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Latissimus dorsi muscle transfer reduces external rotation deficit at the cost of internal rotation in reverse shoulder arthroplasty patients: a cohort study

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Hypothesis: We hypothesized that treatment of rotator cuff arthropathy (RCA) with reverse shoulder arthroplasty (RSA) and an additional latissimus dorsi transfer (LDT) in patients with an active external rotation deficit (ERD) would restore external rotation (ER) with concomitant deterioration in internal rotation.
Methods: In our cohort study, 26 RCA patients with an active ERD (ie, positive lag sign and maximum active ER of 0°) underwent RSA between September 2007 and February 2015; LDT was completed in 13 of these patients. In addition, 88 control patients without ERD who underwent only RSA were identified. Clinical outcomes of strength, range of motion, Constant-Murley score, and Shoulder Pain and Disability Index score, as well as complications, were documented 6, 12, 24, and 60 months postoperatively. We made comparative analyses using statistical mixed models.
Results: The LDT procedure extended the surgical time by 26 minutes ($P = .003$). LDT patients had up to 22° better postoperative active ER than control patients ($P < .001$), although this was accompanied by an internal rotation deficit (77% vs 46% of control patients could not reach the lumbosacral region, $P = .010$). We calculated a 23% risk of local procedure–related complications for RSA patients with an active ERD and LDT.
Conclusion: Patients with RCA and an active ERD seem to benefit from an LDT, although this is accompanied by the potential loss of internal rotation. This additional procedure is associated with an extended surgical time as well as a possible increase in the risk of a complication occurring.
Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Shoulder; arthroplasty; reverse shoulder replacement; latissimus dorsi transfer; shoulder external rotation; functional outcomes

With the advent of reverse shoulder arthroplasty (RSA), poor clinical outcomes previously achieved by hemiarthroplasty[18,27] to treat patients with glenohumeral arthritis and severe rotator cuff deficiencies have greatly improved.[5,19,24] Nonetheless, RSA remains unable to compensate for the decrease in external rotator function.[5,21,22]

Institutional Review Board–Ethics Committee Approval was granted by the following institution: Cantonal Ethics Committee of Zürich, Stampfenbachstrasse 121/Postfach, 8090 Zürich. Approval for analyses of the local clinical register (KEK-ZH No. 2014-0483) was granted on January 23, 2015.

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Patients with stage 3 or 4 fatty infiltration[11] of the infraspinatus and teres minor have significantly lower shoulder function[21]; in particular, a decrease in strength results in shoulder imbalance within the horizontal plane[25] that affects a patient's ability to position his or her arm in space. Loss of external rotation (ER) severely impairs daily activities such as eating and brushing one's teeth or hair. Although good deltoid function can sufficiently prevent pseudoparalysis and restore flexion,[22,26] the deltoid alone is incapable of mechanically reconstituting ER.[5,22,26] Nonoperative treatment of external rotator loss is futile because no other muscle can compensate for the loss of infraspinatus and teres minor function.

A combined latissimus dorsi and teres major tendon transfer using a periosteal flap was first described by L'Episcopo[14] to restore ER in patients with obstetric paralysis. This technique altered the insertion point of the 2 tendons to a lateral and posterior position on the humerus such that the muscles became external as opposed to internal rotators. More recently, 2 different RSA techniques with a combined latissimus dorsi tendon transfer were developed to simultaneously restore elevation and ER.[3,10] The first involves release of the latissimus dorsi tendon through an axillary approach and transfer to the greater tuberosity at the insertion site of the teres minor,[10] whereas the technique of Boileau et al[3] is a modified L'Episcopo single deltopectoral approach that reattaches both tendons at a more inferior point distal and lateral to the original insertion zone of the external rotators on the greater tuberosity.

Several studies examining patients who underwent RSA in combination with transfer of the latissimus dorsi and/or teres minor reported improvements in flexion, ER, and the Constant score at postoperative follow-ups ranging from 12 to 105 months.[4,6,10,15,16,20] However, it is still not known whether the transfer of 2 internal rotators results in the loss of their contribution to internal rotation (IR) and whether their transposition to the greater tuberosity adds an ER force vector to the humeral head; both factors have the potential to work against achieving postoperative active IR, and this aspect is especially important for patients with simultaneous subscapularis deficiency. The expected changes in IR remain underreported, and comparative reports focused on patient outcome after both RSA with latissimus dorsi transfer (LDT) and RSA without LDT are lacking. Therefore, we assessed functional and safety outcomes after a combined RSA and latissimus dorsi–teres minor (LD-TM) transfer using a modified single-incision L'Episcopo technique. Our hypothesis was that restoring ER would result in a deterioration in IR.

Materials and methods

Patient selection

Since 2006, all patients who received a shoulder arthroplasty were prospectively documented in a local registry, including clinical and radiographic evaluation findings preoperatively (ie, baseline) as well as at 6, 12, 24, and 60 months after surgery. From this database, patients who had rotator cuff arthropathy (RCA) and were treated by RSA with the Promos Reverse prosthesis (Smith & Nephew Orthopaedics, Baar, Switzerland) were screened for inclusion in our retrospective study. Among the RCA patients treated with RSA, 2 specific patient groups were identified with an accompanying active external rotation deficit (ERD), which was defined by a positive lag sign and maximum active ER of 0° (ERD groups): The first ERD group included patients treated with an additional LD-TM transfer (ERD-LDT group), and the second ERD group included patients without an LD-TM transfer (ERD-NoLDT group [control group 1]). A third patient group with no accompanying active ER deficit (defined by no positive lag sign and maximum active ER > 0°) and therefore no LD-TM transfer was also selected (NoERD-NoLDT group [control group 2]). All patients were required to have a complete baseline clinical examination and at least 24-month follow-up data from a total 60-month postoperative period (as part of the planned schedule of our clinic registry). Patients were excluded if they were unwilling to provide consent for their clinical data to be used for research purposes.

Surgical technique and postoperative protocol

The Promos Reverse prosthesis was implanted according to manufacturer instructions. A deltopectoral approach was used with patients under general anesthesia in the beach-chair position. Tenotomy or tenodesis of the long head of the biceps was performed in all cases. The remaining subscapularis was tenotomized, and refixation was performed at the end of the procedure, whenever possible. All humeral stems were uncemented and positioned in 5° to 10° of retroversion. The humeral component had a standard neck-shaft angle of 155°. The baseplate was placed flush with the inferior border of the inferior glenoid rim and then secured with a central peg and 2 supplementary screws fitted proximally and distally. The 4-mm inferior eccentric glenosphere is preferred over its concentric counterpart and routinely applied in our clinic to reduce the risk of inferior notching.

An additional LD-TM transfer using a modified single-incision L'Episcopo technique[3] was performed based on both surgeon and patient discretion. After resection of the humeral head and preparation of the humeral prosthetic bed, the pectoralis major tendon was detached and the insertion of the common LD-TM tendon was exposed (Fig. 1, *A*). The common tendon attachment was then detached with small bone chips and loaded with 4 to 5 No. 2 FiberWire sutures (Arthrex Swiss, Belp, Switzerland) using the Mason-Allen technique. The LD-TM complex was distally mobilized, if possible, until palpation of the vascular pedicle on the inner surface of the latissimus dorsi muscle. After palpation (without visualization) of the radial nerve, the humerus was circumvented epiperiosteally at the level of the original LD-TM tendon insertion and the sutures were pulled dorsally from medial to lateral, with care taken to ensure no rotation of the sutures or tendon occurred. Tendon fixation was then achieved slightly lateral and distal to the origin of the teres minor with transosseous sutures (Fig. 1, *B*). The pectoralis major tendon was refixed with 3 to 4 Mason-Allen transosseous sutures. All sutures were first placed in a transosseous manner with tightening and knotting only performed after implantation of the humeral RSA component. The duration of the RSA implantation with or without additional LD-TM transfer was recorded as the time from initial skin incision to skin closure.

The arm was postoperatively immobilized in a shoulder sling with an abduction pillow positioned in 10° of IR for 6 weeks, which

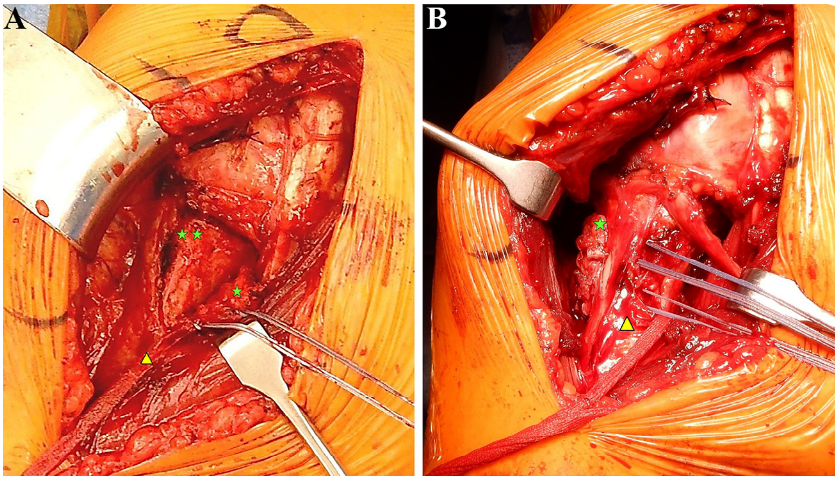

Figure 1 Reverse shoulder arthroplasty patient (right shoulder) highlighting latissimus dorsi–teres major (LD-TM) transfer using modified single-incision L'Episcopo technique. (**A**) Harvesting of LD-TM (*1 star*) with exposed humerus (*2 stars*) and partially detached pectoralis major (*triangle*). (**B**) Transferred LD-TM and refixation with transosseous sutures before tying of knot (*star*) and partially detached pectoralis major (*triangle*) (pictures courtesy of Michael Glanzmann, MD, Schulthess Clinic senior orthopedic consultant).

allowed only passive motion. At week 7 after surgery, patients began active mobilization exercises, followed by progressive strengthening exercises after 3 months.

Clinical assessments

Patients were clinically examined at baseline and 6, 12, 24, and 60 months after the RSA. Patient demographic characteristics (age, sex), baseline general health status (American Society of Anesthesiologists Physical Status classification), shoulder health status (arthropathy according to the classification of Hamada et al,[12] acromiohumeral distance[7]), and surgery details were documented as part of our local registry. Clinical parameters included shoulder range of motion (ROM) (ie, elevation, abduction, ER at 0° of abduction, and IR according to the Apley scratch test), shoulder strength in 90° of abduction and along the scapular plane, and functional outcome indicated by the Constant-Murley score (CMS)[8] and patient-reported Shoulder Pain and Disability Index (SPADI).[2] Local postoperative surgery-related complications and revision operations were documented throughout the follow-up period up to 24 months after surgery. At 24 and 60 months, patients were asked to rate the status of their operated shoulder in comparison with before surgery on a 5-point Likert scale and were asked whether they would agree to undergo the same operation again.

Data management and statistical analysis

Registry data were managed using the REDCap Electronic Data Capture system[13] and exported for statistical analysis using Intercooled Stata 13 software (StataCorp, College Station, TX, USA). Baseline patient demographic, diagnostic, functional, and operative parameters were tabulated separately per group using standard descriptive statistics and compared using clinical judgment to assess differences that could influence the study outcomes. The outcome parameters of ROM, strength, CMS, and SPADI score were also presented per group at baseline, as well as at each examination time point. Comparative analyses were primarily conducted between the ERD groups to assess the effect of the LDT procedure. We used generalized linear mixed models and random-effect logistic regression for continuous and dichotomous outcomes, respectively, to account for repeated measurements at each follow-up examination. In all models, we included the patient age at surgery as well as respective preoperative parameter values. The risk of local shoulder complications was calculated per ERD group along with its 95% confidence interval (CI) and compared by age-adjusted binomial regression. The statistical significance level was set at .05.

Results

Our local shoulder arthroplasty registry included 480 RCA shoulders in 449 patients treated by RSA using a Promos Reverse prosthesis between September 2007 and February 2015. Of the 480 cases, 408 had a documented 24-month follow-up examination (Fig. 2). We identified 26 patients (26 shoulders) with an accompanying active ERD including 13 who underwent additional LD-TM transfer. Postoperative data were also available at 60 months for more than half of the patients in the 3 patient groups at the time of our analysis. Nine patients were not due for the last follow-up. Fifteen patients reported poor general health status and/or declined further examination while reporting a good shoulder condition. In the control groups, 5 patients died after 24 months for unknown reasons (n = 3) or reasons unrelated to the RSA (n = 2).

Patients in the ERD-LDT group were on average 6.5 years younger (95% CI, 1.2-11.8 years) than ERD-NoLDT patients (Table I). The preoperative acromiohumeral distance was similar between the ERD groups and was lower than that in the NoERD-NoLDT group. There was a similar distribution of cranialization and pronounced glenohumeral arthritis (ie, grade 4B or 5 arthropathy) among the 3 patient groups. In addition, no obvious differences in baseline shoulder function were noted, although the ERD-LDT group had about 20° better flexion and abduction than the ERD-NoLDT group.

Table I Baseline patient demographic characteristics and shoulder status per treatment group

Parameter	NoERD-NoLDT (control group 2)		ERD-NoLDT (control group 1)		ERD-LDT		Diff (95% CI)
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	
Age at surgery, yr	88	73.8 (7.7)	13	75.0 (7.5)	13	68.5 (6.3)	−6.5 (−11.8 to −1.2)
Sex, n (%)							
Female	65 (74)		8 (62)		8 (62)		
Male	23 (26)		5 (38)		5 (38)		
ASA classification, n (%)							
I			1 (8)		1 (8)		
II	46 (52)		5 (38)		8 (62)		
III	42 (48)		7 (54)		4 (31)		
Acromiohumeral distance, mm	88	7.8 (4.2)	13	3.9 (3.9)	12*	4.9 (2.8)	1.0 (−1.7 to 3.7)
Arthropathy classification,† n (%)							
Grade 1	52 (59)		4 (31)		3 (23)		
Grade 2	2 (2)		1 (8)		1 (8)		
Grade 3	3 (3)		1 (8)		3 (23)		
Grade 4A	6 (7)		2 (15)				
Grade 4B	7 (8)		3 (23)		6 (46)		
Grade 5	18 (20)		2 (15)				
Flexion, °	88	80.7 (38.1)	13	68.2 (38.0)	13	87.3 (52.0)	19.2 (−15.9 to 54.2)
Abduction, °	88	66.3 (32.2)	13	57.3 (33.6)	13	85.8 (45.2)	28.5 (−2.1 to 59.1)
External rotation in 0° of abduction, °	88	29.3 (15.0)	13	−2.3 (8.3)	13	−11.5 (12.1)	−9.2 (−17.2 to −1.2)
Strength in abduction, kg	88	0.7 (1.8)	13	0.0 (0.0)	13	0.8 (1.3)	0.8 (0.1 to 1.5)
CMS (0, worst; 100, best)	84	31.1 (14.7)	13	31.4 (14.0)	13	36.8 (14.4)	5.5 (−5.5 to 16.4)
SPADI score (0, worst; 100, best)	87	34.6 (17.5)	10	37.6 (20.9)	12	41.6 (21.9)	4.0 (−14.0 to 22.0)

NoERD-NoLDT, no active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-NoLDT*, active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-LDT*, active external rotation deficit and additional latissimus dorsi–teres major transfer performed; *SD*, standard deviation; *Diff*, difference between ERD-NoLDT and ERD-LDT groups; *CI*, confidence interval; *ASA*, American Society of Anesthesiologists Physical Status classification system (in which ASA I indicates normal healthy patient; ASA II, patient with mild systemic disease; and ASA III, patient with severe systemic disease that is not incapacitating); *CMS*, Constant-Murley score; *SPADI*, Shoulder Pain and Disability Index.

* For 1 patient, baseline radiographs were obtained at an external clinic and the acromiohumeral measurement could not be made because of the lack of calibration.

† Arthropathy was classified according to Hamada et al.[12]

Operative details

All arthroplasties with an additional LD-TM transfer were carried out by 1 of 3 senior consultant shoulder surgeons at our clinic with more than 20 years' experience using the same operative procedure, whereas 4 additional consultant shoulder surgeons (with ≥5 years' experience) implanted the RSAs without a muscle transfer. The tenotomized subscapularis tendon was refixed completely in 86 RSAs (76%) and only partially in 23 (20%), with no difference between the 3 patient groups ($P = .454$). In 5 RSAs (4%) (ie, 3 in the NoERD-NoLDT group and 1 in each of the ERD groups), refixation could not be performed. A biceps tenotomy or tenodesis was performed in 37 NoERD-NoLDT patients and in 5 and 7 ERD patients in the NoLDT and LDT groups, respectively. The biceps procedures did not impact the length of surgery ($P = .870$). On the other hand, LDT procedures increased the surgical time by 26 minutes on average (95% CI, 10-41 minutes; $P = .003$) compared with the ERD-NoLDT group. The mean surgery duration was 95 minutes (standard deviation, 21 minutes) for both control groups ($P = .076$). The overall average blood loss was 240 mL (standard deviation, 117 mL), with no significant difference between the 3 groups ($P = .851$).

Clinical follow-up

Baseline flexion, abduction, shoulder strength, CMS, and SPADI score significantly improved throughout the 60-month follow-up period in all patient groups ($P < .001$) (Tables II and III). The LDT procedure was not associated with any significant differences in these ROM and function parameters when compared with the ERD-NoLDT group ($P \geq .125$). However, there was a consistent mean difference of 1.6 to 1.8 kg in shoulder strength between the ERD groups after 12 months postoperatively, which benefited patients with the additional LD-TM transfer. The LDT procedure was associated with a significant improvement in ER in 0° of abduction, which reached an average maximum of 22° at 24 months after surgery and was similar to that in the NoERD-NoLDT group (Fig. 3). A mean ER value of around 0° persisted throughout the entire postoperative period in the ERD-NoLDT group ($P = .411$), which was significantly

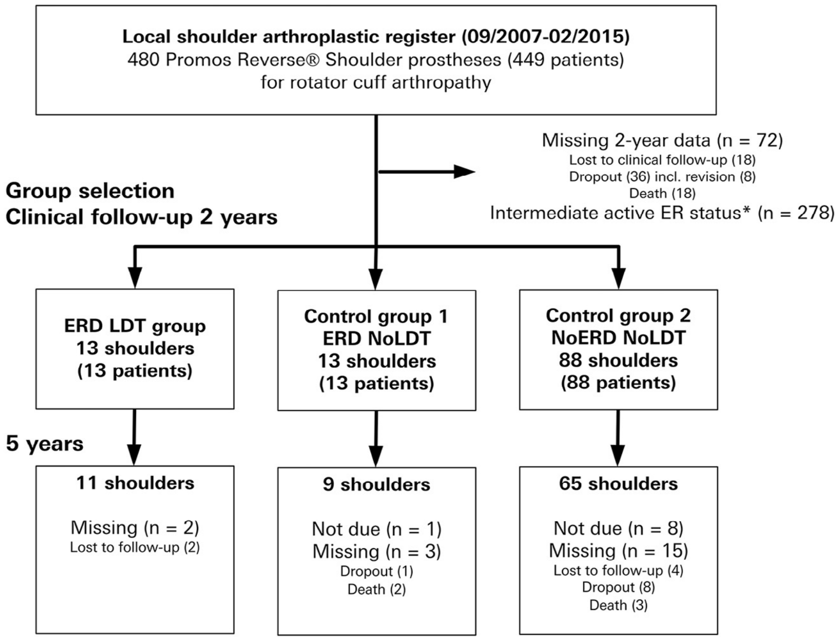

Figure 2 Patient selection flowchart. *ER*, external rotation; *ERD*, external rotation deficit; *LDT*, latissimus dorsi transfer; *NoLDT*, no latissimus dorsi transfer; *NoERD*, no external rotation deficit. *ER status with either positive lag sign or maximum active ER of 0°, but not both.

Table II Range-of-motion parameters per treatment group

Parameter	NoERD-NoLDT (control group 2)		ERD-NoLDT (control group 1)		ERD-LDT		Diff (95% CI)	*P* value	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)		Linear regression	Mixed model
Flexion, °									.134
Baseline	88	81 (38)	13	68 (38)	13	87 (52)	19 (−16 to 54)		
6 mo	86	135 (20)	12	145 (23)	13	125 (23)	−28 (−47 to −8)	—	
12 mo	86	140 (19)	12	138 (19)	13	136 (16)	−7 (−21 to 8)	—	
24 mo	80	139 (19)	13	132 (15)	13	134 (22)	1 (−16 to 17)	—	
60 mo	52	133 (13)	7	133 (15)	10	137 (17)	0 (−17 to 17)	—	
Abduction, °									.573
Baseline	88	66 (32)	13	57 (34)	13	86 (45)	28 (−2 to 59)		
6 mo	86	124 (27)	12	129 (24)	13	129 (28)	−11 (−33 to 12)	—	
12 mo	86	133 (24)	12	124 (22)	13	139 (20)	12 (−8 to 32)	—	
24 mo	80	130 (27)	13	117 (23)	13	129 (26)	14 (−10 to 37)	—	
60 mo	52	126 (27)	7	125 (28)	10	133 (23)	1 (−25 to 27)	—	
External rotation in 0° of abduction, °									<.001
Baseline	88	29 (15)	13	−2 (8)	13	−12 (12)	−9 (−17 to −1)		
6 mo	86	25 (15)	12	1 (6)	13	12 (11)	14 (6 to 23)	.002	
12 mo	86	27 (15)	12	2 (10)	13	18 (12)	17 (6 to 28)	.005	
24 mo	80	27 (15)	13	−4 (10)	13	22 (7)	28 (20 to 36)	<.001	
60 mo	52	27 (12)	7	2 (16)	10	18 (13)	17 (−3 to 38)	.090	

NoERD-NoLDT, no active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-NoLDT*, active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-LDT*, active external rotation deficit and additional latissimus dorsi–teres major transfer performed; *SD*, standard deviation; *Diff*, comparative analysis between ERD-NoLDT and ERD-LDT groups presenting linear regression coefficients (latissimus dorsi–teres major transfer effect) adjusted for respective baseline values and age; *CI*, confidence interval.
Preoperative (baseline) values represent only the differences in group means and their 95% CIs. *P* values indicate linear regression *P* values and overall mixed-model *P* values for latissimus dorsi–teres major transfer effect adjusted for baseline values and age.

Table III Shoulder function parameters per treatment group

Parameter	NoERD-NoLDT (control group 2)		ERD-NoLDT (control group 1)		ERD-LDT		Diff (95% CI)	*P* value, mixed model
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)		
Strength in abduction, kg								.125
Baseline	88	0.7 (1.8)	13	0.0 (0.0)	13	0.8 (1.3)	0.8 (0.1 to 1.5)	
6 mo	84	4.3 (2.0)	11	3.7 (2.5)	13	4.8 (2.4)	0.8 (−1.6 to 3.3)	
12 mo	84	5.2 (2.3)	12	4.1 (2.0)	13	6.2 (2.5)	1.6 (−0.6 to 3.7)	
24 mo	78	5.0 (2.3)	13	3.5 (1.7)	12	5.5 (2.9)	1.7 (−0.5 to 4.0)	
60 mo	52	5.1 (2.4)	7	4.3 (1.5)	10	6.5 (2.5)	1.8 (−0.7 to 4.4)	
CMS (0, worst; 100, best)								.544
Baseline	84	31 (15)	13	31 (14)	13	37 (14)	5 (−5 to 16)	
6 mo	80	66 (12)	11	62 (10)	13	61 (17)	0 (−14 to 13)	
12 mo	78	71 (11)	11	59 (14)	9	73 (8)	13 (1 to 25)	
24 mo	71	68 (13)	12	61 (15)	11	63 (16)	0 (−14 to 14)	
60 mo	40	69 (13)	7	64 (15)	9	67 (15)	1 (−15 to 18)	
SPADI score (0, worst; 100, best)								.605
Baseline	87	35 (18)	10	38 (21)	12	42 (22)	4 (−14 to 22)	
6 mo	81	72 (20)	11	66 (15)	12	66 (15)	−1 (−15 to 13)	
12 mo	80	77 (17)	11	68 (17)	11	74 (13)	6 (−10 to 21)	
24 mo	80	78 (20)	9	71 (24)	10	73 (20)	3 (−22 to 28)	
60 mo	56	84 (18)	8	66 (19)	10	67 (24)	−2 (−27 to 24)	

NoERD-NoLDT, no active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-NoLDT*, active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-LDT*, active external rotation deficit and additional latissimus dorsi–teres major transfer performed; *SD*, standard deviation; *Diff*, comparative analysis between ERD-NoLDT and ERD-LDT groups presenting linear regression coefficients (latissimus dorsi–teres major transfer effect size) adjusted for respective baseline values and age; *CI*, confidence interval; *CMS*, Constant-Murley score; *SPADI*, Shoulder Pain and Disability Index.
Preoperative (baseline) values represent only the differences in group means and their 95% CIs. *P* values indicate overall mixed-model *P* values for latissimus dorsi–teres major transfer effect adjusted for baseline values and age.

different by 28° compared with the ERD-LDT group at 24 months after surgery (95% CI, 20°-36°; *P* < .001). IR improved significantly in both no-LDT control groups (*P* < .001), with up to 83% of patients (5 of 6) in the ERD-NoLDT group being able to reach the lumbosacral junction at 60 months (Fig. 4). In contrast, the proportion in the ERD-LDT group dropped significantly from 92% at baseline (12 of 13) to 38% (5 of 13), 46% (6 of 13), and 60% (5 of 10) at 12, 24, and 60 months, respectively (*P* < .001).

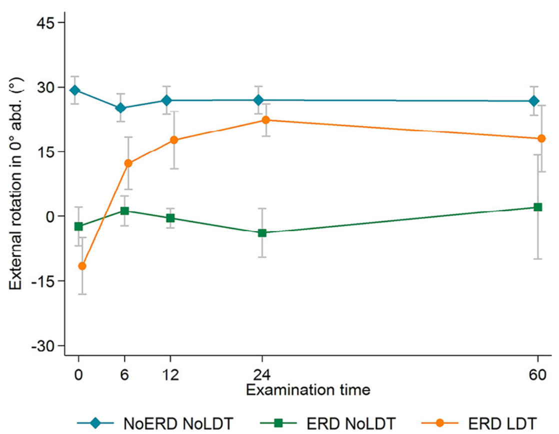

Figure 3 Achievement of external rotation in 0° of abduction (*abd*) per treatment group before and at 6, 12, 24, and 60 months after reverse shoulder arthroplasty. *NoERD*, no external rotation deficit; *NoLDT*, no latissimus dorsi transfer; *ERD*, external rotation deficit; *LDT*, latissimus dorsi transfer.

Local surgery-related complications

No revisions of a prosthetic component were performed up to the last follow-up in any RSA patient included in this study. However, we documented 1 local postoperative surgery-related complication (8% [1 of 13 patients]) in the ERD-NoLDT group and 3 such complications (23%) in 3 ERD-LDT patients (risk ratio, 3; 95% CI, 0.36-25). We documented 10 complications in 9 patients in the NoERD-NoLDT group (10%) (Table IV). Of note, 1 NoERD-NoLDT patient with a scapular spine fracture reported 2 years after RSA had an additional acromial fracture originally documented at 6 weeks after RSA, which showed increasing signs of loosening around the glenoid component at the 24-month follow-up. In the second patient with signs of glenoid loosening, humeral loosening was also documented at the 60-month follow-up owing to grade III scapular notching.

Patient improvement and satisfaction

At both the 24- and 60-month follow-ups, the majority of patients in the LDT and no-LDT groups reported that they felt much better than before surgery and that they would undergo the same operation again (Table V). At 60 months, 2 LDT

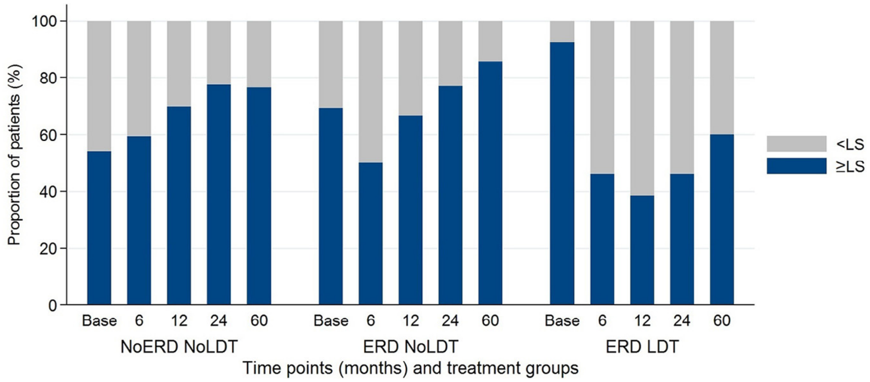

Figure 4 Achievement of internal rotation using Apley scratch test per treatment group before and at 6, 12, 24, and 60 months after reverse shoulder arthroplasty. *LS*, lumbosacral junction; *Base*, baseline; *NoERD*, no external rotation deficit; *NoLDT*, no latissimus dorsi transfer; *ERD*, external rotation deficit; *LDT*, latissimus dorsi transfer.

Table IV Local postoperative surgery-related complications

Complication type	No. of patients with ≥1 complication		
	NoERD-NoLDT	ERD-NoLDT	ERD-LDT
Periprosthetic fracture			1*
Transferred tendon retear			1†
Transient radial palsy			1
Increasing shoulder pain	3‡	1	
Scapular spine fracture	2§		
Glenoid loosening	2		
Superficial wound infection	1‖		
Postoperative hematoma	1¶		
Dysesthesia	1#		

NoERD-NoLDT, no active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-NoLDT*, active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-LDT*, active external rotation deficit and additional latissimus dorsi–teres major transfer performed.

* The patient underwent open reduction–internal fixation for a fracture sustained from a fall at 21 months after index reverse shoulder arthroplasty. This periprosthetic fracture was located distal to the transferred tendon site at the height of the prosthesis tip.

† The patient had a traumatic retear with massive loss of external rotation due to a fall 45 months after index reverse shoulder arthroplasty.

‡ Two patients presented with pain after direct trauma on the shoulder in one and suspected plica impingement in the other.

§ Both non-trauma fractures were treated conservatively.

‖ Infection due to a suture granuloma was treated with wound disinfection and oral antibiotics.

¶ Hematoma led to transient neurologic symptoms that completely resolved before standard hospital discharge.

\# Persistent dysesthesia reported in the ipsilateral hand was believed to be the result of intraoperative plexus irritation by an interscalene perineural catheter.

patients (2 of 10) and 1 patient in the no-LDT group (1 of 8) remained unsure about undergoing the same operation again, even though they reported an improvement in their shoulder. Conversely, 2 other LDT patients reported a worsening of their shoulder condition yet would opt to undergo the same operation again; one of these patients sustained an LDT tear after a fall 45 months after surgery, while the other did not report any local complications.

Discussion

RSA improves pain, flexion, and abduction in patients with cuff tear arthropathy or a rotator cuff tear in combination with pseudoparalysis as long as the deltoid muscle remains functional.[5,9,19,22,26] However, the deltoid muscle alone cannot restore active ER in patients with ruptured or fatty infiltrated infraspinatus and teres minor muscles.[5,21,22] Our analysis of functional and safety outcomes after a combined RSA and LD-TM transfer, as well as our comparison of these results with those of control patients receiving RSA with and without ER deficits, reinforces the validity of previous studies reporting improvements in ER, flexion, and CMS observed after this combined surgical intervention.[4,6,10,15,16,20] We report similar improvements in flexion, abduction, strength in abduction, CMS, and SPADI score for both control and test patients in our study, in which ER in 0° of abduction improved only for LDT patients. Our hypothesis was that restoring ER would result in a deterioration in IR; this was confirmed because IR deteriorated only after LD-TM transfer and did not improve by the final 60-month postoperative follow-up. This outcome may result from a combined tenodesis effect of the transfer and loss of IR force provided by the involved muscles; which effect is stronger is unclear at this time because of a lack of clinical evidence. Our results indicate that the additional LDT increases the risk of patients being unable to actively reach the lumbosacral region after RSA. It is therefore of utmost importance to inform the patient about a possible IR deficit and to check the active IR of the contralateral shoulder during the preoperative clinical examination. In the case of an active IR deficit on the opposite side that does not permit a sufficient apron grip (ie, abduction, retroversion, and internal rotation as if tying an apron at the back), the indication for the additional LD-TM transfer must be critically considered, especially for older patients.

Table V Level of patient satisfaction at 24- and 60-month postoperative time points

	NoERD-NoLDT (control group 2)		ERD-NoLDT (control group 1)		ERD-LDT	
	24 mo	60 mo	24 mo	60 mo	24 mo	60 mo
Status of affected shoulder, n (%)*						
Much better	68 (81)	52 (88)	6 (55)	6 (86)	7 (70)	7 (70)
Somewhat better	11 (13)	6 (10)	4 (36)	1 (14)	2 (20)	1 (10)
Unchanged	4 (5)	0 (0)	1 (9)	0 (0)	0 (0)	0 (0)
A little worse	1 (1)	1 (2)	0 (0)	0 (0)	0 (0)	1 (10)
Much worse	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	1 (10)
Would decide to undergo same operation again, n (%)						
No	2 (2)	1 (2)	1 (9)	0 (0)	0 (0)	0 (0)
Yes	80 (95)	54 (92)	9 (82)	7 (88)	9 (90)	8 (80)
I do not know	2 (2)	4 (7)	1 (9)	1 (13)	1 (10)	2 (20)

NoERD-NoLDT, no active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-NoLDT*, active external rotation deficit and no additional latissimus dorsi–teres major transfer performed; *ERD-LDT*, active external rotation deficit and additional latissimus dorsi–teres major transfer performed.

* Patients were asked, "How are you today compared to before surgery regarding your affected shoulder?"

We used a modified single-incision L'Episcopo technique for this study and found that the approach allowed for good identification and dissection of the LD-TM tendons without stretching the neurovascular unit in any way. Local surgery-related complications in the LDT group were increased compared with our control groups. While we cannot exclude the higher risk of complications for LDT patients, the calculated 23% risk is based on 3 events that included 2 injuries resulting from trauma events. The case of radial palsy resolved completely during the standard hospital stay period; in contrast to the 2-incision technique, no permanent neurologic complications were observed.[16] In our opinion, the neurovascular structures could be safely identified and protected using our chosen technique. Only 1 complication resulting from a trauma occurred in the control groups. Although we had 1 case of a superficial infection, deep infection complications that have been previously reported[16] were absent in our study population.

At our clinic, we routinely implant the humeral component at 5° to 10° of retroversion when using a standard neck-shaft angle of 155°; this is a sensible compromise because more retroversion and less retroversion would impair internal and external shoulder rotation, respectively. In a cadaveric study, lower retroversion of the humeral component improved passive IR.[23] However, such an effect was not observed with active IR in a clinical setting.[1,17] Reduced retroversion of the humeral component or anteversion would also limit ER, which should be improved specifically with the LDT.

The mean operating time in the LDT group was 26 minutes longer than that in the control group without the LD-TM transfer. Puskas et al[16] reported a longer mean duration of 153 minutes (range, 115-280 minutes) for their 2-incision approach. LDT did not increase average blood loss compared with the control groups. Additional procedures such as biceps tenotomy or tenodesis did not prolong the operating time.

The retrospective design of this study is a limitation owing to potential selection bias. Patients receiving the LD-TM transfer procedure were younger and showed slightly better preoperative ROM in flexion and IR. All analyses were therefore adjusted for patient age and shoulder function at baseline. We cannot, however, fully exclude the possibility of confounding bias due to other factors because of the observational nature of our study. The refixation of the subscapularis tendon was important to consider with regard to its potential effect on IR and ER, yet we had very few RSAs without refixation including 1 in each ERD group. Given the rarity of the ERD condition, sample sizes remained small, and therefore, nonsignificant results should be interpreted considering a low analytical power in the group comparisons. Furthermore, while selection was based on the availability of data at 24 months after surgery, the last follow-up examination at 60 months was missing for some patients; the majority, however, reported poor general health status and/or declined further examination while reporting a good shoulder condition. Nonetheless, the results presented at this final time point should be confirmed.

Conclusion

The combined RSA and LD-TM transfer is a surgical option for improving ER deficits and potentially increasing abduction strength. However, IR decreases immediately after surgery, with no significant improvement over a 60-month period. Furthermore, the operating time is prolonged, more extensive rehabilitation is necessary, and the risk of complications may be increased. Even though the loss of ER is very limiting during daily life activities, we believe that the decision for a combined RSA and LD-TM transfer should be tailored to each patient's specific needs. The function of the contralateral upper extremity and especially the degree of IR should be taken into consideration. Long-term results at 60 months and beyond require further evaluation.

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