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Massive tears of the rotator cuff treated with a deltoid flap

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Abstract We retrospectively reviewed the charts of 29 patients younger than 65 years at surgery treated with deltoid flap reconstruction for massive postero-superior rotator cuff tears. All tears involved supraspinatus and infraspinatus tendons and were associated with tendon stump retraction to the glenoid rim, a preservable long biceps tendon, and an intact subscapularis tendon. Mean follow-up was 10.5 years. Patient satisfaction rate was 89%. Mean global Constant score improved from 43 to 71.5 points, mean pain score from 6.3 to 13.2, mean anterior flexion from 100 to 157°, and force in elevation from 2.3 to 3 kg. Two thirds of patients had no humeral head migration. Of the 18 patients whose flap was examined by magnetic resonance imaging, 15 had no tear and 12 had a flap signal of muscle intensity; mean flap thickness was 5 mm. Pre-operative factors associated with poorer outcomes were upwards humeral head migration with a subacromial space smaller than 6 mm, presence of glenohumeral osteoarthritis, and supraspinatus amyotrophy greater than 40%. Deltoid flap reconstruction is a valid option in this patient population.

Résumé Nous avons examiné les dossiers de 29 malades âgés de moins de 65 ans traités par lambeau deltoïdien de la rupture massive postéro-supérieure de la coiffe des rotateurs. Toutes les ruptures ont impliqué les tendons supraspinatus et infraspinatus et ont été associées avec une rétraction des extrémités tendineuses à la glène, un long tendon du biceps conservable, et un tendon du muscle subscapularis intact. Le suivi moyen était de 10,5 années. Le taux de satisfaction des malades était de 89%. Le score moyen de Constant a été amélioré de 43 à 71,5 points, le score de la douleur de 6,3 à 13,2, la flexion moyenne antérieure de 100° à 157°, et la force d'élévation de 2,3 kg à 3 kg. Deux tiers des malades n'avaient aucune migration de la tête humérale. Des 18 malades dont le lambeau a été examiné par l'image de résonance magnétique, 15 n'avaient aucune rupture et 12 avaient un signal du lambeau d'intensité musculaire; l'épaisseur moyenne du lambeau était 5 mm. Les facteurs préopératoires associés avec les résultats plus médiocres étaient: migration vers le haut de la tête humérale avec un espace subacromial inférieur à 6 mm, présence d'arthrose glénohumérale, et amyotrophie du muscle supraspinatus de plus de 40%. La reconstruction par lambeau deltoïdien est une bonne option dans cette population de malade.

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Introduction

Massive postero-superior rotator cuff tears involving the supraspinatus and infraspinatus tendons with a preservable long biceps tendon but no possibility of repair by simple tendon-to-bone suturing are generating debate about the optimal treatment strategy. Non-operative treatment has proved less satisfactory than surgery [20, 22]. Superior arthrolysis or arthroscopic debridement with or without long biceps tenotomy or tenodesis is the least invasive operative method. Cuff repair requires open surgery with either tendon stump re-attachment after muscle and tendon advancement or reconstruction by latissimus dorsi or deltoid muscle transfer. Cuff repair prevents loss of shoulder strength and glenohumeral osteoarthritis [17]

and also provides better results than does palliative arthroscopic debridement [9, 14]. Functional outcomes are better when the cuff remains intact after surgery [12]. However, the risk of recurrent tears increases with the number of repaired tendons. More importantly, surgical repair of massive rotator cuff tears requires several days in the hospital and a 6-month-long rehabilitation program, whereas arthroscopic debridement is an outpatient procedure followed by a brief period of rehabilitation. Information on long-term outcomes is clearly needed to assist in the choice between palliative arthroscopic debridement and rotator cuff repair in patients with massive rotator cuff tears.

The objective of this study was to conduct a retrospective evaluation of long-term clinical, radiographic, and magnetic resonance imaging (MRI) outcomes in a

cohort of patients with massive postero-superior rotator cuff tears treated with deltoid muscle flap reconstruction.

Material and methods

Consecutive patients aged 50–65 years and treated between 1988 and 1998 by deltoid muscle flap reconstruction for massive rotator cuff tears were identified by chart review. Eligibility criteria were presence of a full-thickness tear in the supraspinatus and infraspinatus tendons with retraction of the tendon stumps to the glenoid rim, a preservable long biceps tendon, and an intact subscapularis tendon. Deltoid flap reconstruction was performed as described by one of us [3] (Fig. 1a–c).

Each of the 29 patients who met the study criteria underwent a pre-operative and a post-operative evaluation including Constant score determination [5] and standard radiographs. In addition, ultrasonography was performed pre-operatively in 16 patients and

Fig. 1 **a** Schematic drawing of the shoulder region seen from the side. The dotted line represents the superior and external surgical approach. **b** Schematic drawing of the shoulder region seen from above. The dotted line represents the contour of the deltoid flap. **c**

The deltoid flap sutured to the trimmed edges of the rotator cuff tear. *S. Scap*, *m* subscapularis; *S.E.*, *m* supraspinatus; *SS.E.*, *m* infraspinatus; *Pt. Rond*, *m* teres minor

MRI was done pre-operatively in 13 patients and post-operatively in 18. Mean patient age at surgery was 56 (range, 51–65; median, 56) years. There were 18 men and 11 women. Of the 29 patients, ten were physically inactive, seven were heavy manual labourers, and 12 had less strenuous manual jobs. Mean time from symptom onset to surgery was 12.6 (range, 6–24; median, 12) months.

Mean pre-operative Constant sub-scores were as follows: pain, 6.3/15 (2–12; median, 10); activities of daily living (ADL), 8.9/20 (2–15; median, 10); active flexion measured using a goniometer, 101° (40–160°; median, 90°); active external rotation, 5.5/10 (2–10; median, 6); active internal rotation, L2 (D6–L2; median, L2); and force, 2.3 kg (1–4 kg; median, 2 kg). These figures yielded a mean absolute Constant score of 42.7/100 (27–68/100) and an age-weighted and gender-weighted Constant score of 52/100 (33–72/100). The mean subacromial space as measured on pre-operative radiographs was 8.6 mm (3–12 mm). Of the 29 patients, 21 had no evidence of glenohumeral osteoarthritis and eight had Samilson stage I glenohumeral osteoarthritis. Intra-operative examination of the cuff showed a tear extending to the glenoid rim in the coronal plane in all 29 patients. In the sagittal plane, the tear consistently involved the entire supraspinatus tendon, whereas 16 patients had a tear through the entire infraspinatus tendon and 13 through the upper half of the infraspinatus tendon.

Statistical analysis The STATA software package was used for statistical tests. After checking that the data were normally distributed, quantitative variables were evaluated using Student's *t* test and analysis of variance and qualitative variables using the chi-square test or the Fisher test. Values of *p* smaller than 0.05 were considered statistically significant.

Results

Mean follow-up was 10.5 (range, 5–15; median, 12) years. Comparisons of pre-operative and post-operative Constant score values showed a significant gain in the sub-scores of pain and ADL. In addition, all three mean range of motion sub-scores were significantly improved as compared to pre-operative values. The mean absolute Constant score value at last follow-up was 71.5/100, and the mean weighted Constant score value was 92.7/100, with a significant mean gain of 80% (Table 1).

The subjective evaluation showed that 19 patients were very satisfied, seven were satisfied, two were disappointed, and one was dissatisfied, with a post-operative Constant score of 63, Samilson grade III glenohumeral osteoarthritis, and a posterior tear in the flap.

The mean subacromial space decreased from 8.6 mm pre-operatively to 6.8 mm on the radiographs taken at last follow-up. The deltoid flap was effective in preventing humeral head migration in the coronal plane in two thirds of patients. However, these results did not translate into a

statistically significant preventive effect of humeral head centring. Of the 15 patients with a centred humeral head, three had stage I osteoarthritis pre-operatively and post-operatively. In seven patients with humeral head migration on the pre-operative radiographs, all still had this abnormality at last follow-up, and seven of the 22 other patients (32%) acquired humeral head migration. Of these 14 patients with humeral head migration, five had Samilson stage I and one had Samilson stage III glenohumeral osteoarthritis. Humeral head migration in the coronal plane was not significantly associated with glenohumeral osteoarthritis. A single patient with Samilson stage I glenohumeral osteoarthritis before surgery experienced progression to stage III; this patient had a tear in the deltoid flap.

MRI was performed in 18 patients at last follow-up. In 15 of these patients, the flap was intact, whereas in three a tear was seen, one in the middle of the flap and two posteriorly. All flaps were thick anteriorly with a mean of 5 (2–8) mm. Posterior flap thickness was variable, with a mean of 4.5 (1.5–8) mm for the 15 intact flaps. Over the humeral head, flap texture was muscular in 12 patients (Fig. 2) and fibrous in six. Of the six fibrous flaps, five were 2 mm or less in thickness posteriorly. The portion of the flap located over the greater tuberosity was consistently identical in appearance to the adjacent deltoid muscle, with no amyotrophy or fatty degeneration. The long biceps was normal in 13 patients, ruptured in one, subluxated in three, and at the site of tendinopathy in one. Mean fatty degeneration scores were 2 for the supraspinatus, 3 for the infraspinatus, and 1 for the subscapularis, yielding a mean global fatty degeneration index of 2. Results were similar after exclusion of the three patients with ruptured deltoid flaps. Mean amyotrophy of the supraspinatus and infraspinatus muscles was 60%.

Correlations were looked for to help identify the optimal strategy for treatment and pre-operative patient information. The influence of time from symptom onset to surgery could not be investigated because the distribution of the values was not normal. The following variables did not significantly predict or influence the operative result: patient age, gender, level of physical activity, pre-operative infraspinatus muscle amyotrophy, infraspinatus tear size, and fatty muscle degeneration. Mean absolute Constant score was significantly lower in patients whose subacromial space was less than 6 mm pre-operatively as compared to the other patients (62/100 and 75/100, respectively). Samilson stage I glenohumeral osteoarthritis at the pre-operative evaluation was also associated with a

Table 1 Pre-operative and post-operative Constant scores and range of motion. ADL activities of daily living; ROM range of motion; AAE active anterior elevation; ER external rotation

	Pre-operative	Post-operative	<i>p</i> value
Pain	6.3 (2–12)	13.2 (10–15)	<i>p</i> =0.0001 (Student's test)
ADL	9 (2–15)	16 (11–19)	<i>p</i> =0.01 (Fisher's test)
ROM	17 (8–24)	32 (22–38)	<i>p</i> =0.02 (Student's test)
Strength (kg)	2.3 (1–4)	3 (1–6)	NS (Student's test)
Constant score	42.7	71.5 (63–81)	<i>p</i> =0.0001 (Student's test)
AAE (°)	100° (40–60)	157° (120–170°)	<i>p</i> =0.0001 (Student's test)
ER (/10)	5.5 (2–10)	7.5	NS (Student's test)

Fig. 2 Post-operative magnetic resonance imaging (MRI) of the shoulder. Sagittal T2-weighted image showing a signal of muscle intensity from the deltoid flap

significantly lower mean absolute Constant score at last follow-up (74/100 and 64/100, respectively).

The severity of supraspinatus muscle amyotrophy before surgery was significantly correlated with the mean absolute Constant score at last follow-up. In patients with supraspinatus amyotrophy ranging from 40 to 60% of the area of the fossa, the mean absolute Constant score at last follow-up was 76/100 as compared to 66/100 in patients with amyotrophy greater than 60%. The pre-operative subacromial space did not predict flap integrity at last follow-up; in contrast, the subacromial space at last follow-up was significantly smaller in patients with a torn flap than in those with an intact flap (4.3 and 7.8 mm, respectively). The mean absolute Constant score at last follow-up was significantly higher in the 12 patients with intact flaps greater than 2 mm in thickness posteriorly than in the six patients with torn or intact flaps less than 2 mm in thickness posteriorly (74/100 and 71/100, respectively), although the difference was not statistically significant.

Discussion

The disappointing results of open surgery with arthrolysis in massive rotator cuff tears [4] led one of us to investigate use of a custom-made active muscle flap taken from the anterior part of the middle deltoid muscle (Fick zone III) and stitched to the edges of the tear previously trimmed down to thick bleeding tissue [3]. This method is appealing because the deltoid flap works synergistically with the infraspinatus and supraspinatus muscles and because both the blood vessel and the nerve supply to the flap are preserved. Thus, the procedure interposes live

tissue between the acromion and the proximal humerus forming a three-bellied muscle that opposes upward migration of the humeral head. The outcomes in our patients after a mean follow-up of 10 years and 6 months showed that deltoid flap reconstruction was largely successful in ensuring pain relief with adequate range of motion and shoulder strength. Mean active flexion was 157°, most patients were able to place their hand behind their neck and the dorsum of the hand on T9, and mean elevation strength was 3 kg. Presence at surgery of glenohumeral osteoarthritis, however mild (Samilson stage I), supraspinatus muscle amyotrophy greater than 40%, and a subacromial space no greater than 6 mm were significantly associated with poorer outcomes, according to Vad et al. [20].

We sought to compare our results to published data on deltoid flap reconstruction, other repair techniques, and arthroscopic debridement with acromioplasty. This proved to be an arduous task, because our study differed from earlier work in that we selected a well-defined patient population based on the following inclusion criteria: age between 50 and 65 years at surgery, full-thickness tear through the entire supraspinatus tendon and at least the upper half of the infraspinatus tendon with stump retraction to the glenoid rim precluding repair by simple tendon-to-bone suture, preservability of the long biceps, and an intact subscapularis tendon. The subjective results in our series, with 89% of satisfied or very satisfied patients, were similar to those in earlier published series of deltoid flap reconstruction [7, 10, 15, 19]. Our mean Constant score was 71.5, with a mean gain of 28.8 points after a mean follow-up of 126 months. After a mean follow-up of 84 months, Gedouin et al. [10] found a mean Constant score of 62 with a 25-point gain in 41 patients. The discrepancies across these studies are probably ascribable to differences in the number of torn tendons and in tear size in the coronal plane. In a study of 13 patients with lesions of greater severity than those in our study, Le Huec [15] found a mean Constant score of only 47. The mean gain in active external rotation in our study was 2 of 10 points. The force increase was only 35% in our series as compared to 45% [10]. Thur [19] is the only author who reported recovery of normal force in 72% of patients. In a study of 20 cases, Dierickx [7] found a 75% force increase but used the UCLA score, which does not provide an accurate evaluation of shoulder force.

Tendon re-attachment after muscle advancement was first used by Debeyre [6] for supraspinatus tears and further developed by Goutallier [13] for supraspinatus and infraspinatus tears. The goal is to achieve tension-free tendon-to-bone suture by detaching and advancing the infraspinatus and supraspinatus muscles from the scapula then using the rhomboid muscle to strengthen the infraspinatus muscle. In a study of 49 patients, Goutallier [13] found a mean Constant score of 66 after a mean follow-up of 3 years. The score was higher in patients with an intact cuff at last follow-up than in those with recurrent tears. The technical challenges raised by the need to detach muscles altered by amyotrophy and fatty degeneration

have limited the use of muscle and tendon advancement. Because the advanced muscles are fragile, this author now recommends routine rhomboid muscle transfer to strengthen the infraspinatus muscle.

In 16 patients with irreparable rotator cuff tears treated with latissimus dorsi flap reconstruction and re-evaluated 3 years later, Gerber [11] found a mean Constant score of 67.5/100 with gains of 52° for flexion and 23° for external rotation. Published data [2, 21] suggest that functional outcomes after latissimus dorsi flap reconstruction may be similar to those recorded after deltoid flap reconstruction. Although a useful degree of active external rotation is restored, humeral head migration and glenohumeral osteoarthritis seem to develop rapidly in a sizeable proportion of patients. No data on the anatomic condition of latissimus dorsi flaps have been reported.

Outcomes after palliative arthroscopic debridement of full-thickness tears with stump retraction to the glenoid rim were investigated in a multi-centre study of 283 patients [18]. After a mean follow-up of 3 years, the mean Constant score was 65.8 in patients aged 60 years or younger and 60.7 in patients aged 61–65 years. Among the patients with tears involving the supraspinatus tendon and at least half the infraspinatus tendon, 26 were re-evaluated after a mean follow-up of 5.3 years. Subjective results were similar to ours, with 84% of patients stating they were satisfied or very satisfied. At last follow-up, the mean Constant score was 67.4, and 31% of patients had scores lower than 65. Pain and force scores were similar to those in our patients. In contrast, mean active flexion decreased from 135° pre-operatively to 131° at last follow-up, whereas an increase from 101 to 157° was noted in our study. Several of studies [1, 8, 9, 14] are biased by the patient selection criteria, heterogeneity in the anatomic lesions, and choice of objective evaluation methods. In aggregate, available data suggest that arthroscopic debridement may be as effective as deltoid flap repair in relieving pain and may be perceived as satisfactory by most patients despite smaller range of motion and force gains than those obtained with surgery. Follow-ups in published studies are too short to allow conclusions about the stability of results over time. Melillo [16] reported deterioration of results in the long-term in patients treated with arthroscopic debridement.

In summary, 10-year outcomes after deltoid flap reconstruction in the absence of complications are characterized by near-normal range of motion (157°), freedom from pain, and decreased force (3 kg). In addition, deltoid flap reconstruction seems to decrease the risk of humeral head migration and to slow or halt the progression of glenohumeral osteoarthritis. Regarding arthroscopic debridement, longer-term data on humeral head migration and glenohumeral osteoarthritis are needed to determine the place of this procedure in the treatment of rotator cuff tears in patients younger than 65 years of age.

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