Results of latissimus dorsi tendon transfer for irreparable cuff tears


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Summary  Rupture of the supraspinatus and infraspinatus tendon (and teres minor) can cause loss of active external rotation (ER), entailing severe functional disability in daily activities. Latissimus dorsi tendon transfer (LDTT), proposed by Gerber in 1988, appears to be the best adapted solution in these cases of irreparable posterior and superior cuff tears. Between 2001 and 2004, 30 patients were operated on by the technique described by Gerber, with the transfer fixed anteriorly to the subscapularis tendon and laterally to the greater tuberosity by transosseous suture. One patient, subsequently requiring revision with a reversed prosthesis, was considered as a failure. Twenty-six patients were reviewed with a mean follow-up delay of 34 ± 12 months. There were 14 men and 13 women. Mean age was 55.5 years (36 to 71 years). Preoperatively, active ER was symmetric in seven cases, loss of active ER was moderate with positive lag sign in five cases, significant with positive dropping sign in six cases, and severe in nine cases. Fatty muscular degeneration was present and significant in all cases for the infraspinatus muscle and in 14 cases for the teres minor muscle (associated with significant ER loss). Subjectively, 85% of the patients were very satisfied or satisfied and the Subjective Shoulder Value (SSV) was 68 ± 17%. The pain score improved from 4.8 ± 3 preoperatively to 12.2 ± 2 postoperatively, strength from 3.7 ± 2 kg to 4.2 ± 1.8 kg, mean Constant score from 50 ± 12 to 74 ± 9, and Constant score adjusted for age and gender from 62 ± 15% to 91 ± 11%. Mean active ER gain was 7° (−30° to +50°). The loss of active ER was aggravated in one case, unchanged in three, improved in nine and corrected in six. Hornblower sign was corrected in six cases and persisted in nine. Postoperatively, 8% of the patients were unable to eat and drink, compared to 64.7% preoperatively. The results of this series are comparable to those found in the literature for first-intention cases. LDTT restored active ER, but the results were incomplete and variable. Improvement was better in case of severe preoperative active ER deficit and insufficiency of the teres minor muscle. Recovery of strength was not observed in the present series.

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had pseudoparalysis of the shoulder with impaired active repairs, and one acromioplasty. A history of surgery on the same shoulder: two open cuff were liable for worker’s compensation. Three patients had including seven with significantly manual jobs. Six cases went twenty patients (74%) were working at the time of surgery, involved in 20 cases (74%) and the dominant side in 25 (92%).

Functional management and arthroscopic debride-ment are both effective against pain, but fail to restore function, and the clinical result degrades over the long term [1]. Reverse prostheses are only indicated in elderly patients with associated shoulder joint damage. Latissimus dorsi tendon transfer (LDTT), introduced by Gerber et al. in 1988 [2], would seem to be the best adapted attitude towards this specific problem of cuff rupture. Results reported in the literature have been satisfactory but variable without objective assessment criteria [3–8].

The present study analyzes results obtained with LDTT in the particular case of irreparable superior and posterior rotator cuff rupture with or without impaired active mobility, to shed light on clinical and radiological prognostic criteria.

Material and methods

Between 2001 and 2004, 30 patients were operated on, by a single surgeon (LNJ), by LDTT for superior and posterior rotator cuff rupture with supraspinatus and infraspinatus tendon involvement, sometimes extending to the teres minor. One case was excluded because of a significant subscapularis tendon lesion. Two patients were lost to follow-up after the 1-year postoperative check-up (Constant score, 42 and 36 respectively).

There were 14 men and 13 women; mean age at surgery was 55.5 years (range: 36 to 71). The right shoulder was involved in 20 cases (74%) and the dominant side in 25 (92%). Twenty patients (74%) were working at the time of surgery, including seven with significantly manual jobs. Six cases were liable for worker’s compensation. Three patients had a history of surgery on the same shoulder: two open cuff repairs, and one acromioplasty.

All but one patient had nocturnal shoulder pain. Five had pseudoparalysis of the shoulder with impaired active anterior elevation. Seven showed no active ER deficit. Five had a slight active ER deficit, revealed by a positive lag sign [9]. Six showed significant active ER deficit with a positive dropping sign: the patient could not maintain the position of maximum of ER imposed by the examiner, with the elbow at the side; the forearm dropped back to 0° ER despite the patient’s effort to maintain the position [10]. Nine showed severe impairment: the forearm could not be stabilized in neutral rotation and, at maximal passive ER, the hand automatically returned to the belly in internal rotation. ER strength was assessed according to the international classification from 0 to 5 (grade 0: no muscle contraction; grade 1: muscular fasciculation preventing movement; grade 2: contraction enabling movement without antigravity function; grade 3: antigravity function; grade 4: active movement against gravity and resistance; grade 5: normal motor function). Arm-at-the-side ER strength (ER1) was assessed at 4 in six cases, 3 in ten cases and 2 in seven cases (six cases not tested). The ER deficit hindered or prevented eating and drinking for 11 of the 17 patients interviewed (64.7%). Lift-off test and belly press tests were negative in all cases.

Subacromial space, between the superior tip of the humerus and the inferior acromial cortex, was measured in neutral, external and internal rotation. The distance was normal under neutral rotation in 12 cases (grade 1 according to Hamada et al. [11]) and less than 6 mm in 12 cases (Hamada grade 2). In three cases, there was true subacromial “arthritis” (Hamada grade 3). In eight cases, there was a small humeral bone spur (grade 1 on Samilson et Prieto’s osteoarthritis classification [12]).

All patients underwent arthro-CT-scan to assess muscle atrophy and degeneration in each cuff component according to the 5-grade classification of Goutallier et al. [13]. There were 25 cases of supraspinatus atrophy and 24 cases of fatty infiltration greater than grade 2. In all cases, there were infraspinatus atrophy and fatty infiltration of grade 2 or more (grade 2: five cases; grade 3: 15 cases; grade 4: seven cases). There was teres minor atrophy in 12 cases and fatty infiltration of grade 2 or more in 13 cases (grade 2: six cases; grade 3: six cases; grade 4: two cases). There was no atrophy or significant fatty muscular degeneration of the subscapularis.

Introduction

Superior and posterior rotator cuff rupture with supraspinatus tendon involvement is not rare. It can cause a specific deficit symptomatology, with loss of active external rotation (ER). The resultant functional disability is a true ataxia, with loss of spatial control of the hand in the most severe cases.

When the rupture is irreparable, management is a delicate issue which must take account of both pain and the functional impairment – especially in young, working patients. Functional management and arthroscopic debridement are both effective against pain, but fail to restore function, and the clinical result degrades over the long term [1]. Reverse prostheses are only indicated in elderly patients with associated shoulder joint damage. Latissimus dorsi tendon transfer (LDTT), introduced by Gerber et al. in 1988 [2], would seem to be the best adapted attitude towards this specific problem of cuff rupture. Results reported in the literature have been satisfactory but variable without objective assessment criteria [3–8].

The present study analyzes results obtained with LDTT in the particular case of irreparable superior and posterior rotator cuff rupture with or without impaired active mobility, to shed light on clinical and radiological prognostic criteria.

Level of evidence. — Level IV. Therapeutic Study.

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Indications for surgery were as follows:

- irreparable supra- and infraspinatus tendon rupture with grade-2 or more fatty muscle degeneration in a young, working patient, whatever the active ER status;
- irreparable supra- and infraspinatus tendon rupture with active ER deficit causing disabling functional impairment, whatever the age and fatty muscle degeneration status.

All patients were operated on using the same technique, inspired by that described by Gerber et al. [2]. The patient was installed in lateral decubitus and proctile. The first step comprised an anterior transdeltoid cuff approach for lesion assessment and antero-inferior acromioplasty. Except in one case of biceps rupture, biceps tenodesis was performed in the bicicipital groove. Three cases of partial superior subscapularis lesion required repair. Posterior incision then gave access to the latissimus dorsi muscle. After humeral release, careful dissection conserved the vasculonervous pedicles of the muscle body. The latissimus dorsi, which is always very thin, was reinforced with an absorbable PDS strip [Johnson & Johnson Intl, c/o European Logistics Centre, Belgium) to secure the suture. The tendon was introduced flat under the deltoid muscle into the subacromial space, to the greater tuberosity. Terminolateral fixation onto the superior edge of the subscapularis anteriorly and lateral fixation onto the superior edge of the subscapularis anteriorly and lateral fixation onto the greater tuberosity was by non-absorbable transosseous suture. At end of surgery, the upper limb was positioned in a 60° abduction sling for 45 or 60 days. Exclusively, early passive rehabilitation was initiated the day after surgery.

Pre- and postoperative shoulder status was assessed by the subjective and 65 for the objective assessment [14]. The score adjusted for gender and age was expressed as a percentage. A subjective shoulder value (SSV) score further assessed shoulder status as a percentage of the normal status claimed by the patient [15]. All patients underwent standard pre- and postoperative frontal X-ray examination in all three rotations.

Statistical analysis was performed by an independent operator, using Statview 5 (SAS Institute) software. T-tests were used on continuous and Chi² tests on discrete variables. Non-parametric Wilcoxon tests were used on continuous variables where sample sizes were small. The significance threshold was set at 5%.

Table 1 presents the clinical results. Pain scores showed significant improvement, with 24 patients having postoperative scores equal to or greater than 10. Strength recovery, on the other hand, was low, at a mean 0.5 kg. Overall, the mean Constant score rose by 24 points and the weighted score by 29%, improvement being mainly seen in the subjective criteria. There was no postoperative pseudoparalysis. Mean arm-at-the-side active ER gain was 7° (range: −30° to +50°). One ER deficit worsened postoperatively, three were unchanged, nine improved and six were corrected. No active deficit occurred postoperatively. ER1 improved in 50% of cases, and decreased in 4%. Postoperatively, the hornblower’s sign was corrected in six cases and persisted in nine. No hornblower’s signs occurred postoperatively. ER2 improved in 55% of cases, and decreased in 10%. Two patients (8%) were hindered in eating and drinking postoperatively.

Patients with history of surgery to the same shoulder showed significantly poorer results, subjectively and objectively (mean Constant score 67 ± 3 vs 75 ± 9, SSV score 43 ± 21% vs 71 ± 14%).

### Results

One patient, reoperated at 18 months by total reversed prosthesis for painful clinical degradation due to evolutive shoulder joint arthritis, was counted as a failure of treatment. The results reported concerned the 26 patients reviewed at a mean 34 ± 12 months’ follow-up (range: 24 to 62). Subjectively, 15 patients (58%) were very satisfied, seven (27%) satisfied, three (11%) disappointed, and one (4%) dissatisfied by their results. Mean SSV score was 68.4 ± 17% (range: 20 to 95).

Twelve of the 20 patients in employment had gone back to work. Six of those with manual jobs resumed work, with adaptations made to the job in two cases. Worker compensation status did not impact return to work or Constant score.

### Table 1 Pre- and postoperative clinical data.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain score/15 points</td>
<td>4.8 ± 3</td>
<td>12.2 ± 2</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Strength in kilograms</td>
<td>3.7 ± 2</td>
<td>4.2 ± 1.8</td>
<td>0.31</td>
</tr>
<tr>
<td>Constant score</td>
<td>50 ± 12</td>
<td>74 ± 9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Adjusted Constant score</td>
<td>62% ± 15</td>
<td>91% ± 11</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Active anterior elevation</td>
<td>155° ± 42°</td>
<td>173° ± 13</td>
<td>0.1</td>
</tr>
<tr>
<td>Mean active external rotation 1</td>
<td>8.9° ± 33°</td>
<td>15.6° ± 23</td>
<td>0.24</td>
</tr>
<tr>
<td>No external rotation deficit</td>
<td>7</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Lag sign</td>
<td>5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Dropping sign</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Severe dropping sign</td>
<td>9</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hornblower’s sign</td>
<td>15</td>
<td>19</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

### Table 2 Pre- and postoperative X-ray data.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subacromial space neutral rotation</td>
<td>5.7 ± 2.3 (2—10)</td>
<td>5.5 ± 2.3 (1—11)</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Subacromial space external rotation</td>
<td>6.3 ± 3 (1—11)</td>
<td>5.5 ± 2.3 (1—10)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Subacromial space internal rotation</td>
<td>6.1 ± 2.3 (3—11)</td>
<td>7.2 ± 2.5 (2—13)</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Samilson index</td>
<td>0.36 ± 0.47</td>
<td>0.85 ± 0.61</td>
<td>ns</td>
</tr>
</tbody>
</table>

ns: non significant.
Table 2 shows the X-ray results. There was a reduction in subacromial space in neutral and ER, with a significant increase in internal rotation. Samilson scores increased by one grade in 10 cases and two grades in two cases. There was no significant difference in clinical results for Hamada grades 0 and 1. Dropping sign persisted in two of the three cases of Hamada grade 3.

Table 3 presents results according to clinical status and infraspinatus and teres minor muscle status. The degree of pre- and postoperative active ER deficit depended on teres minor atrophy and fatty muscle degeneration (p < 0.05). Where there was no or only moderate preoperative deficit (positive lag test), mean active ER, which was always initially positive, decreased postoperatively and the mean gain in Constant score was 16 points. Where the preoperative deficit was significant or severe, mean active ER, which was always initially negative, increased postoperatively and the mean gain in Constant score was 30 points. From the anatomical point of view, only teres minor fatty muscle degeneration negatively impacted the absolute and weighted postoperative Constant score (p < 0.05).

One patient was reoperated at 11 months for lack of functional recovery despite being free of pain and of peripheral neurological lesion on EMG. Surgery found loosening of tendon transplant fixation. The tendon seemed of good quality and was floating in the joint space. Repair consisted in fixing back the latissimus dorsi transplant. Mobility recovered satisfactorily despite the incomplete clinical result. Two other patients presented transitory axillary nerve lesions which spontaneously resolved, and an algodystrophy syndrome without impact on the final result.

Discussion

Gerber et al. [2] recommended LDTT in rotator cuff pathology to compensate the active ER deficit secondary to superior or posterior cuff rupture. From an anatomical [2,16–18] and biomechanical [17,19,20] point of view, LDTT seems the most coherent and logical attitude to restore impaired active ER and active anterior elevation. The benefit of associating teres major transfer has been discussed in biomechanical [20] and clinical studies [2,21]. Deltoïd [22–24] and subscapularis [2–4,7] functional integrity are prerequisite to transfer efficacy. More recently, Costouros et al. [25] stressed the importance of the teres minor muscle in the quality of the resultant ER. The results of LDTT in revision after cuff repair are not as good as in first intention surgery [8,22,24].

The results on the present series were similar to those reported in the literature for first-intention surgery [4,5,26]. Subjectively, the high rate of satisfaction resulted from both the consistent impact on pain and on the functional improvement enabling such simple but primordial gestures of daily activities such as eating and drinking to be recovered. The total Constant score partially fails to reflect this functional recovery, due to the discrepancy between the subjective and objective assessments [4,5]. The three cases of partial superior subscapularis lesion without fatty muscle degeneration repaired preoperatively did not impact the result.

The present results argue for recovery of active anterior elevation, even though one of the two patients lost to follow-up presented with persistent pseudoparalysis at 1 year after surgery, with a Constant score of 36 points. Depending on the author, severe [26,27] or long-standing [23] pseudoparalysis of the shoulder is a more or less definitive contra-indication for LDTT. Age would not seem to be a prognosis factor, except in the case of elderly patients with general weakness [26].

LDTT is effective in restoring active ER [4–6,26,28], but only partially and to a variable degree. In the present series, recovery was especially marked where the initial deficit was severe and associated with a deficient teres minor muscle. Normal active ER was recovered in 30% of cases arm-aside, and in 40% in abduction. Such recovery was most often obtained where the initial deficit was moderate, being uncertain or partial in other cases. In the present series, where there was no preoperative deficit, ER amplitude and strength did not appear to be improved, as reported by Dumont et al. [23]. Our attitude towards this indication remains critical, awaiting long-terms results. Although the issue is controversial [4,5,26,28], the present series did not show recovery of strength either in abduction or in ER. Recovery of internal rotation was easy and always complete. The result depends upon the subacromial space and the upward migration of the humeral head [3]. Hamada grade 3 [11] with acetabulization of the humeral head and loss of subacromial space required for tendon transfer passage is of poor prognosis. A degenerative glenohumeral joint raises the risk of secondary arthritic decompensation [23,27].

No determining intraoperative prognosis factor emerged. Latissimus dorsi tendon and muscle length never preclude

Table 3 Results according to initial clinical status and muscular degeneration of the infraspinatus and teres minor.

<table>
<thead>
<tr>
<th></th>
<th>No active ER deficit 7 cases</th>
<th>Lag sign 5 cases</th>
<th>Dropping sign 6 cases</th>
<th>Severe dropping sign 9 cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 3-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus fatty infiltration (%)</td>
<td>100</td>
<td>60</td>
<td>67</td>
<td>78</td>
</tr>
<tr>
<td>Grade 3-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teres minor fatty infiltration (%)</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>78</td>
</tr>
<tr>
<td>Teres minor atrophy (%)</td>
<td>0</td>
<td>0</td>
<td>67</td>
<td>89</td>
</tr>
<tr>
<td>Preoperative hornblower sign</td>
<td>14%</td>
<td>20%</td>
<td>83%</td>
<td>100%</td>
</tr>
<tr>
<td>Postoperative hornblower sign</td>
<td>0</td>
<td>0</td>
<td>40%</td>
<td>78%</td>
</tr>
<tr>
<td>Preoperative active ER</td>
<td>41.4 ± 13°</td>
<td>39 ± 13</td>
<td>0.8 ± 9°</td>
<td>−28 ± 8°</td>
</tr>
<tr>
<td>Postoperative active ER</td>
<td>37 ± 19°</td>
<td>27 ± 13°</td>
<td>11 ± 13°</td>
<td>−5 ± 17°</td>
</tr>
<tr>
<td>Preoperative Constant score</td>
<td>54 ± 7</td>
<td>54 ± 15</td>
<td>42.8 ± 13</td>
<td>51 ± 11</td>
</tr>
<tr>
<td>Postoperative Constant score</td>
<td>72 ± 7</td>
<td>69 ± 15</td>
<td>76 ± 7</td>
<td>77 ± 5</td>
</tr>
</tbody>
</table>
transfer [4, 16, 19] so long as the entire tendon is harvested and the muscle sufficiently released [23]. Where exactly to fix the transfer on the humerus is subject to discussion: some authors [6, 19, 20] recommend the summit of the greater tuberosity, on biomechanical grounds, to optimize the transferred tendon’s action; others [2, 23, 26, 27] try to obtain an additional tenodesis effect by a more anterior fixation to the lesser tuberosity and/or subscapularis associated to a lateral greater tuberosity fixation by transosseous suture. We opted for the latter procedure, reinforcing the latissimus dorsi tendon, which is always very thin. Absorbable PDS augmentation enables the transplant to be put under tension, thereby enhancing the tenodesis effect and securing the bone suture [29].

It remains difficult to analyze the action mechanisms of tendon transfer (specific motor action, tenodesis effect) and the reasons for failure. There is at present no means of reliably exploring the position and fixation of a tendon transfer [4]. A certain number of incomplete results are probably due to failure of the tendon fixation [5—26].

Despite all attempts to obtain a tenodesis effect, transfer did not succeed in recentering the humerus head, as had been hoped [2, 3] — except in internal rotation, which puts the transplant covering the humeral head under tension. EMG studies [3, 5, 6, 26] confirm the electrical activity of the modified latissimus dorsi muscle, but its role in active ER is variable and a matter of debate.

The present results show that the transferred tendon acts by compensating teres minor muscle deficiency. The absence of capacity to recenter the humeral head which characterizes infraspinatus function, the greater compensation of active ER in the most severe cases associated with teres minor deficiency and the better compensation of active ER in abduction, as confirmed by Aoki et al.’s EMG data [5], all point to teres minor rather than infraspinatus function.

**Conclusion**

LDTT is optimally indicated for irreparable posterosuperior rotator cuff rupture with significant active ER deficit and impaired teres minor function. By at least partially correcting the active ER deficit, LDTT enables recovery of daily activities, reducing functional disability. Where there is no active ER deficit, results are limited to subjective criteria and the indication is debatable and requires long-term assessment.

LDTT does not correct lack of strength, which remains significant and is the main sequela reported by patients. The present study highlights the role of the teres minor muscle: teres minor deficiency, entailing a clinical deficit in active ER, is specifically corrected by latissimus dorsi transfer.

**References**


