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Fanny Elia, Vadim Azoulay, Julie Lebon, Amélie Faraud, Nicolas Bonneville, et al.. Clinical and anatomic results of surgical repair of chronic rotator cuff tears at ten-year minimum follow-up. *International Orthopaedics*, 2017, 41 (6), pp.1219-1226. 10.1007/s00264-017-3456-8 . hal-02135141

HAL Id: hal-02135141

<https://hal.science/hal-02135141>

Submitted on 21 May 2019

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To cite this version :

Elia, Fanny and Azoulay, Vadim and Lebon, Julie and Faraud, Amélie and Bonneville, Nicolas  and Mansat, Pierre  *Clinical and anatomic results of surgical repair of chronic rotator cuff tears at ten-year minimum follow-up.* (2017) *International Orthopaedics*, 41 (6). 1219-1226. ISSN 0341-2695

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Clinical and anatomic results of surgical repair of chronic rotator cuff tears at ten-year minimum follow-up

Fanny Elia¹ · Vadim Azoulay¹ · Julie Lebon¹ · Amélie Faraud¹ · Nicolas Bonneville¹ · Pierre Mansat¹

Abstract

Purpose The purpose of this study was to evaluate long-term clinical and anatomic results after open rotator cuff repair.

Materials and method Fifty-three patients were included in this study. Rotator cuff tears were limited to one tendon in 34, and two tendons or more in 19. The supraspinatus tendon was involved alone in 30 cases, and the subscapularis in four. Clinical, radiographic and MRI evaluations were performed for all patients at ten-year minimum follow-up.

Results At 11.4-years average follow-up, satisfactory results were obtained with improvement on pain level, in range of motion with a gain in active anterior elevation and in external rotation as well as in strength in abduction. Absolute Constant score reached 74.7 points and adjusted Constant score 99.6%. SSV was 82.5% with a SST score of 10 points. Osteoarthritis changes increased with follow-up with osteoarthritis lesion in 69% of the cases. MRI evaluation found a re-tear of the repair

in 42% of the cases: 30% when only the supraspinatus tendon was initially involved, and 63% when two or more tendons were repaired. Tear size and quality of the repair were the most important prognosis factors for re-tear of the repair. No correlation was found between the occurrence of a new tear and the clinical outcome.

Conclusion Surgical repair of chronic rotator cuff tendon tear can produce consistent and lasting pain relief and improvement in range of motion. Re-tear of the repair was not correlated with degradation of clinical results. Best results were obtained for isolated supraspinatus tear with a complete surgical repair.

Keywords Rotator cuff tear · Fatty infiltration · Muscle atrophy · Prognosis factors

Introduction

Surgical repair of chronic rotator cuff tears is one of the most common surgical procedures for shoulder surgeons. Performed open or under arthroscopy clinical results are often satisfactory. However, anatomical studies have shown increased incidence of tendon re-tear with follow-up. Re-tear rate varied from 20 to 50% depending of the studies [1–4]. Failure of tendon healing or tendon re-tear is not always correlated to functional impairment, with often a painless or slight painful shoulder, with a functional range of motion [5]. However, shoulder strength is often decreased [1].

In literature, there are only a few studies already published evaluating clinical and anatomical results of surgical repair of rotator cuff tendon lesions with long-term follow-up [6–8]. In 2001, Cofield et al. [9] published the results of 105 shoulders with rotator cuff repairs at 13.4-year follow-up. However, only the clinical results were evaluated, and no anatomic

✉ Pierre Mansat
mansat.p@chu.toulouse.fr; pierre.mansat@univ-tlse3.fr

Fanny Elia
fannyelia86@gmail.com

Vadim Azoulay
vazoulay@aol.com

Julie Lebon
julie.lebon@hotmail.fr

Amélie Faraud
amelie.faraud@hotmail.fr

Nicolas Bonneville
nicolasbonneville@yahoo.fr

¹ Département d'Orthopédie et Traumatologie – Urgences Mains, Hôpital Pierre Paul RIQUET, Hôpital Universitaire de Toulouse, Place du Dr Baylac, 31059 Toulouse Cedex, France

evaluation of the repair was performed. More recently in 2015, Saraswat et al. [10] reported the results of 59 open cuff tendon repairs at ten-year follow-up. Similarly, only the clinical results and quality of life were evaluated.

A retrospective study has been performed in our department in order to evaluate patients who underwent a surgical repair of chronic rotator cuff tears in 2003, to analyze clinical results but also anatomical evolution of the repair at minimum ten-year follow-up. Our hypothesis was that at more than ten-year follow-up, repair of rotator cuff tendon tears gave reliable tendon-healing rate, with preservation of satisfactory functional range of motion.

Material and methods

Patients demographics

A retrospective study was conducted in our Upper Limb Surgery Department of the University Hospital. Approval was obtained from the local ethics committee under the number: 07–1015. All patients were informed about utilization of their personal data for the study and all approved. Inclusion criteria were all patients that underwent open rotator cuff tendon repair in our department in 2003, that were reviewed clinically with a shoulder MRI control at minimum ten-year follow-up. Exclusion criteria were patients who had a revision surgery for rotator cuff repair in 2003, or primary open rotator cuff repair in 2003 with less than ten-year follow-up, or without MRI shoulder control, or with history of shoulder trauma, shoulder infection, proximal humerus tumour, avascular necrosis of the humeral head, muscle transfer, or an isolated acromioplasty without tendon repair. In 2003, open surgical repair of chronic rotator cuff lesions has been performed on 114 patients (115 shoulders). Thirty-two patients were lost for follow-up. Twenty-one were contacted by phone but did not want to come back for evaluation. Nine patients were deceased at the time of the study. Finally, 53 patients (53 shoulders) were reviewed clinically with a radiographic analysis and MRI evaluation at ten-year minimum follow-up. There were 29 men and 24 women of $59 \pm$ eight years on average at surgery (range, 38–75). The dominant side was involved in 34 cases (64%). All patients' characteristics are summarized in Table 1.

Surgical procedure

Open rotor cuff repair was performed under combined regional and general anaesthesia by three senior surgeons. The patient was positioned in the beach chair position and a superior-lateral approach was used. The deltoid was incised between the anterior and lateral part. After section of the coracoacromial ligament, an acromioplasty was performed.

Table 1 Patients' epidemiology characteristics

Shoulders (N = 53)	Preoperative data
Age	59 ± 8 (38–75)
Sex ratio	29 male/24 female (1.2)
Dominant side	34 (64%)
Smoker	9 (17%)
History of steroid injection	24 (45%)
ATC trauma	17 (32%)
Type of activity	
Sedentary	31 (58%)
Light manual labor	7 (13%)
Heavy manual labor	12 (23%)
Repetitive activities	3 (6%)
Work compensation	6 (11%)

Resection of the lateral clavicle was performed for treatment of degenerative arthritic changes in only ten cases. After evaluation of the tendon tear, mobilization of the tendon was performed and repair was done by Mason-Allen trans-osseous non-absorbable number two sutures or with anchors. The tears were repaired totally in 45 and partially in eight cases. The long head of the biceps was preserved in 37 and tenodesed in 16. The deltoid was then repaired with non-absorbable sutures.

Post-operative management

Post-operatively patients were immobilized in a sling for 45 days. Pendulum exercises were started at day two, and passive motion was started at day 15 until day 45. Active motion was started at day 45, and strengthening exercises at day 90.

Outcome measures

Clinical and radiographic evaluations were performed for all patients. Outcome measures included Constant score, SST, and simple shoulder value (SSV). Range of motion was measured using a goniometer. Strength was evaluated with the shoulder at 90° abduction with a dynamometer.

Radiographic analysis was performed pre-operatively and post-operatively using an A/P view as well as a lateral view of the shoulder. The type of the acromion, the acromio-humeral distance (AHD), the critical shoulder angle (CSA), as well as the osteoarthritis changes according to Samilson and Prieto classification were analyzed [11]. Hamada classification was also used pre-operatively [12]. An MRI or an arthro-CT were also performed pre-operatively and were available for 44 patients to evaluate the tear size, the fatty infiltration index (FI) according to Goutallier classification [13], as well as the trophicity of the rotator cuff muscles according to Warner classification [14]. Muscles were considered as

functional when FI was equal or inferior to 2, and non-functional for FI greater than 2. All patients sustained an MRI of the operated shoulder at follow-up. The analyses of the imaging data, to evaluate the cuff integrity and muscle infiltration, were analyzed by one radiologist and one surgeon. The patients' data and clinical findings were blinded during evaluation of the imaging data. The quality of the repaired tendons was staged according to Sugaya classification [15]. Stages 1, 2 and 3 were considered as intact repair whereas stages 4 and 5 were considered as re-tear. Fatty infiltration index as well as the muscle trophicity were also evaluated at follow-up.

Statistical analysis

Statistical analyses were performed using SPSS 20.0 (128 IBM SPSS, Atlanta, GA). Tests used were related to the type of variable analyzed. Univariate analyses consisted in treating each variable in an isolated way. Bivariate analyses then made it possible to study the links between two variables. Four types of tests could then be considered: chi-square test was carried out to study the link between two variables of the qualitative type, Pearson's correlation to study the link between two variables of the quantitative type, and Student's t-test and Fisher's exact or ANOVA to study the link between variables of a quantitative type and variables of a qualitative type. Post-hoc test was also performed to evaluate the link between the two modalities in an isolated manner. The whole of the tests carried out at the time of bivariate statistics generated an indicator of significance. Statistical tests were considered significant at $p < 0.05$.

Results

Pre-operative lesions

All lesions characteristics are summarized in Table 2. Rotator cuff tears were limited to one tendon in 34, and two tendons or more in 19. The supraspinatus tendon was involved alone in 30 cases, and the subscapularis in four. According to Goutallier et al. [13], the fatty infiltration index was 1.1 for the supraspinatus, 0.7 for the infraspinatus, 0.3 for the teres minor, and 0.4 for the subscapularis. According to Warner et al. [14], muscle trophicity of the supraspinatus was 0.6, 0.2 for the infraspinatus, 0.1 for the teres minor, and 0.2 for the subscapularis.

Overall results

At 11.4-year follow-up (range, 10.8–12), patients were still satisfied from the surgery with SSV of $82.5\% \pm 20$ (range, 20–100), and SST score of 9.9 ± 2.6 points (range, 1–12).

Table 2 Patients' shoulder imaging analysis characteristics

Shoulders (N = 53)	Preoperative data
Acromial spur	47 (88%)
Critical shoulder angle	$35.7^\circ \pm 3.2$ (28–41)
A/C joint arthritis	24 (45%)
Hamada classification (n = 53)	
Stage 1	44 (83%)
Stage 2	5 (9%)
Stage 3	4 (8%)
Stage 4	0
Stage 5	0
Samilson classification (n = 53)	
Stage 0	34 (64%)
Stage 1	17 (32%)
Stage 2	2 (4%)
Stage 3	0
Stage 4	0
Rotator cuff tendon tear	
Supra spinatus	30 (57%)
Sub scapularis	4 (7%)
≥ 2 tendons involved	19 (36%)
Fatty infiltration (n = 44)	
Supraspinatus	1.1
Infraspinatus	0.7
Teres minor	0.3
Subscapularis	0.4
Muscle trophicity (n = 44)	
Supraspinatus	0.6
Infraspinatus	0.2
Teres minor	0.1
Sub scapularis	0.2

The absolute Constant score was $74.7\% \pm 17$ (range, 21–100) with an adjusted score of $99.6\% \pm 23$ (range, 30–129), significantly better than before surgery ($p < 0.0001$ and $p < 0.0005$, respectively). Overall results are summarized in Table 3.

Clinical results

Satisfactory pain relief was still remaining with pain score of 13.4 ± 2.3 points (range, 8–15) compared to 8.5 ± 1.6 points (range, 5–11) pre-operatively ($p < 0.0001$). Range of motion was significantly better at follow-up than before surgery with active anterior elevation of $158^\circ \pm 26$ (range, 45–170) compared to $140^\circ \pm 28$ (range, 70–170) ($p = 0.045$) and with external rotation of $51.4^\circ \pm 17$ (range, 10–70) compared to $42^\circ \pm 13$ (range, 15–70) ($p = 0.001$). Strength in abduction was improved as well from $3.1 \text{ kg} \pm 3.5$ (range, 0–16) pre-operatively

Table 3 Comparison of clinical data preoperatively and at follow up

Measure (N = 53 shoulders)	Preop	Postop	Statistics
Pain (points)	8.5 ± 1.6 (5 11)	13.4 ± 2.3 (8 15)	P < 0.0001
Activity (points)	8.9 ± 2.7 (5 16)	17 ± 4.3 (5 20)	P < 0.0001
Mobility (points)	21.8 ± 8.5 (4 40)	34.5 ± 7.6 (6 40)	P < 0.0001
Strength (points)	3.1 ± 3.5 (0 16)	9.9 ± 7 (0 25)	P < 0.0001
Absolute Constant score (points)	42.3 ± 12.4 (19 71)	74.7 ± 17.7 (21 100)	P < 0.0001
Adjusted Constant score (%)	52.5 ± 15.4 (23 82)	99.6 ± 23.6 (30 129)	P < 0.0005
SSV (%)		82.5 ± 20 (20 100)	
SST (points)		9.9 ± 2.6 (1 12)	
Active anterior elevation (°)	141 ± 28.4 (70 170)	158 ± 26.3 (45 170)	P = 0.045
Active external rotation (°)	42 ± 12.8 (15 70)	51.4 ± 17.1 (10 70)	P = 0.001

Statistical tests were considered significant at $p < 0.05$

to $9.9 \text{ kg} \pm 7$ (range, 0–25) post-operatively ($p < 0.00001$). All clinical results are summarized in Table 3.

Radiographic results

Radiographic analysis showed preservation of a normal acromio-humeral distance in most cases with a distance averaging $7.8 \pm 2.2 \text{ mm}$ (range, 2–13). Osteoarthritis changes increased with follow-up with osteoarthritis lesion in 69% of the cases ($p = 0.041$). Radiographic results are summarized in Table 4.

MRI analysis

MRI evaluation found a re-tear of the repair in 42% of the cases. It was 30% when only the supraspinatus tendon was initially involved, and 63% when two or more tendons were initially repaired ($p = 0.031$). Fatty infiltration index increased significantly between the pre-operative evaluation and the analysis at follow-up. Fatty degeneration index increased in 28 cases out of 53 (53%) for the supraspinatus and the teres minor and in 32 cases out of 53 (60%) for the infraspinatus and the subscapularis. The muscles were considered as functional in 82% of the cases ($FI \leq 2$), and poorly functional in 18% ($FI > 2$). Muscle trophicity did not worsen between the pre-operative evaluation and the analysis at follow-up with a normal trophicity in 63% of the cases, and a decreased trophicity on 37% of the cases. Trophicity was normal in 19 cases for the supraspinatus, 37 cases for the infraspinatus, 44 cases for the teres minor and 37 cases for the subscapularis. MRI results are summarized in Table 4.

Prognosis factors

Re tear rate

Tear size ($p = 0.031$) and quality of the repair ($p = 0.002$) were the most important prognosis factors for re-tear of the repair.

Pre-operative strength ($p = 0.02$), as well as muscle trophicity of the supraspinatus ($p = 0.030$) and the infraspinatus ($p = 0.002$) have also influenced significantly the re-tear rate at follow-up. Age at surgery, had also influenced the incidence of re-tear, with a rate of 34.5% for patients under 60 years (29 patients), 37% for patients between 60 and 65 years (11 patients), 72% for patients between 65 and 70 years (5 patients) and 73% for patients above 70 years (8 patients). However, the difference was not statistically significant ($p = 0.078$). Gender, smoking habits, steroid injections, dominant side, history of trauma, work compensation, Hamada classification, pre-operative osteoarthritis, pre-operative Constant score, fatty infiltration index, and surgical technique did not influence the re-tear rate at follow-up.

Post operative Constant score

There was no correlation between the occurrence of a new tear and the clinical outcome as most of the patients kept a satisfactory functional score ($p = 0.512$). Post-operative Constant score was only correlated with pre-operative active anterior elevation ($p = 0.004$), pre-operative Hamada classification ($p = 0.002$), and to quality of tendon repair (complete or partial) ($p = 0.004$).

Best results were obtained for isolated supraspinatus tear with normal pre-operative trophicity with a complete surgical repair.

Discussion

Results of surgical repair of chronic rotator cuff tears are often satisfactory. However, anatomical studies have shown increased incidence of tendon re-tear with follow-up not always correlated with functional impairment [1–5]. In our study, we found that surgical repair of chronic rotator cuff tendon tear can produce consistent and lasting pain relief and improvement in range of motion. However, a 42% re-tear rate was

Table 4 Comparison of imaging analysis of the shoulder pre operatively and at follow up

Measure	Pre operative	At follow up	Statistical analysis
Acromio humeral distance (mm)		7.8 ± 2.2 (2 13)	
Critical shoulder angle (°)	35.7 ± 3.2 (28 41)	35.7 ± 3.2 (28 41)	P = 1
Samilson classification			
Stage 0	34 (64%)	11 (21%)	P = 0.041
Stage 1	17 (32%)	26 (49%)	
Stage 2	2 (4%)	10 (19%)	
Stage 3	0	0	
Stage 4	0	6 (11%)	
Fatty infiltration index			
Supraspinatus	1.1	2	P = 0.530
Infraspinatus	0.7	1.9	P = 0.004
Teres minor	0.3	1.3	P = 0.149
Subscap	0.4	1.5	P = 0.006
Muscle trophicity			
Supraspinatus	0.6	0.9	P = 0.427
Infraspinatus	0.2	0.4	P = 0.04
Teres minor	0.1	0.2	P = 0.028
Subscapularis	0.2	0.5	P = 0.00005
Tendon healing according to Sugaya			
Stage 1		5 (9%)	
Stage 2		15 (28%)	
Stage 3		11 (21%)	
Stage 4		11 (21%)	
Stage 5		11 (21%)	

Statistical tests were considered significant at $p < 0.05$

observed at 11-year average follow-up not correlated with degradation of clinical results. Tear size, quality of the repair, and muscle trophicity, were the main prognosis factors of this re-tear rate. Best results were obtained for isolated supraspinatus tear with normal pre-operative trophicity with a complete surgical repair.

There are only a few series in literature reviewing the results of rotator cuff repair at ten year or more follow-up [6–10, 16–21]. Most of the series reported only functional results but rarely anatomic evaluation of the repair. Even the type of tendon tears and the surgical techniques were different. Satisfactory outcomes at ten years or more follow-up have been reported in all series varying between 69 and 80% of the cases, with Constant score ranging from 62 to 74 points, adjusted Constant score from 73 to 99.6%, active anterior evaluation from 131 to 154°, and active external rotation at side from 49 to 61°. In all series, the patients were still improved compared to pre-operative values, validating the principle of surgical rotator cuff repair (Table 5).

In 2001, for Cofield et al. [9], tear size was the most important determinant outcome with regard to active motion, strength, rating of the result, patient satisfaction, and need for a reoperation. Older age, less pre-operative active

motion, preoperative weakness, and distal clavicular excision were all associated with larger tear size. In 2007, Gladstone et al. [22] showed that muscle atrophy and fatty infiltration of the rotator cuff muscles, particularly of the infraspinatus, played a significant role in determining functional outcome after cuff repair. The satisfactory functional results at follow-up were not correlated with the quality of the repair, since in the few studies with an anatomic evaluation of the tendons, the healing rate was obtained in only 6 to 58% of the cases (Table 5).

Many factors have been outlined to influence tendon healing. In 1991 and 1995, Harryman et al. [23] and Gazielly et al. [3] showed that re-tear rate was correlated with the number of tendons involved with 10–20% re-tear rate for isolated supraspinatus tendon tear and more than 50% if two or more tendons were involved. In 2006, Postel et al. [24] found in their series a 9% re-tear-rate at 8.8 years follow-up. Prognosis factors were more than two tendons involved, muscular degeneration equal or greater than 2, and acromio-humeral distance less than 5 mm. In our series, at more than ten-year follow-up, the re-tear rate was only 30% for isolated supraspinatus tendon repair, whereas it was 63% if two or more tendons were involved.

Table 5 Results of literature for rotator cuff tendon repairs for series with follow-up of ten years or more

Authors	Patients (N)	Age (mean, years)	Follow-up (mean, years)	Type of tendon tear	Surgical technique	Functional score	Healing rate
Adamson et al [16]	30	-	10	-	Open	80% satisfactory results	-
Cofield et al [9]	105	58	13.4	-	Open	80% satisfactory (AAE 154°/ER 69°)	-
Galatz et al [17]	33	55	10	-	Open	Constant 81.2 points/91%	-
Sperling et al [18]	29	44.7	16.2	3 small, 15 medium, 6 large, 5 massive	Open	55% satisfactory results	-
Zumstein et al [6]	23	-	9.9	Massive	Open	Adj Constant score 85%, SSV 82%	43% (MRI)
Borgmesters et al [19]	75	52	20	-	Open	Constant 64.4 points, Adj Constant 81.3%, SST 8 (AEE 139°/ER 49°)	-
Marrero et al [20]	33	-	12.6	-	Arthroscopic	UCLA 31.8 points, 87.7% excellent and good outcomes	-
Vastamäki et al [7]	67	52	20	-	Open	Constant 61.9 points, SST 8.1	6% (MRI)
Bell et al [21]	49	54.5	15.6	8 large, 40 medium, 1 small	Mini-open	69% satisfactory, 3 reoperations	-
Paxton et al [8]	15	64.6	10	Massive	Arthroscopic	ASES 79.4 points, VAS 2.2 points, SST 9.2, Adj Constant 73.2%	6% (Ultrasound)
Saraswat et al [10]	59	53	10	-	Mini-open	ASES 56, WORC 88.7 (AEE 131°/ER 51°)	-
Our series	53	59	11.5	30 Suprasp, 4 Subscap, 19 ≥ 2 tendons	Open	Constant 74.7 points, Adj Constant 99.6%, SSV 82.5%, SST 9.9 (AAE 158°/ER 51°)	58% (MRI)

In 2003, Goutallier et al. [25] outlined the influence of muscular fatty infiltration on the prognosis of rotator cuff surgical repair with worse results if there was muscle fatty infiltration of the supra and infraspinatus. Same results were obtained by Postel et al. [24], Gerber et al. [26], and Thomazeau et al. [27]. In our series, no influence of the fatty infiltration index was found on the re-tear rate. However, it was correlated with Constant score at follow-up. Muscle atrophy was correlated with the re-tear rate for the supra-spinatus ($p = 0.03$) and for the infra-spinatus ($p = 0.002$). In 2006, Fuchs et al. [5] found significant subjective and objective improvement and very high patient satisfaction. However, muscular atrophy or fatty infiltration did not decrease after tendon repair. In fact, fatty infiltration in the supraspinatus and infraspinatus muscles increased significantly. In 2007, same results were observed by Gladstone et al. [22]. A successful repair did not lead to improvement or reversal of muscle degeneration and a failed repair resulted in significantly more progression. However, healed repairs seemed to demonstrate minimal progression. Similarly, in our study we observed increased fatty infiltration index with follow-up, especially for the infraspinatus muscle. However, the muscles were considered as functional in 82% of the cases ($FI \leq 2$) and poorly functional in 18% ($FI > 2$).

On the other hand, muscle trophicity did not worsen significantly between the pre-operative evaluation and the analysis at follow-up with a normal trophicity in 63% of the cases, and a decreased trophicity in 37% of the cases.

Osteoarthritis seems also to increase with follow-up. In 2006, Postel et al. [24] found increased osteoarthritis changes were correlated with pre-operative FI of the infraspinatus and subscapularis as well as the pre-operative acromio-humeral distance. In our study, osteoarthritis changes increased with follow-up with osteoarthritis lesion in 69% of the cases compared to 36% pre-operatively ($p = 0.041$).

In 2005, using an arthroscopic technique, Boileau et al. [2] found a re-tear rate at 29-month follow-up of 29% after repair of isolated supraspinatus tendon tear. Factors that were negatively associated with tendon healing were increasing age and associated delamination of the subscapularis or infraspinatus tendon. Only ten (43%) of 23 patients over the age of 65 years had completely healed tendons. The same influences were observed by Cofield et al. [9]. In our study, older patients had a higher re-tear rate than younger patients.

Additional prognosis factors have been found by other authors like preoperative acromio-humeral distance [26, 28], smoking status [29, 30], use of anti-inflammatory drugs [31], use of steroid injections [32, 33], and quality of vascularization of the footprint [34, 35]. However, we could not demonstrate any statistical influence of these parameters in our study.

Weakness of our study was related to the number of patients lost for follow-up, as 114 patients (115 shoulders)

were operated in 2003 and only 53 patients (53 shoulders) were reviewed. Weak statistical power may explain that some usual prognosis factors could not be found correlated statistically with the re-tear rate and the post-operative Constant score. However, the main strength of this study was that these 53 patients were reviewed clinically with a radiographic analysis and MRI evaluation at ten-year minimum follow-up. It is one of the longer studies published in literature with long-term evaluation of open rotator cuff repair with functional outcome and anatomic analysis.

Conclusion

At more than ten-years follow-up, open surgical repair of chronic rotator cuff tendon tear gave satisfactory results with consistent and lasting pain relief and improvement in range of motion compared to pre-operative values. However, a 42% re-tear rate was observed at 11-year average follow-up not correlated with degradation of clinical results. Tear size, quality of the repair, and muscle trophicity were the main prognostic factors of this re-tear rate. The best results were obtained for isolated supraspinatus tear with normal pre-operative trophicity with a complete surgical repair. We recommend early rotator cuff repair to get the better results with follow-up.

Compliance with ethical standards

Conflict of interest No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Funding statement No funding has been received related to this study.

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