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Original article

Open side-to-side repair for non-repairable tendon-to-bone rotator cuff tear. Clinical and anatomic outcome at a mean 5 years' follow-up

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ABSTRACT

Introduction: Anatomical tendon-to-bone repair of retracted rotator cuff tear is a difficult challenge given the high rate of recurrence.
Hypothesis: The study hypothesis was that side-to-side repair of U-shaped retracted tear allows tendon healing with satisfactory medium-term clinical results.
Materials and methods: Between 1999 and 2007, 35 patients (mean age 53.5 years) were operated on with this open technique. On the De Orio and Cofield classification, tendon lesions were medium in 5 cases, large in 25 and massive in 5. Subacromial space was in all cases greater than 7 mm. Fatty infiltration grade was less than or equal to 2 on Goutallier's classification in all cases except for 1 grade 3 (supraspinatus only). At last follow-up, patients were assessed clinically (Constant score) and radiographically. Tendon healing was assessed by ultrasound (31 cases) or CT-arthrography (4 cases).
Results: Mean follow-up was 60 months. Constant score improved significantly, from 64.7 ± 10 preoperatively to 77.1 ± 14 postoperatively ($P < 0.05$). Recurrence rate was 17.1%. Subacromial space was < 6 mm postoperatively in 2 cases.
Discussion: Side-to-side repair, bringing the posterior cuff onto the anterior edge of the tear, allowed tension-free repair of retracted tear if the preoperative reparability criteria are met: subacromial space equal to or greater than 7 mm, and absence of fatty infiltration significantly greater than grade 2 on the Goutallier classification. Under these conditions, clinical and anatomical results were satisfactory at a mean 5 years' follow-up.
Level of evidence: IV, retrospective.

1. Introduction

Rotator cuff tear is a frequent cause of shoulder pain and functional impotence. Tendon repair surgery is recommended in case of failure of medical management or of risk of lesion extension, especially in young patients [1]. However, the recurrence rate after repair of large or massive tear ranges from 17% to 94%, depending on the report [2–8]. Patient age, lesion size and fatty infiltration of the affected muscles are consensual prognostic factors that have enabled preoperative reparability criteria to be defined [9]: subacromial space equal to or greater than 7 mm, and fatty infiltration grade equal to or less than 2 on the Goutallier classification [10]. Even when these conditions are respected, not all tears can be repaired directly and anatomically by bone reinsertion onto the greater tuberosity without excessive tension that would constitute a further risk factor for iterative tear. The side-to-side repair technique described by McLaughlin [11] and more recently popularized by Burkhart [12,13] involves less tendon tension. In non-mobilizable retracted U-shaped tear, non-anatomic side-to-side repair provides closure by mobilizing the posterior cuff, bringing it over the anterior edge of the tear before fixing it onto the greater tubercle [12–14].

The side-to-side tendon repair technique has been recommended for retracted tear that cannot be repaired directly onto the greater tubercle despite favorable reparability criteria. The present study analyzed clinical and anatomic results for this procedure at a minimum 2 years' follow-up, with the hypothesis that this non-anatomic technique ensures tendon healing and satisfactory medium-term clinical results.

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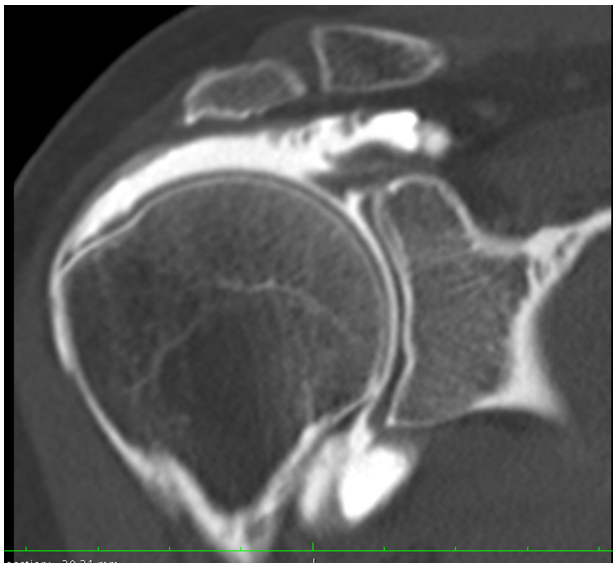

Fig. 1. CT arthrogram. Coronal view. Grade-3 supraspinatus tendon tear with glenoid retraction.

2. Material and methods

Between 1999 and 2007, 68 consecutive patients underwent open rotator cuff repair performed by a single senior surgeon (LNJ) using the side-to-side technique. Inclusion criteria comprised:

- intraoperative finding of full-thickness U-shaped supra- or infraspinatus tendon tear that could not be directly repaired onto the greater tubercle (Figs. 1, 2 and 3);
- subacromial space equal to or greater than 7 mm;
- muscular fatty infiltration grade equal to or less than 2 on the Goutallier classification [10] (except for 1 case of isolated supraspinatus grade 3);
- side-to-side repair with or without fixation onto the greater tubercle;
- minimum 2 years' clinical follow-up with anatomic assessment on ultrasound or CT-arthrography. Exclusion criteria comprised associated subscapularis tendon lesion or history of surgery in the affected shoulder.

Fig. 2. CT arthrogram. Sagittal view, showing the width of the supraspinatus tendon tear and posterior lamellar dissection of the infraspinatus tendon.

Fig. 3. CT arthrogram. Sagittal view, showing grade-2 fatty of the supraspinatus muscle and absence of infiltration in the other muscles.

Eight of the 68 patients had history of rotator cuff surgery and 4 had significant subscapularis tendon lesions. One patient died before follow-up assessment; 16 were lost to follow-up; and in 4, postoperative imaging was lacking or incomplete. Finally, 35 patients met the inclusion criteria. Mean age at surgery was 53.5 ± 7.03 years (range, 37–72 years); 19 females, 16 males. The right shoulder was involved in 26 cases and in 31 cases the affected shoulder was dominant. Onset was traumatic in 24 cases and chronic in 11.

The study was approved by the Centre Orthopédique Santy institutional review board.

Pre- and postoperative clinical assessment comprised standard and gender and age weighted constant scores. Strength was measured on a manual dynamometer. Radiologic assessment comprised AP view in neutral rotation to measure pre- and postoperative subacromial space. Preoperative imaging (CT-arthrography in 24 cases and MRI in 11) assessed tear size and rotator cuff muscle quality [10,15]. Twenty-eight cases (80%) showed isolated supraspinatus tendon tear; 7 (20%) showed associated infraspinatus tendon tear. On the Patte classification [16], retraction was at the humeral head (grade 2) in 9 cases (26%) and at the glenoid level (grade 3) in 26 (74%).

Tear size was reassessed intraoperatively after minimal debridement of the edges. The tear was measured (in centimeters) sagittally and frontally. On the De Orio and Cofield classification [17], there were 5 medium, 25 large and 5 massive tears. Twenty-two cases (63%) showed lamellar dissection of the infraspinatus tendon. After release and posterosuperior juxta-glenoid capsulotomy, side-to-side repair was performed, as direct repair was impossible without excessive tension. One or more non-resorbable sutures were performed in the posterior cuff toward the anterior part of the tear (rotator interval, untorn anterior edge of the supraspinatus), mainly mobilizing the posterior part of the cuff. These sutures also allowed any lamellar dissection to be closed. Secondarily, all of the tendons were fixed to the greater tubercle by transosseous suture, except in 3 patients in whom tension was excessive. Long biceps tenodesis was systematically performed, except in 3 cases where the tendon was torn.

All patients were fitted with an abduction splint for 6 weeks. Passive mobilization, associated to balneotherapy when possible,

Table 1
Standard and weighted pre- and postoperative Constant scores.

	Pain /15 points	Daily life activity /20 points	Mobility /40 points	Strength /25 points	Constant score /100 points	Weighted Constant score (%)
Preoperative	5.44 ± 2.18	12.72 ± 2.71	34.75 ± 4.56	11.8 ± 4.4	64.72 ± 10	79.31% ± 13.6
Postoperative	11.86 ± 3.5	16.83 ± 4.35	37.53 ± 4.88	10.86 ± 5.5	77.09 ± 14.15	98.09% ± 19.28
P	0.05	0.05	NS	NS	0.05	0.05

was initiated as of postoperative day 1. Resumption of daily activity was authorized after 3 months and effort after 6 months.

At follow-up, all patients were examined by an independent surgeon (RM) not involved in the index operation. Subjective Shoulder Value was determined subjectively by the patient by comparison with a normal shoulder graded 100% [2]. Patients were also asked if they were very satisfied, satisfied, disappointed or dissatisfied with the final result. Tendon healing was assessed on ultrasound in 31 cases and on CT-arthrography in 4, and superior cuff thickness, at the location of the supraspinatus tendon, was measured from the greater tubercle to the muscle junction. Full-thickness tear or an aspect of localized tendon defect suggesting partial tear or doubt as to possible full-thickness tear were counted as healing failure [18].

Given the size of the subgroups, means were compared on Wilcoxon test. Continuous variables were compared on Pearson correlation coefficient. Three or more matched groups were compared on Friedman non-parametric test. The significance threshold was set at $P \leq 0.05$.

3. Results

Mean follow-up was 60 months (range, 24–110 months).

Subjectively, 25 patients (71.4%) were very satisfied, 5 (14.3%) satisfied, 4 (11.4%) disappointed and 1 (2.9%) dissatisfied. Mean Subjective Shoulder Value was 77.5 ± 23.1%.

Mean constant score improved significantly from 64.7 ± 10 preoperatively to 77.1 ± 14 postoperatively ($P < 0.05$), and Constant score weighted for age and gender from 79.3 ± 13 to 98.1 ± 19 ($P < 0.05$). On subscore analysis, pain and daily life activity scores showed significant improvement, whereas mobility and strength were relatively unchanged (Table 1). There was no significant correlation between functional results and age, traumatic versus non-traumatic onset, number of torn tendons, lesion size on the De Orio and Cofield classification [17], preoperative fatty infiltration, lamellar dissection or fixation onto the greater tubercle or not.

Mean subacromial space increased from 9.1 ± 1.7 mm to 9.9 ± 2.4 mm ($P = 0.09$). Postoperatively, subacromial space was less than 6 mm in 2 shoulders (5.7%). The rate of iterative tear was 17.1%, with 4 full-thickness and 2 partial or doubtful tears. Mean superior cuff tendon thickness without iterative tear was 4.71 ± 1.6 mm. Postoperatively, superior cuff tendon thickness was independent of intraoperatively assessed lesion size. Increased strength correlated with healed tendon thickness ($P < 0.05$). In case of repeat tear, standard and weighted Constant scores were significantly lower: 64.1 ± 21 versus 79.7 ± 10.8 and 85.3 ± 29 versus 100.7 ± 16, respectively ($P < 0.05$).

4. Discussion

To avoid iterative tearing after rotator cuff repair, preoperative reparability criteria have been proposed in the light of recognized prognostic factors for tendon healing [9]:

- subacromial space at least 7 mm;
- fatty infiltration grade in the affected muscles equal to or less than 2 on the Goutallier classification [10].

Even so, however, certain tears cannot be repaired directly, by fixing the tendon onto the greater tubercle, without excessive tension. Direct repair of large and massive tears is a challenge, given the recurrence rate of 17% to 94% [2,4,6–8,19]. The non-anatomic side-to-side repair technique provides satisfactory results in these cases [3,12,13,20–23] (Table 2). Studies report good clinical results and high satisfaction rates, with recurrence ranging between 19% and 48% [20,21,23]. Burkhart et al. [13] reported good and excellent clinical results in large and massive tear at a mean 3.5 years' follow-up, comparable to those for direct repair of medium to small tears. In 2003, Jones et Savoie [3] reported 88% good and excellent clinical results, independently of lesion size, after arthroscopic side-to-side repair of 47 large and massive tears. Secondary fixation onto the tuberosities seems not to affect long-term clinical

Table 2
Results in side-to-side rotator cuff repair series.

	Number of cases	Mean age (range)	Goutallier grade	Follow-up (months)	Constant score /100 points	UCLA score	Percentage repeat tear
Burkhart et al., 2001 [13]	25	No data	No data	42	No data		No data
Jones et Savoie, 2003 [3]	50	61 yrs (41–76)	No data	32 12–63	No data	32.4	No data
Wolf et al., 2005 [22]	42	59.8 yrs (42–79)	No data	73 (48–120)	No data	33	No data
Rousseau et al., 2012 [21]	58	66.6 yrs (46–80)	GG 1.47	38 ± 7	69.3 ± 12.3	No data	44%
Van Der Zwaal et al., 2012 [20]	31	59 yrs ± 4.7	2–3	26.5	No data	No data	19%
Kim et al., 2013 [23]	24	59.6 yrs (24–60)	No data	30.6 (24–60)	79.1 ± 12.6	No data	48%
Present series	35	53.5 yrs (37–72)	≤ 2	60 (24–110)	77.1 ± 14	No data	17.1%

GG: global Goutallier fatty infiltration grade.

results [22]. In 2012, Van Der Zwaal et al. [20] reported good clinical results and a 19% rate of iterative tear after modified side-to-side repair of massive tear, at a mean 26.5 months' follow-up; they recommended uninterrupted "shoestring bridge" side-to-side repair, using multiple stitches to reduce tendon tension, as confirmed on biomechanical study [24]. Rousseau et al. [21] reported satisfactory clinical results and an iterative tear rate of 44% at a mean 38 months' follow-up in an elderly population with a mean age of 66 years. The present series confirmed the literature data, with a high satisfaction rate (85%), good functional results and a moderate recurrence rate (17.1%). The present results are comparable, clinically and anatomically, to those reported in a series of muscle advancement procedures in a population that was similar to the present in terms of age, lesion size and low fatty infiltration of the muscles; the iterative tear rate was 15%, but with shorter follow-up (1–4 years) [25].

In case of large tear, recurrence may occur in 2 stages [8,26]: early (within the first 6 postoperative months), or secondarily, at more than 1 year. In a series of massive tears, recurrence rose from 34% at a mean 3.1 years to 44% by 9.9 years [2,26]. In the present series, the mean 5-year follow-up covered most early and secondary iterative tears, highlighting a satisfactory anatomic outcome with a moderate (17%) recurrence rate. In comparison with other reports, the present low mean age (53 years) and absence of marked preoperative fatty infiltration appeared to be factors for good prognosis.

In the light of the importance of tendon tension at the repair site, McLaughlin [11] was one of the first to define prerequisites for effective repair, recommending side-to-side suture before fixing the tendon onto the tuberosities. More recently, Burkhart [12,13] demonstrated the interest of arthroscopic side-to-side repair in large and massive tear. The first step consists in identifying the shape of the tear, side-to-side repair being especially appropriate in U-shaped lesions [13,27].

Burkhart et al. [13] attribute U-shaped tears to medial and especially posterior retraction of the torn cuff. Mochizuki et al.'s anatomic studies [14] showed that the greater tubercle insertion of the supraspinatus muscle is very anterior and very limited compared to the infraspinatus tendon insertion along the superior part of the greater tubercle. Given these findings, it seems logical, in U-shaped tear, to perform posterior-to-anterior side-to-side repair, mobilizing the infraspinatus tendon to achieve tight repair without tension, with tendon continuity from infraspinatus to subscapularis, restoring the superior cuff tendon.

The present study has several limitations, mainly due to cohort size and the retrospective design without control. However, large rotator cuff tear with good residual muscle quality is infrequent and represents a challenge for surgery. To the best of our knowledge, there have been few reports of clinical and anatomic results with side-to-side repair at significant follow-up.

In conclusion, side-to-side repair allows tendon repair without tension. Respect of preoperative reparability criteria (subacromial space equal to or greater than 7 mm and fatty muscle infiltration grade equal to or less than 2 on the Goutallier classification [10]) enables selection of patients whose only unfavorable criterion is lesion size, which seems thereby to be minimized. The choice of repair technique is guided by lesion size and shape, as recommended by Burkhart [13,26].

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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