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Clinical and structural outcome 20 years after repair of massive rotator cuff tears

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Background: Short- and mid-term outcomes after massive cuff tear repair are well reported, but there is no documentation of the clinical and structural outcomes at 20 years of follow-up. The hypothesis of the present study was that at 20 years, deterioration of the shoulder would have occurred and led to a substantial number of reoperations.

Methods: The authors retrospectively recalled all 127 patients operated for massive rotator cuff tears in 1994 at 6 different centers. At the 20-year follow-up, 26 patients died and 35 were lost to follow-up. Thirteen (10.2%) had been reoperated. This left 53 patients for personal clinical assessment. Forty-nine consented to standardized radiographic evaluation for assessment of osteoarthritis, 36 patients underwent magnetic resonance imaging, allowing assessment of tendon healing, atrophy, and fatty infiltration (FI) of the cuff muscles.

Results: The final Constant-Murley score (CS) was 68 ± 17.7 (range, 8-91) vs. 44 ± 15.3 (range, 13-74) preoperatively ($P < .05$). The final Subjective Shoulder Value (SSV) was 73% ± 23% (range, 0-100). Retears (Sugaya IV and V) were found in 17 cases (47%). Nine patients (17%) had cuff tear arthropathy (Hamada stage 4). The CS and SSV for the shoulders with FI stages III or IV were significantly inferior (53 ± 19 points and 65% ± 14% respectively) than for those with FI stages 0-II (respectively, 71.6 ± 6 points and 73% ± 4%) ($P < .05$).

Conclusions: Twenty years after surgical repair of massive rotator cuff tears, the functional scores remain satisfactory, and the rate of revision is low.

This study received IRB approval (no. 2013-A01788-37).

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Rotator cuff tears are among the most frequent shoulder conditions causing pain and functional impairment. It is estimated that rotator cuff tears are responsible for 4.5 million annual patient visits in the United States and of nearly 250,000 operative repairs.[10,24] Numerous authors reported considerable improvement in clinical and imaging outcome following repair of massive rotator cuff tears using various surgical techniques, though most studies have limitations due to tear size definition, small cohort size, or short follow-up.[3-33] Until now, true long-term clinical and structural results after operative repair of massive rotator cuff tears are missing.

The objective of this study was to report the clinical and structural outcome 20 years after repair of large and massive rotator cuff tears in a sizeable cohort. The hypothesis was that 20 years after surgery, the benefit of surgery would have substantially decreased or disappeared, because of a high tendon failure rate and advanced osteoarthritis, with a need for revision with procedures such as reverse shoulder arthroplasty.

Material and methods

Study design

The authors retrospectively studied the records of all patients who underwent surgical repair of massive (≥2 tendons torn full-thickness) rotator cuff tears in 6 different centers in the year 1994. To be included in the study, the patients had to be adults with massive rotator cuff tears that were treated with an open operative repair. Patients were excluded if they had a history of shoulder surgery, or if the tear could only partially be repaired. A total of 127 patients fulfilled these criteria and were recalled in 2014 for evaluation at a follow-up of 20 years. All patients provided informed consent for this IRB-approved study. For clinical assessment, all patients underwent a structured interview, a standardized physical examination, and scoring according to Constant and Murley (CS)[4] and assessment of the Subjective Shoulder Value (SSV).[12]

On standard radiographs, we assessed glenohumeral arthritis with the Samilson-Prieto classification.[29] We considered stage 0, 1, and 2 as nonarthritic and 3 and 4 as arthritic. Cranial head migration was analyzed on true anteroposterior radiographs taken in neutral rotation using the Hamada and Fukuda classification[16,17] as modified by Walch.[32]

The magnetic resonance imaging (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 analyze tendon healing, and (2) T1-weighted sequences in the transverse and sagittal planes, to analyze fatty infiltration and muscle conditions. Fatty infiltration was analyzed according to Goutallier/Fuchs.[8,14] We defined stages 0/1 and 2 as functional muscles and stages 3 and 4 as nonfunctional muscles. Tendon healing was analyzed with the Sugaya classification[30]: we defined types I-III as healed and types IV and V as retorn tendons.

Surgical technique

The repairs were carried out with the patient in a beach-chair position using an open, anterosuperior approach with the use of nonabsorbable transosseous sutures.[25] All cuffs were totally repaired at the end of the operation. An adjuvant anterior acromioplasty was performed in all shoulders.

Postoperative rehabilitation

Following surgery, the arm was supported in a sling at 20°-45° of abduction for 5.2 ± 1.9 weeks (median, 6; range, 1.5-12). 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 10.3 ± 8.4 weeks (median, 6; range, 3-32). Patients were not allowed to perform any strengthening or strenuous work for 6 months after surgery. Low-demand sports and activities were allowed after 6 months.

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, intergroup differences were evaluated using Wilcoxon rank-sum tests (Mann-Whitney *U* test). When 3 or more groups were compared, Kruskall-Wallis tests were used. Categorical data were analyzed using Pearson chi-square tests or Fisher exact tests. Stepwise descending multivariate linear and logistic regression analysis were performed. Model assumptions were checked before the analyses were performed. P values $< .05$ were considered statistically significant.

Results

Of the original cohort of patients, 26 patients (20.5%) had died from unrelated causes. Thirty-five patients (28.0%) were lost to follow-up corresponding to a 1.4% loss per year. Thirteen (10.2%) patients were reoperated before the 20-year follow-up and not included in the final functional analysis (5 revision repairs, 2 long biceps tenotomies, 1

Table I Patient demographics (N = 53)

Age at surgery, y, mean ± SD (range)	53 ± 7.8 (33-73)
Men/women, n	34:19
Dominant side, n (%)	40 (76)
Smokers, n (%)	9 (22)
Previous trauma, n (%)	28 (61)
Work-related accidents, n (%)	9 (22)
Return to work, mo, median	4.6

SD, standard deviation.

Table II Clinical results

	Preoperative	Final follow-up
Complications, n		
Total		6
Stiffness		4
Others		2
Constant score, points		
Pain	7.2 ± 3.0 (2-15)	12.6 ± 3.3 (4-15)
Activity	8.9 ± 3.5 (2-18)	16 ± 4.9 (0-20)
Mobility	24.2 ± 8.6 (8-40)	30.7 ± 10.6 (0-40)
Strength	5.0 ± 4.4 (0-19)	7.8 ± 4.7 (1-20)
Total	44.5 ±15.3 (13-74)	68 ± 17.7 (8-91)
Constant score		
SFA, n (%)		
Sedentary	0	7 (13.2)
Occasionally active	4 (8.9)	12 (22.6)
Active	12 (26.7)	18 (34)
Very active	29 (64.4)	16 (30.2)
SSV		72.6 ± 23.3 (0-100)
SST		9.1 ± 2.9 (0-12)

SFA, Shoulder Function Assessment; *SSV*, Subjective Shoulder Value; *SST*, Simple Shoulder Test.
Unless otherwise noted, values are mean ± standard deviation (range).

Table III Influence of tendon repair integrity on clinical results

	Tendon in continuity (Sugaya I-III) (n = 26)	Tendon retear (Sugaya IV and V) (n = 19)	*P* value
Total CS (/100 points)	75 ± 11.1 (44-89)	57.8 ± 21.2 (8-91)	.01
SSV, %	79 ± 16 (40-100)	64 ± 23 (24-100)	.03
SST (/12 points)	9.9 ± 2.0 (5-12)	7.3 ± 3.6 (0-12)	.01

CS, Constant-Murley score; *SSV*, Subjective Shoulder Value; *SST*, Simple Shoulder Test.

Table IV Impact of fatty infiltration (FI) of cuff muscles on Constant score, Subjective Shoulder Value (SSV), and tendon retear

	CS	SSV	Tendon retear
FI SSP postoperation	<.001	ns	<.001
FI ISP postoperation	Did not reach statistical significance		
FI SSC postoperation			
FI TM postoperation			

SSP, supraspinatus; *ISP*, infraspinatus; *SSC*, subscapularis.

lavage for infection, 2 capsular releases, and 3 reverse arthroplasties). This left a cohort of 53 patients (19 women, 36%) with a mean age of 54 years (range, 33-73) for final analysis (Table I). Out of this study cohort, 49 patients (31% women) consented to standard radiographs and 36 patients (33% women) to MRI at the 20-year follow-up. In the 53 shoulders evaluated clinically, the CS improved from a mean of 44 (range, 13-74) preoperatively to 68 (range, 8-91) points at 20 years; improvement of pain was from a mean of 7 to 13 points (15 points = freedom from pain; 0=worst imaginable pain) and that of strength from 5 to 8 points (1 point representing 454 gm [1 lb] of strength at 90° of scapular plane abduction). The SSV at 20-year follow-up was 73% (range, 0%-100%) and the Simple Shoulder Test[22] score was 9.1 (range, 0-12). Six patients (11%) had had a postoperative complication (4 stiff shoulders and 2 others), which were treated conservatively (Table II).

Among the 49 standard radiographs, advanced osteoarthritis was revealed in 3 (6.1%) cases. Cuff tear arthropathy (Hamada-Fukuda stage 4) was diagnosed in 9 cases (18%) and associated with a lower mean CS (61 vs. 71 points) ($P = .02$).

Of the 36 shoulders evaluated using MRI, repair integrity was Sugaya type I in 3 (8.3%), type II in 6 (16.7%), type III in 10 (27.8%), type IV in 7 (19.4%), and type V in 10 (27.8%) cases. Thus, repair integrity (Sugaya I-III) was 53%, and repair failure, 47%. Repair integrity was associated with a significantly better mean CS (75 vs. 58 points, $P = .01$). If we had the 3 revisions to reverse shoulder arthroplasty (5.6%), the rate of retear is 52% (Table III). Advanced fatty infiltration (Goutallier III or IV) was found in 15 cases for supraspinatus (SSP) (42%), 26 cases for infraspinatus (72%), and 8 cases for subscapularis (22%). Postoperative SSP fatty infiltration was significantly associated with inferior clinical results (CS and SSV; $P < .001$).

The association of rotator cuff fatty infiltration (SSP, infraspinatus, subscapularis, and TM) with CS, SSV, and tendon retear rate is reported in Table IV. Postoperative SSP fatty infiltration was identified as a predictive parameter for postoperative CS and tendon retear (Table IV). The most predictive factor for long-term clinical outcome is tendon repair integrity. Multivariable regression analysis revealed no additional significant associations between other independent variables (eg, preoperative tear size, chronicity of

Table V Literature review

First author	Year	Journal	Approach	Indications/technique	Cohort, n	Age	Follow-up duration	CS			SSV		
								Preop	Postop	Impr., %	Preop	Postop	Impr., %
Burkhart[3]	2007	*Arthroscopy*	Arthroscopy	Massive tears, grade 3+4 fatty degeneration rotator cuff	22	66	39 mo		75				
Denard[5]	2012	*Arthroscopy*	Arthroscopy	Massive tears, preop pseudoparalysis Group 1: primary repair Group 2: revision	Group 1: 39 Group 2 14	Group 1: 62 Group 2: 63	Group 1: 75 mo Group 2: 72 mo					Group 1: 82 Group 2: 57	
Gerber[11]	2000	*J Bone Joint Surg Am*	Open	Massive tears	29	56	37 mo	49	85 (rel)	73		78	
Glanzmann[13]	2010	*J Shoulder Elbow Surg*	Open deltoid flap	Massive posterosuperior tears	31		53 mo + 175 mo	31 31	46 66	48 112			
Gupta[15]	2013	*Am J Sports Med*	Mini-open	Massive or 2 tendon tears, tissue matrix xenograft	26	60	32 mo						
Kim[19]	2012	*Am J Sports Med*	Arthroscopy	Massive tears, suture bridge technique	66	61	25 mo	44	75	70			
Ohzono[26]	2017	*Am J Sports Med*	Arthroscopy	Massive and large tears	155	64	2.5 y						
Rokito[28]	1999	*J Bone Joint Surg Am*	Open	Massive and large tears	30		65 mo						
Vastamaki[31]	2013	*Clin Orthop Relat Res*	Open	Rotator cuff repairs, large and massive in 46% of patients	67	52	16 y		66				
Zumstein[33]	2008	*J Bone Joint Surg Am*	Open	Massive tears	27		9.9 y		85 (rel)			82	

CS, Constant score; *preop*, preoperative; *postop*, postoperative; *Impr.*, improvement; *SSV*, Subjective Shoulder Value.

symptoms, occupational injuries, level of activity, and smoking habits). Surgical procedures on the biceps tendon or acromioclavicular joint resection were not associated with the quality of the clinical outcome (CS and SSV) or tendon healing.

Discussion

The principal findings of this study are first that 20 years following repair of massive rotator cuff tears, the CS is on average 24 points higher than preoperatively. This improvement markedly exceeds the minimal clinically important difference established for this scoring system. Second, only 10% of the patients have required further surgery, and roughly 2.4% needed revision into reverse shoulder replacement. In addition, at 20 years, 55% of the shoulders are subjectively excellent or good (SSV $\geq$ 80).

Structurally, 53% of all repaired tendons are still in continuity, but only 8.3% have perfect integrity (Sugaya type I). Therefore, the hypothesis must be refuted that at 20 years, the clinical benefit of repair of massive rotator cuff tears is lost and revision surgery is frequently necessary.

Our analysis demonstrates that clinical outcome (CS) and tendon retear at 20 years are significantly associated with postoperative fatty infiltration of the SSP. The most predictive parameter for postoperative clinical outcome (CS, SSV, and SST) is tendon repair integrity (Table III).

There is little consensus on the optimal strategy to manage massive rotator cuff tears, and only a few studies report long-term outcomes following repair. The respective cohort sizes range from 22 to 155 patients. Follow-up periods are generally between 25 and 65 months,[1,3,5,9,11-13,15,19,21,26,28] with the exceptions of 2 studies that extend to 10[33] and 16 years[31] (Table V).

The mean 20-year CS in the present series was 68 points, which is in line with results reported in the literature. Considering that postoperative CSs are often correlated with preoperative CS, our 20-year results indicate more than 50% improvement. This means that the initial benefit of surgery persists, even at long-term follow-up. This is of interest because recent trends have led surgeons to use reverse shoulder arthroplasty to treat these patients, with substantial subjective and functional improvement but with high complication rates.[7,27] In terms of cost-effectiveness, primary arthroscopic rotator cuff repair with conversion to reverse total shoulder arthroplasty on potential failure was found to be the most cost-effective strategy for the treatment of massive rotator cuff tears in patients with pseudoparalysis.[6,23]

The major strength of this study is the availability of clinical and imaging results, which were specifically collected and evaluated in a very standardized fashion 20 years after surgery. Our data therefore allow for analysis of tendon repair integrity, correlation between structural and clinical results, as well as information about longevity of the results.

The study has limitations because of its retrospective design without a control group, which makes it a Level IV observational study. Nonetheless, it provides previously unavailable information on a well-defined patient group with a well-defined pathology treated in a homogenous manner and analyzed also in a highly standardized fashion. It may be said that current arthroscopic techniques are different and that anterior acromioplasty is no longer a routine. Nonetheless, the clinical results document that open techniques are able to serve as a benchmark for the assessment of alleged improvements. Second, the patients lost to follow-up are regrettable but at 20 years inevitable in the environment of the 6 centers. It should be considered that a yearly loss of follow-up of 1.4% over 20 years represents an acceptable level of follow-up. Third, the study population with a mean age of 53 years and trauma-associated massive tears in 61% is compatible with a hypothesis that an older population with massive tears might have a less favorable prognosis.[2] Finally, we would certainly have preferred to obtain imaging studies in all patients but had to accept the refusal of the respective patients who for various reasons elected not to have imaging studies mostly because they felt it would not change anything for them.

Conclusion

At 20 years after open repair of massive rotator cuff tears, 55% of the patients have an excellent or good subjective result, about 10% are revised, and only 2.4% have needed a reverse total shoulder arthroplasty. Significantly better results can be obtained if the repair remains intact and if fatty infiltration of the supraspinatus muscle can be prevented.

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