J Shoulder Elbow Surg (2019) ■, 1–7

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Latissimus dorsi transfer for massive posterosuperior rotator cuff tears: what affects the postoperative outcome?

Mohamed Moursy, MD[a,b,*], Jonas Schmalzl, MD[c], Aditya S. Kadavkolan, MD[a,d], Niko Bartels, MD[a], Lars-Johannes Lehmann, MD[a,c]

[a]*Orthopaedic and Trauma Surgery Centre (OUZ), Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany*
[b]*Department of Traumatology and Orthopaedic Surgery, University Hospital Salzburg, Salzburg, Austria*
[c]*Department of Traumatology and Hand Surgery, St. Vincentius Clinic, Teaching Hospital Albert-Ludwigs-University Freiburg, Karlsruhe, Germany*
[d]*Dr. LH Hiranandani Hospital, Mumbai, India*

Background: The management of irreparable posterosuperior rotator cuff tears (IPSRCTs) in young active individuals is still a challenge. The aim of this study was to evaluate the influence of sex, surgical technique, previous surgical procedures, tear genesis, and presence of a preoperative external rotation lag sign on the functional outcome after latissimus dorsi transfer (LDT) for IPSRCTs.
Methods: Retrospectively, all patients with IPSRCTs treated with LDT during a 10-year period were followed up. Preoperative evaluation included the visual analog scale (VAS) score, range of motion, and the Constant score (CS). Postoperatively, the VAS score, range of motion, CS, American Shoulder and Elbow Surgeons score, and Subjective Shoulder Value were recorded. Preoperative and postoperative radiologic evaluation was performed using the Hamada-Fukuda classification and the acromiohumeral interval.
Results: In total, 67 of 79 patients (85%), with a mean age of 63 years, were available for follow-up at 54 ± 28 months. The CS improved from 24 ± 6 points preoperatively to 68 ± 17 points at follow-up ($P < .001$). Active flexion increased from 83° ± 47° to 144° ± 35°; abduction, from 69° ± 33° to 134° ± 42°; and external rotation, from 24° ± 18° to 35° ± 21°. Postoperatively, the Subjective Shoulder Value was 69% ± 19% and the American Shoulder and Elbow Surgeons score was 76 ± 21. The VAS score decreased from 6.3 ± 1.1 to 1.8 ± 2 ($P < .001$). Abduction strength increased from 0.4 ± 0.4 kg to 3.6 ± 2.2 kg ($P < .001$). The acromiohumeral interval decreased from 7.9 ± 2.6 mm to 5.1 ± 2.2 mm, and arthropathy worsened from Hamada-Fukuda stage 1.4 to stage 2.1. The rate of conversion to a reverse prosthesis was 6%.
Conclusion: LDT represents a reliable and reproducible treatment option with good clinical midterm results after surgical treatment. Sex, genesis, preoperative presence of an external rotation lag sign, and previous surgical procedures do not affect the overall clinical outcome.

Institutional review board approval was received from the University of Mannheim/Heidelberg (study No. 2015-556N-MA) prior to the study.

*Reprint requests: Mohamed Moursy, MD, Department of Traumatology and Orthopaedic Surgery, University Hospital Salzburg, Müllner Hauptstraße 48, A-5020 Salzburg, Austria.
E-mail address: m.moursy@gmail.com (M. Moursy).

https://doi.org/10.1016/j.jse.2019.03.028

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Latissimus dorsi transfer; Herzberg technique; L'Episcopo technique; influencing factors; irreparable rotator cuff tear; results; sex; genesis

The management of irreparable posterosuperior rotator cuff tears (IPSRCTs) in young active individuals is challenging. On the one hand, these individuals demand sustained pain relief, but on the other hand, they require strength to be regained for active function. Arthroscopic débridement alone or in combination with long head of the biceps tenotomy can achieve pain control but fail to restore shoulder function; in addition, postoperative results deteriorate with time.[33] Furthermore, reverse shoulder arthroplasty is not an option in young active patients.[17] Therefore, tendon transfers involving the latissimus dorsi (LD) muscle with or without the teres major (TM) muscle have evolved as a suitable treatment option; essentially, 3 different methods are described in the literature. L'Episcopo[24] described the first tendon transfer for the shoulder joint in 1934. In a case of loss of abduction and external rotation due to an obstetric brachial plexus palsy, a combined transfer of the TM and LD muscles was performed. An isolated latissimus dorsi transfer (LDT) was first described by Gilbert and Tassin[13] in 1984 for obstetric brachial plexus palsy in patients with suprascapular nerve palsy. Considering massive posterosuperior rotator cuff tears as a similar pathology, Gerber et al[12] used the concept of LDT to restore the function of external rotation in abduction in massive rotator cuff tears. Through a 2-incision technique, the LD is transferred to the insertion of the supraspinatus muscle and sutured to the remaining rotator cuff stump as well as the subscapularis muscle.[12] The third method was described by Herzberg et al[19] and involves LDT to the infraspinatus footprint through a single-incision technique.[31] Since the first description of LDT for the management of IPSRCTs by Gerber et al, LDT with or without TM transfer has been described by multiple authors with different techniques and has become a commonly performed procedure in active individuals with IPSRCTs.[1,3,6,9,10,14,15,18,20,21,23,27,29,34,36]

Various studies have focused on the identification of variables affecting the outcome of LDT. First, the status of the remaining rotator cuff has been reported to be an important factor influencing the outcome as an irreparable subscapularis tear results in a poor outcome after LDT.[3,10,35] Second, fatty infiltration of the teres minor muscle greater than Goutallier grade 2 has been found to have a negative impact on the outcome of LDT.[8,11] It is interesting to note that a tear of the teres minor tendon does not affect the postoperative outcome.[8]

Regarding the relevant surgical anatomy, the LD muscle originates from the sixth thoracic vertebra and thoracolumbar fascia and inserts in the humeral shaft between the pectoralis major and TM. The mean length of the tendon is 5.2 cm; width, 2.9 cm; and thickness, 1 mm. After tendon transfer, the superior part of the muscle is under increased stress as the increase in length needed to reach the greater tuberosity is 6.8 cm. The neurovascular bundle enters the muscle 9.2 cm from the insertion. The potential excursion of the LD is 33.9 cm; this muscle is the longest in the shoulder girdle and is most suited for transfer.[4,19] The TM, on the other hand, is a shorter muscle with a potential excursion of 14.9 cm; its superior edge may need to undergo lengthening by up to 47% for insertion into the greater tuberosity. The neurovascular bundle of the TM enters its medial half.

Materials and methods

In this retrospective case series, 106 patients aged 38 to 77 years who had undergone LDT between 2003 and 2013 were initially included. All patients underwent magnetic resonance imaging (MRI) of the affected shoulder for diagnosis. After failed conservative treatment with extensive physiotherapy for at least 6 months, LDT was indicated. The muscle transfers were performed in individuals with IPSRCTs who presented with (1) stage 3 fatty infiltration of the supraspinatus tendon according to Thomazeau et al,[32] (2) difficulty in tendon approximation to the greater tuberosity, and (3) stage 3 retraction of the supraspinatus tendon as described by Patte.[30] If the patients reported an adequate trauma in the past 3 months resulting in notable deterioration of their shoulder function and the MRI scan showed an IPSRCT with signs of a partially traumatic genesis such as hematoma or tendon kinking, they were diagnosed with an acute-on-chronic IPSRCT. Patients with glenohumeral arthritis Hamada-Fukuda stage > 2, an irreparable subscapularis tear, an inability to comply with the postoperative rehabilitation protocol, an incapability to stabilize the arm at 90° of abduction with the elbow fully flexed as well as those in whom there was a dynamic anterosuperior subluxation of the humeral head on resisted abduction, were excluded from the study. After the exclusion criteria were applied, 79 patients were included in the study, of whom 67 were available for follow-up at an average of 54 ± 28 months after surgery. Of these patients, 39 were operated on according to the Herzberg technique and 28 were operated on by the L'Episcopo technique. No randomization was involved regarding the technique performed in the patient group. All patients were operated on by the same surgeon. Two

Table I Baseline characteristics and postoperative outcomes

	Data
Follow-up rate, n (%)	67 of 79 (85)
Sex, n (%)	
Men	41 (61)
Women	26 (39)
Genesis, n (%)	
Traumatic	39 (58)
Degenerative	28 (42)
Surgical technique, n (%)	
Herzberg	35 (52)
L'Episcopo	32 (48)
Revision rate, n (%)	
Postoperative complications	0 of 67 (0)
Prosthesis	4 of 67 (6)
Total	4 of 67 (6)
Previous operation before LDT, n (%)	34 of 67 (51)
Mean age (range), yr	63 (38-77)
Mean follow-up (SD), mo	54 (±28)
Mean CS (SD), points	24 (±6) pre and 68 (±17) post
Mean age- and sex-adapted CS (SD), %	31 (±9) pre and 90 (±23) post
Mean forward flexion (SD), °	83 (±47) pre and 144 (±35) post
Mean glenohumeral abduction (SD), °	69 (±33) pre and 134 (±42) post
Mean external rotation (SD), °	24 (±18) pre and 35 (±21) post
Mean force at 90° of abduction (SD), kg	0.4 (±0.4) pre and 3.6 (±2.2) post
Mean VAS score (SD)	6.3 (±1.1) pre and 1.8 (±2) post
Mean ASES score (SD), points	76 (±21) post
Mean SSV (SD), %	69 (±19) post
Mean AHI (SD), mm	7.9 (±2.6) pre and 5.1 (±2.2) post
Mean Hamada-Fukuda classification	1.4 pre and 2.1 post

LDT, latissimus dorsi transfer; *SD*, standard deviation; *pre*, preoperatively; *post*, postoperatively; *CS*, Constant score; *VAS*, visual analog scale; *ASES*, American Shoulder and Elbow Surgeons; *SSV*, Subjective Shoulder Value; *AHI*, acromiohumeral interval.

different techniques were used as the surgeon's preference changed over time. Patient-specific data are outlined in Table I.

Clinical and radiologic evaluation

For follow-up examination, patients were asked to grade their pain on a visual analog scale (VAS). Active range of motion was measured with a goniometer to evaluate elevation, abduction, and external rotation of the elbow at the side. The overall functional outcome was assessed using the Constant score (CS) and American Shoulder and Elbow Surgeons (ASES) score as shoulder-specific measures. In addition, the Subjective Shoulder Value (SSV) was used as a patient-focused outcome tool. The patients were clinically assessed preoperatively and postoperatively with the CS; the SSV and ASES score were only assessed postoperatively.

Radiographic evaluation was carried out with conventional scapular anteroposterior and axillary radiographs that were evaluated according to the Hamada-Fukuda classification.[16] Superior migration of the humeral head was quantified in the subacromial space using the acromiohumeral interval and in the glenohumeral articulation by the Maloney line.

Surgical technique

A diagnostic arthroscopy was first performed in all patients, and arthroscopic long head of the biceps tenotomy was performed. Acromioplasty was performed if indicated.

Modified Herzberg technique

LDT was performed with the patient in the lateral decubitus or prone position through an incision starting below the posterolateral corner of the acromion following the triceps for 6 to 8 cm. The LD and TM tendons were identified and sharply dissected from the humerus. When separation of the 2 tendons was not possible, a combined transfer was performed. A bony trough was prepared at the insertion of the infraspinatus, and the tendons were fixed with 4 FiberWire sutures (Arthrex, Naples, FL, USA) with modified Mason-Allen stitches. The crucial technical steps of this technique are illustrated in Figure 1.

L'Episcopo technique

With the patient in the lateral decubitus position, the deltoid muscle was elevated through an angled incision from the posterior border of the deltoid to the axillary fold. The quadrangular space with the axillary nerve was identified. Afterward, the LD and TM tendons were identified and dissected from the humerus while the radial nerve was being protected. After release of the attachments, the tendon or tendons were sutured with 2 suture anchors to the lateral aspect of the proximal humerus.

Postoperative protocol

Postoperatively, the shoulder was immobilized in 30° of external rotation and 45° of abduction. After 4 weeks, active exercises, with avoidance of movements provoking pain, were begun in all planes. After 12 weeks, full shoulder motion was permitted and the patient was allowed to return to light manual work and sports activities.

Statistical analysis

Statistical analysis was performed with SPSS software (version 22; IBM, Armonk, NY, USA) using the independent-samples Mann-Whitney *U* test and the Kruskal-Wallis test. Quantitative variables were described by means, standard deviations, minimums, and maximums. Normal distributions were tested by the Shapiro-Wilk test and confirmed graphically by a histogram. To determine prognostic factors for the functional outcome, we tested correlations between the VAS score, SSV, and CS and the following parameters: sex, previous surgical procedures before muscle transfer, preoperative external rotation lag sign, surgical

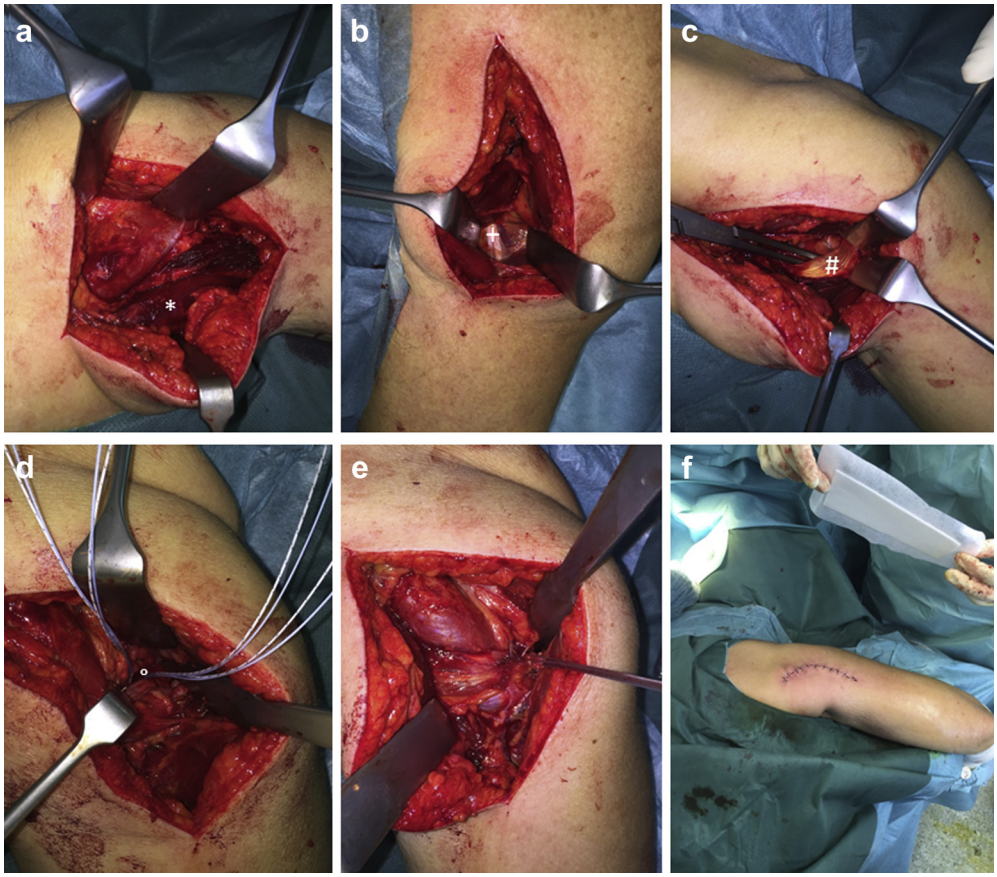

Figure 1 Latissimus dorsi transfer with modified Herzberg technique. The incision is made below the posterolateral corner of the acromion following the triceps for 6 to 8 cm. The teres major (*) is identified first (**a**), followed by the latissimus dorsi tendon (#) (**c**). (**b**) The radial nerve (+) should be visualized. When separation of the 2 tendons is not possible, a combined transfer should be performed. Two suture anchors are placed at the insertion of the infraspinatus (°) (**d**), and the tendons are fixed with modified Mason-Allen stitches (**e**). After skin closure (**f**), the shoulder is immobilized with an abduction pillow.

technique (Herzberg vs. L'Episcopo), and genesis (traumatic vs. degenerative).

Results

The mean duration of follow-up was 54.2 ± 28.2 months. The preoperative CS was 24 ± 6 points and improved to 68 ± 17 points at follow-up ($P < .001$); the age- and sex-adapted CS increased from 31% ± 9% to 90% ± 23% ($P < .001$). Active forward flexion increased from 83° ± 47° to 144° ± 35° postoperatively; similarly, abduction increased from 69° ± 33° to 134° ± 42°, and external rotation increased from 24° ± 18° to 35° ± 21°. Postoperatively, the SSV was 69% ± 19% and the ASES score was 76 ± 21. The VAS score decreased from 6.3 ± 1.1 to 1.8 ± 2 ($P < .001$). Strength in 90° of abduction increased from 0.4 ± 0.4 kg to 3.6 ± 2.2 kg at final follow-up ($P < .001$). Regarding preoperative and postoperative limitations on occupations and sports activity, patients reported an increase from 1.02 (indicating up to 25% ability to work) to 3.02 (indicating >75% ability to work) out of 4 points concerning their occupation and an increase from 0.88 (indicating severe limitation) to 3.13 (indicating mild limitation) out of 4 points concerning their sports activity. The acromiohumeral interval decreased from 7.9 ± 2.6 mm to 5.1 ± 2.2 mm, and arthropathy worsened from Hamada-Fukuda stage 1.4 to stage 2.1. The revision rate with conversion to a reverse prosthesis was 6% (4 patients). It is interesting to note that all 4 patients had undergone LDT by the L'Episcopo technique and preoperatively had presented with Hamada-Fukuda stage 2 glenohumeral arthritis. The reason for conversion was ongoing shoulder pain and severe functional impairment in addition to radiographic progression of glenohumeral arthritis to Hamada-Fukuda stage 3 or 4. All 4 patients required conversion in the first 2 years (range, 8-22 months) after LDT. However, we assume that the progression of osteoarthritis is multifactorial and is not related to the performed procedure. No neurovascular complications or postoperative infections occurred. Preoperative and postoperative parameters are shown in Table I.

In addition, we assessed the influence of the surgical technique (L'Episcopo vs. Herzberg), previous surgical procedures before LDT, and preoperative presence of an

Table II Outcome according to sex, surgical technique, etiology, previous surgical procedures, and presence of preoperative external rotation lag sign

	Factor	n	Constant score, points	*P* value
Sex	Male	41	69	NS
	Female	26	67	
Technique	Herzberg	35	70	NS
	L'Episcopo	32	66	
Previous surgical procedures before LDT	≥1	34	69	NS
	None	33	67	
Etiology	Traumatic	39	70	NS
	Degenerative	28	66	
External rotation lag sign	Positive	56	68	NS
	Negative	11	73	

NS, not significant; *LDT*, latissimus dorsi transfer.

external rotation lag sign of 20° or greater, as well as genesis of the IPSRCT (traumatic vs. degenerative). However, the assessment showed that none of these factors had any significant impact on the outcome (Table II). Table III compares our findings with published data regarding postoperative results after LDT.

Discussion

Multiple studies unanimously showed good clinical results after LDT for IPSRCTs.[1,3,6,9,10,14,15,18,20,21,23,28,30,35,37] However, there are several parameters that affect the outcome and may facilitate patient selection and outcome prognosis.

We compared our results with the available literature and observed that the postoperative CS, SSV, and ASES score were similar, as shown in Table III. In addition, we analyzed the preoperative to postoperative gain in CS, forward flexion, glenohumeral abduction, and external rotation. These results were also comparable with the results of previous studies performed in this regard. Only limited data are available regarding the outcome of nonoperative treatment of IPSRCTs. Levy et al[26] prospectively assessed 17 patients with radiologically confirmed, degenerative, massive rotator cuff tears who were treated with an anterior deltoid rehabilitation program. The CS increased from 26 to 60 points at a minimum of 9 months after treatment. Agout et al[2] reported an improvement in the CS from 41 to 57 points after 12 months in a prospective multicenter study of 68 patients with conservatively treated IPSRCTs. Considering our data, conservative treatment of IPSRCTs seems inferior to treatment with LDT.

Nevertheless, after LDT, completely normal shoulder function cannot be expected. In a systematic review of clinical and structural outcomes after arthroscopic rotator cuff repair, Millett et al[27] demonstrated that the average CS lies between 75 and 86 points.[5,22] Therefore, considering our data, compared with "normal" rotator cuff repairs, the CS after LDT is inferior. Compared with the data published by Cole et al[7] with a 2-year follow-up after arthroscopic rotator cuff repair, the abduction force particularly seems to be compromised after LDT when taking into account our data (3.6 kg in our study vs. 5.9 kg in their study).

Sex

Only Iannotti et al[20] have studied the effect of sex on the outcome after LDT. In a cohort of 14 patients evaluated postoperatively by the Penn Shoulder Score, 5 patients were dissatisfied with the outcome, of whom 4 were women. Thus, Iannotti et al concluded that female sex is related to inferior clinical results; however, given the small cohort and many different factors that could possibly affect the outcome, this might not be true. In our study, the mean CS was minimally higher in men than in women, but these differences were not statistically significant (Table II).

Surgical technique

Moursy and Lehmann[29] observed better postoperative CSs and strength in patients operated on by the Herzberg technique compared with the L'Episcopo technique; however, the observed differences were not statistically significant. In our study, we could confirm these results with a larger patient population. An interesting finding was that all 4 patients who underwent humeral head replacement after LDT had been treated with tendon transfer by the L'Episcopo technique. Nevertheless, a causal relation to the progression of osteoarthritis remains doubtful, as there are too many biasing factors.

Previous surgical procedures

Irlenbusch et al[21] showed a tendency toward inferior clinical results in individuals who underwent previous surgical procedures. Less pain relief was also noted in this group; however, the differences were not statistically significant. A long-term study by El-Azab et al[9] showed similar results with 2 of the 3 failures of muscle transfer belonging to the revision group. Our cohort demonstrated similar results with the CS being lower in the revision group (67 points) than in the primary group (69 points). However, the observation was not statistically significant. All in all, primary LDT seems not to be superior to LDT after previous surgical procedures.

Tear genesis

To date, no data are available on whether the etiology of the tear affects the outcome after LDT. In our study, we observed that the CS increased from 34 points to 70 points in the traumatic group compared with an increase from 36 points to 68 points at final follow-up in patients with

Table III Results of current study compared with published data regarding postoperative results after latissimus dorsi transfer

Authors	n	Technique	Age, yr	Follow-up, mo	CS, relative CS, or PSS		Flexion, °		Abduction, °		External rotation, °		AHI, mm		Hamada-Fukuda classification	
					Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Gerber[10] (1992)	16	Gerber	—	33	—	73%	83	135	72	122	10	23	—	—	—	—
Moursy et al[28] (2009)	42	Gerber or modified Gerber	58	47	41.9 points	69.7 points	105	143	102	142	18	35	—	—	—	—
Habermeyer et al[15] (2006)	14	Single incision	61	32	46.5 points	74.6 points	119	170	118	169	19	33	4.6	5.3	—	—
Irlenbusch et al[21] (2008)	52	Gerber	60.1	50.2	36 points	68 points	79	151	69	143	18	23	5.7	4.7	—	—
El-Azab et al[9] (2015)	86	Gerber	56	111	44%	71.4%	86	134	89	127	18	29	5.9	4.9	1.7	2.2
Gerber et al[11] (2013)	44	Gerber	56	147	56.1%	80.3%	118	132	112	123	18	33	7.4	4.9	1.2	2
Moursy and Lehmann[29] (2012)	12	L'Episcopo	62.2	52	27.2%	73.5%	74	—	—	—	—	—	7.3	5.7	—	—
	16	Herzberg	61.9	39	32.2%	76.3%	—	—	—	—	—	—	6.9	5.9	—	—
Lichtenberg et al (2012)[25]	17	L'Episcopo	57	58	48.3 points	69.5 points	124	167	117	163	13	24	4.5	—	0.8	2.2
	17	Herzberg	61	51	45.1 points	74.2 points	133	176	113	173	29	23	5.2	—	1.6	1.9
Weening and Willems[35] (2010)	16	Gerber	60	26	32.5 points	50.3 points	79	106	74	106	—	—	—	—	—	—
Lehmann et al[23] (2010)	26	Modified Herzberg	60	24	20 points	56 points	—	—	—	—	—	—	4.7	4.8	1.7	1.8
Nové-Josserand et al[30] (2009)	26	Gerber	55.5	34	50 points	74 points	155	173	—	—	9	16	5.7	5.5	—	—
Iannotti et al[20] (2006)	14	Gerber	—	24	PSS, 40	PSS, 66	100	119	—	—	23	32	—	—	—	—
Current study	67	L'Episcopo or Herzberg	63	54	24 points	68 points	83	144	69	134	24	35	7.9	5.1	1.4	2.1

CS, Constant score; *PSS*, Penn Shoulder Score; *AHI*, acromiohumeral interval; *Pre*, preoperatively; *Post*, postoperatively.

degenerative IPSRCTs. Nevertheless, the differences were not statistically significant.

Preoperative presence of external rotation lag sign

Previous studies have shown that fatty atrophy of the TM with Goutallier grade 3 or 4 results in unfavorable outcomes.[8,30] Costouros et al[8] observed that fatty infiltration was more important than tendon integrity in prognosticating the outcome. Therefore, in our cohort, we examined the presence of an external rotation lag sign of 20° or greater on the preoperative clinical examination. However, only minimal differences in the overall outcome could be observed (average CS of 68 points in patients with an external rotation lag sign vs. 73 points in those without it). An interesting finding was that postoperative external rotation was significantly superior in patients without a preoperative external rotation lag sign (54° vs. 32°, $P = .007$).

Limitations

There are several limitations to this study. As this was a retrospective study, no preceding power analysis was performed and a potential type II error might have occurred where only trends have been identified. In addition, postoperative MRI was not performed to evaluate the healing and integrity of the transferred tendon.

Conclusion

For active young patients with IPSRCTs, to date, only limited treatment options are available. LDT represents a reliable and reproducible treatment option with good clinical midterm to long-term results after surgical treatment. Sex, genesis of the IPSRCT, preoperative presence of an external rotation lag sign, and previous surgical procedures before LDT do not affect the overall clinical outcome.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Abouelela AKH, Abou Elsoud M. Latissimus dorsi transfer for irreparable rotator cuff tears. Egypt Orthop J 2014;49:330. https://doi.org/10.4103/1110-1148.154097

2. Agout C, Berhouet J, Spiry C, Bonnevialle N, Joudet T, Favard L. Functional outcomes after non-operative treatment of irreparable massive rotator cuff tears: prospective multicenter study in 68 patients. Orthop Traumatol Surg Res 2018;104(8 Suppl):S189-92. https://doi.org/10.1016/j.otsr.2018.08.003
3. Aoki M, Okamura K, Fukushima S, Takahashi T, Ogino T. Transfer of latissimus dorsi for irreparable rotator-cuff tears. J Bone Joint Surg Br 1996;78:761-6.
4. Buijze G, Keereweer S, Jennings G, Vorster W, Debeer J. Musculotendinous transfer as a treatment option for irreparable posterosuperior rotator cuff tears: teres major or latissimus dorsi? Clin Anat 2007;20:919-23. https://doi.org/10.1002/ca.20547
5. Burks RT, Crim J, Brown N, Fink B, Greis PE. A prospective randomized clinical trial comparing arthroscopic single- and double-row rotator cuff repair: magnetic resonance imaging and early clinical evaluation. Am J Sports Med 2009;37:674-82. https://doi.org/10.1177/0363546508328115
6. Castricini R, Longo UG, De Benedetto M, Loppini M, Zini R, Maffulli N, et al. Arthroscopic-assisted latissimus dorsi transfer for the management of irreparable rotator cuff tears. J Bone Joint Surg Am 2014;96:e119. https://doi.org/10.2106/JBJS.L.01091
7. Cole BJ, McCarty LP 3rd, Kang RW, Alford W, Lewis PB, Hayden JK. Arthroscopic rotator cuff repair: prospective functional outcome and repair integrity at minimum 2-year follow-up. J Shoulder Elbow Surg 2007;16:579-85. https://doi.org/10.1016/j.jse.2006.12.011
8. Costouros JG, Espinosa N, Schmid MR, Gerber C. Teres minor integrity predicts outcome of latissimus dorsi tendon transfer for irreparable rotator cuff tears. J Shoulder Elbow Surg 2007;16:727-34. https://doi.org/10.1016/j.jse.2007.02.128
9. El-Azab HM, Rott O, Irlenbusch U. Long-term follow-up after latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears. J Bone Joint Surg Am 2015;97:462-9. https://doi.org/10.2106/JBJS.M.00235
10. Gerber C. Latissimus dorsi transfer for the treatment of irreparable tears of the rotator cuff. Clin Orthop Relat Res 1992;275:152-60.
11. Gerber C, Rahm SA, Catanzaro S, Farshad M, Moor BK. Latissimus dorsi tendon transfer for treatment of irreparable posterosuperior rotator cuff tears: long-term results at a minimum follow-up of ten years. J Bone Joint Surg Am 2013;95:1920-6. https://doi.org/10.2106/JBJS.M.00122
12. Gerber C, Vinh TS, Hertel R, Hess CW. Latissimus dorsi transfer for the treatment of massive tears of the rotator cuff. A preliminary report. Clin Orthop Relat Res 1988;(232)::51-61.
13. Gilbert A, Tassin JL. Réparation chirurgicale du plexus brachial dans la paralysie obstétricale. [Surgical repair of the brachial plexus in obstetric paralysis]. Chirurgie 1984;110:70-5 [in French].
14. Grimberg J, Kany J. Latissimus dorsi tendon transfer for irreparable postero-superior cuff tears: current concepts, indications, and recent advances. Curr Rev Musculoskelet Med 2014;7:22-32. https://doi.org/10.1007/s12178-013-9196-5
15. Habermeyer P, Magosch P, Rudolph T, Lichtenberg S, Liem D. Transfer of the tendon of latissimus dorsi for the treatment of massive tears of the rotator cuff. J Bone Joint Surg Br 2006;88-B:208-12. https://doi.org/10.1302/0301-620X.88B2.16830
16. Hamada K, Fukuda H, Mikasa M, Kobayashi Y. Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop Relat Res 1990;(254)::92-6.
17. Hartzler RU, Steen BM, Hussey MM, Cusick MC, Cottrell BJ, Clark RE, et al. Reverse shoulder arthroplasty for massive rotator cuff tear: risk factors for poor functional improvement. J Shoulder Elbow Surg 2015;24:1698-706. https://doi.org/10.1016/j.jse.2015.04.015
18. Henry PDG, Dwyer T, McKee MD, Schemitsch EH. Latissimus dorsi tendon transfer for irreparable tears of the rotator cuff: an anatomical study to assess the neurovascular hazards and ways of improving tendon excursion. Bone Joint J 2013;95-B:517-22. https://doi.org/10.1302/0301-620X.95B4.30839
19. Herzberg G, Urien JP, Dimnet J. Potential excursion and relative tension of muscles in the shoulder girdle: relevance to tendon transfers. J Shoulder Elbow Surg 1999;8:430-7.
20. Iannotti JP, Hennigan S, Herzog R, Kella S, Kelley M, Leggin B, et al. Latissimus dorsi tendon transfer for irreparable posterosuperior rotator cuff tears: factors affecting outcome. J Bone Joint Surg Am 2006;88:342-8. https://doi.org/10.2106/JBJS.D.02996
21. Irlenbusch U, Bracht M, Gansen H-K, Lorenz U, Thiel J. Latissimus dorsi transfer for irreparable rotator cuff tears: a longitudinal study. J Shoulder Elbow Surg 2008;17:527-34. https://doi.org/10.1016/j.jse.2007.11.022
22. Lapner PLC, Sabri E, Rakhra K, McRae S, Leiter J, Bell K, et al. A multicenter randomized controlled trial comparing single-row with double-row fixation in arthroscopic rotator cuff repair. J Bone Joint Surg Am 2012;94:1249-57. https://doi.org/10.2106/JBJS.K.00999
23. Lehmann LJ, Mauerman E, Strube T, Laibacher K, Scharf HP. Modified minimally invasive latissimus dorsi transfer in the treatment of massive rotator cuff tears: a two-year follow-up of 26 consecutive patients. Int Orthop 2010;34:377-83. https://doi.org/10.1007/s00264-009-0782-5
24. L'Episcopo J. Tendon transplantation in obstetrical paralysis. Am J Surg 1934;25:122-5.
25. Lichtenberg S, Magosch P, Habermeyer P. Are there advantages of the combined latissimus-dorsi transfer according to L'Episcopo compared to the isolated latissimus-dorsi transfer according to Herzberg after a mean follow-up of 6 years? A matched-pair analysis. J Shoulder Elb Surg 2012;21:1499-507. https://doi.org/10.1016/j.jse.2012.01.002
26. Levy O, Mullett H, Roberts S, Copeland S. The role of anterior deltoid reeducation in patients with massive irreparable degenerative rotator cuff tears. J Shoulder Elbow Surg 2008;17:863-70. https://doi.org/10.1016/j.jse.2008.04.005
27. Millett PJ, Warth RJ, Dornan GJ, Lee JT, Spiegl UJ. Clinical and structural outcomes after arthroscopic single-row versus double-row rotator cuff repair: a systematic review and meta-analysis of level I randomized clinical trials. J Shoulder Elbow Surg 2014;23:586-97. https://doi.org/10.1016/j.jse.2013.10.006
28. Moursy M, Forstner R, Koller H, Resch H, Tauber M. Latissimus dorsi tendon transfer for irreparable rotator cuff tears: a modified technique to improve tendon transfer integrity. J Bone Joint Surg Am 2009;91:1924-31. https://doi.org/10.2106/JBJS.H.00515
29. Moursy M, Lehmann LJ. Latissimus dorsi transfer: L'Episcopo versus Herzberg technique. Acta Orthop Belg 2012;78:296-303.
30. Nové-Josserand L, Costa P, Liotard JP, Safar JF, Walch G, Zilber S. Results of latissimus dorsi tendon transfer for irreparable cuff tears. Orthop Traumatol Surg Res 2009;95:108-13. https://doi.org/10.1016/j.otsr.2008.10.002
31. Patte D. Classification of rotator cuff lesions. Clin Orthop Relat Res 1990:81-6.
32. Schoierer O, Herzberg G, Berthonnaud E, Dimnet J, Aswad R, Morin A. Anatomical basis of latissimus dorsi and teres major transfers in rotator cuff tear surgery with particular reference to the neurovascular pedicles. Surg Radiol Anat 2001;23:75-80.
33. Thomazeau H, Rolland Y, Lucas C, Duval JM, Langlais F. Atrophy of the supraspinatus belly. Assessment by MRI in 55 patients with rotator cuff pathology. Acta Orthop Scand 1996;67:264-8.
34. Walch G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. J Shoulder Elbow Surg 2005;14:238-46. https://doi.org/10.1016/j.jse.2004.07.008
35. Weening AA, Willems WJ. Latissimus dorsi transfer for treatment of irreparable rotator cuff tears. Int Orthop 2010;34:1239-44. https://doi.org/10.1007/s00264-010-0970-3
36. Werner CML, Zingg PO, Lie D, Jacob HAC, Gerber C. The biomechanical role of the subscapularis in latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. J Shoulder Elbow Surg 2006;15:736-42. https://doi.org/10.1016/j.jse.2005.11.002
37. Zafra M, Carpintero P, Carrasco C. Latissimus dorsi transfer for the treatment of massive tears of the rotator cuff. Int Orthop 2009;33:457-62. https://doi.org/10.1007/s00264-008-0536-9