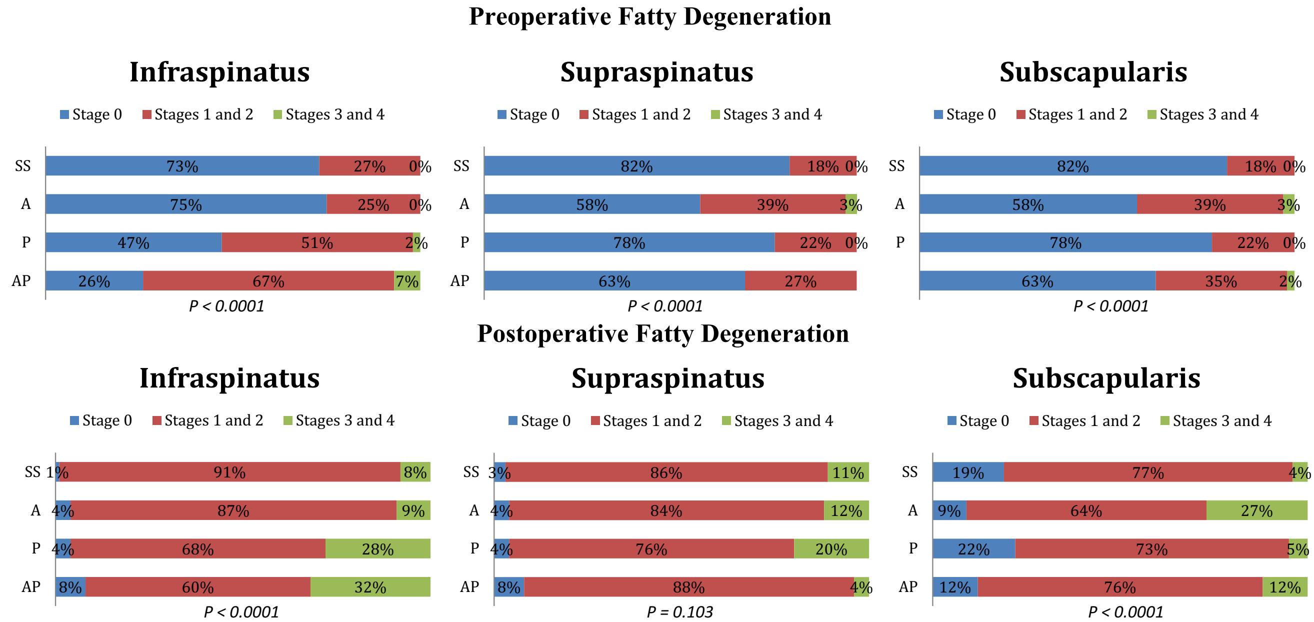

Fig. 2 Pre- and postoperative fatty degeneration according to the modified Goutallier classification. *SS* isolated supraspinatus, *A* tears with anterior extension, *P* tears with posterior extension, *AP* tears with anteroposterior extension

Discussion

This study confirmed that surgical repair of rotator cuff tears gives good long-term functional results, whatever the initial type of tear. The preoperative Constant score showed a significant mean increase of 24 points at the last assessment. Among the patients re-evaluated by MRI, tendon healing 10 years postoperatively (Sugaya types I–III) ranged from 68% for tears with posterior extension to 81% for isolated supraspinatus tears. Our hypothesis that long-term results may be dependent on the initial type of tear was confirmed. 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.

Only six published studies have reported the clinical results of rotator cuff repair more than 10 years postoperatively [1, 2, 6, 10, 28, 29]. In these studies, the size of the cohorts ranged from 30 to 105 patients and mean postoperative interval from 10 to 20 years. The Constant score was the functional result the most frequently used (three of the six studies) [2, 9, 31], with a mean score between 60 and 81. Our series of 511 patients evaluated 10 years postoperatively is the largest cohort described in the literature. The absolute Constant score was 77.7 ± 12.7, which is in agreement with these previously published series.

With a 20-year follow-up and 67 patients, Vastamäki et al. [31] reported a relatively low Constant score (mean 58) and a high rate of full-thickness retear (94%) evaluated by MR arthrography. More recently, Nich et al. [23] reported the results of isolated supraspinatus repair and observed a retear rate of 17.4% on MRI evaluation 8.6 years postoperatively, which corresponds to our own results in the isolated supraspinatus group (19%). Zumstein et al. [33] reported the MRI results of 33 patients surgically treated for massive rotator cuff tears by open surgery, finding a retear rate of 57% at 9.9 years postoperatively. In this series, there was a major difference in the retear rate between tears with anterior extension (30%) and tears with posterior extension (67%). Our results showed the same trend. In our series, a significantly lower failure rate was observed in the isolated supraspinatus tear group than in the group of more extensive rotator cuff tears. This trend was also observed by Kluger et al. [18] in a prospective study with postoperative ultrasound evaluation of surgical rotator cuff repair. Mean follow-up was 96 months and overall healing failure rate was 33%, with a significant correlation between the size of the preoperative tear (> 500 mm^3) and risk of retear. However, Ranebo et al. [24] observed that 22 years after acromioplasty alone without surgical repair of full-thickness rotator cuff tear, 29% of patients had required reoperations and 74 had rotator cuff tear arthropathy (Hamada ≥ 2). Zumstein et al. [33] reported that in spite of successful rotator cuff repair, fatty degeneration of muscle inevitably progresses in the long term. In our study, fatty degeneration of the infraspinatus muscle was significantly worse ($P < 0.0001$) in tears with posterior extension and tears with anteroposterior extension. The same was observed for the subscapularis muscle

($P < 0.0001$) and for tears with anterior extension and tears with anteroposterior extension, in spite of initial watertight repair and a low preoperative rate of fatty infiltration. The preoperative integrity of a tendon thus seems to determine the degree of fatty degeneration of its muscle in the long term. Our study shows that it is the tendons that are torn preoperatively that determine the progression to irreversible fatty degeneration of the corresponding muscle, in spite of watertight repair. This was also observed by Galatz et al. [10] and Gerber et al. [12] who reported that fatty degeneration increased in all rotator cuff muscles during the 3 years following open rotator cuff repair in spite of complete repair.

The main strength of the present study is that it is the first to report 10-year clinical outcomes and MRI findings from a large cohort of patients treated surgically for full-thickness rotator cuff tears. Our data therefore enabled reliable analysis of repair integrity and longevity. The study has a number of limitations typical of retrospective investigations, including (1) the large proportion of patients lost to follow-up (40.6%); (2) the heterogeneity of suture techniques and anchor materials used; and (3) the inability to obtain MRI scans on the full cohort assessed clinically.

Conclusion

Ten years after rotator cuff repair, 68–81% of tendons had healed, 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, in spite of a 10% complication rate and a 12% revision rate.

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Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.

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Ethical approval The Ethical committee of the Medical university of Strasbourg gave a favorable opinion on your request about project of clinical research: Ten-year multi-center clinical and MRI evaluation of isolated supraspinatus repairs (No: IDR 2013-A01788-37).

Informed consent Patients were informed, and they consented to conduct the study.

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