J Shoulder Elbow Surg (2021) 30, 641–651

ELSEVIER

JOURNAL OF SHOULDER AND ELBOW SURGERY

www.elsevier.com/locate/ymse

Posterior latissimus dorsi transfer for massive irreparable posterosuperior rotator cuff tears: does it work in the elderly population? A comparative study between 2 age groups (≤55 vs. ≥75 years old)

Jean Kany, MD[a,*], Padmanaban Sekakaran, MSc, PT[b], Rajkumar S. Amavarathi, DNB, FRCS[c], Prateek Patil, MS[d], Jean Grimberg, MD[e], Philippe Valenti, MD[f], Jean David Werthel, MD[g]

[a]*Clinique de l'Union, Shoulder Department, Ramsay GDS, Saint Jean, France*
[b]*Sparsh Hospital for Advanced Surgeries, Bangalore, India*
[c]*Division of Arthroscopy and Sports Surgery, Department of Orthopaedics, St John's Medical College and Hospital, Bangalore, India*
[d]*Orthopedics, DNB Orthopedics, FNB Sports Medicine, Clinique de l'Union, Shoulder Department, Ramsay GDS, Saint Jean, France*
[e]*LIRCOS, Clinique Jouvenet, Shoulder Department, Ramsay GDS, Paris, France*
[f]*Clinique Bizet, Shoulder Department, Paris, France*
[g]*Hôpital Ambroise Pare, Shoulder Department, Paris, France*

Hypothesis and/or background: Management of irreparable posterosuperior rotator cuff tears (RCTs) presents a significant challenge to shoulder surgeons. Previous studies on latissimus dorsi transfer (LDT) have demonstrated good to excellent outcomes in younger patients, but this indication is debatable in the elderly. The main objective of this study was to compare the results of LDT in a group of patients aged ≤55 years vs. one of patients aged ≥75 years. We hypothesized that LDT could give equally good results in the elderly as in the younger population.
Methods: Between 2014 and 2017, a total of 153 patients who underwent LDT either for irreparable posterosuperior RCT or for failed prior repair were enrolled. All LDTs were performed by a single surgeon, were arthroscopically assisted, and fixed onto the humeral head with 2 anchors. A retrospective comparative clinical study was conducted. Patients with a minimum of 24 months of follow-up were divided into 2 groups: group A (≤55 years old at surgery) and group B (≥75 years old at surgery). The age-adjusted Constant-Murley score (aCMS), Subjective Score Value (SSV), Simple Shoulder Test (SST), Activities of Daily Living requiring active External Rotation (ADLER) score, visual analog scale for pain (VAS), American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score, patient's satisfaction, and rate of LD tendon rupture at last follow-up were compared.
Results: A total of 66 patients met inclusion criteria. Four in 66 patients (6%) were lost to follow-up. There were 31 patients in group A and 31 patients in group B. The mean age was 52 and 77 years for the respective groups. Preoperatively, the 2 groups were comparable

The Institutional Review Board of Clinique de l'Union approved this study.

*Reprint requests: Jean Kany, MD, Clinique de l'Union, Ramsay GDS, 31240 Saint Jean, France.
E-mail address: jean.kany@clinique-union.fr (J. Kany).

https://doi.org/10.1016/j.jse.2020.06.018

with respect to other characteristics like the mean number of ruptured tendons, mean preoperative Hamada stage, mean SST, and mean aCMS. The mean follow-up was 33 and 31 months, respectively. At last follow-up, there was no significant difference in the scores evaluated between groups A and B with SSV (61 vs. 66.7 points), ADLER (23 vs. 26.4 points), VAS (2.8 vs. 2.2 points), and ASES (64.4 vs. 72.4 points), respectively, except for the aCMS (75 vs. 96.3; ±001) and the SST (6.2 vs. 8.3; $P < .001$). Patient's satisfaction was not significantly different in both groups (81% of either satisfied or very satisfied patients in both groups). The rate of LD tendon rupture was higher in group A: 10 (33%) vs. 8 (26%).

Conclusion: Posterior transfer of latissimus dorsi tendon could be an effective surgical option for the treatment of massive irreparable posterosuperior cuff tears in patients ≥75 years of age.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Latissimus dorsi transfer; elderly; irreparable cuff tear; arthroscopy-assisted; massive cuff tear; posterosuperior tendon transfer

The management of rotator cuff tears (RCTs) presents a significant challenge to shoulder surgeons. RCT can happen after major traumatic injury to the shoulder in young patients. However, most RCTs occur in the older population because of degenerative changes in the tendons and muscle bellies.[31,50] The tendons may be severely degenerated, which can lead to a spontaneous tear without any traumatic event. The onset of degeneration can happen early in life and progress very quickly in some patients. The prevalence of RCT at the age of 70 years can range from 35%-40%.[34,50] Standard care of management involves repair of the torn rotator cuff tendons depending on age, symptoms, clinical examination, and anatomic lesions.[16,35] Of the RCTs that are diagnosed, 10%-30% are massive and irreparable.[49] Currently, shoulder surgeons have different treatment options for the massive and irreparable cuff tears. These include partial repair, repair with medialization, superior capsule reconstruction, muscle transfers, graft jacket reconstruction, subacromial balloon spacer, and reverse shoulder arthroplasty (RSA).[7,8,19,21,33,43] Overall, RSA is considered as one of the most effective and reliable procedures in the elderly.[15,37,44] This might be true considering the current available evidence, but RSA has its own drawbacks: it is an artificial prosthesis with limited life span, a salvage nonanatomic procedure with complication rates up to 50% leading to possible severe consequences. Moreover, RSA alone has not been successful in restoring rotations at the shoulder joint.[7] Finally, with the increasing life span of populations around the world,[32] the average number of years spent by an individual with an RCT and disability is on the rise. Apart from the medical aspects, the other important consideration to be taken into account is the cost factor.[3,11,40] Hence, there is a need to develop alternative procedures already known to match the needs of the patients and for optimum outcomes.

One of the most promising procedures available for the treatment of massive irreparable RCT is tendon transfer. Latissimus dorsi (LD) tendon has been shown to give satisfactory outcomes when transferred posteriorly for irreparable posterosuperior tears.[17-19] Several studies have reported favorable outcomes for this transfer in the last decade, but these focus mainly on younger patients.[2,14,39] LD transfer (LDT) has the advantage of restoring elevation and external rotation at the shoulder compared to a sole RSA except in case of pseudoparalytic shoulder.[5] Previous studies on LD have demonstrated good to excellent outcomes in younger patients, especially the ones where the transferred tendon healed successfully and where the function of the subscapularis is preserved,[27] but this technique is still debatable in the elderly as it is considered as a demanding and invasive procedure. On the contrary, tendon transfers have revolutionized the treatment of nonrecovering nerve palsies in the upper limb such as radial nerve palsy without any age limit.[1,42]

The main objective of this study was to document, analyze, and compare the results of LDT for massive and irreparable posterosuperior RCT in a group of patients aged ≤55 years vs. one of patients aged ≥75 years. We put forward a hypothesis that posterior LDT can be an effective procedure for massive irreparable cuff tears in the elderly.

Materials and methods

Study population

Between January 2014 and December 2017, we conducted a retrospective single-institute clinical level III study with a single surgeon (J.K.) performing the same surgical procedure. During this time frame, 153 patients underwent arthroscopy-assisted LDT for a massive and irreparable posterosuperior RCT. All patients aged ≤55 years (group A) or ≥75 years (group B) with a minimum of a 24-month follow-up were included in the analysis. Written information forms and signed patient consents were obtained before the surgical procedure.

LDT inclusion and exclusion criteria

Indications for arthroscopy-assisted LDT were persistent pain, after failed conservative treatment or after failure of a previous surgical treatment (including biceps tenotomy, débridement, or an

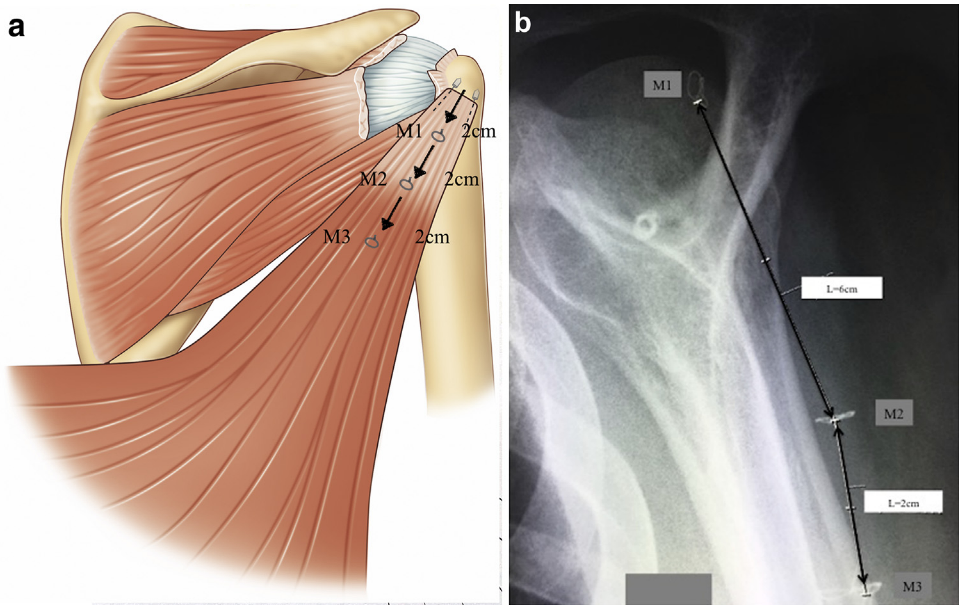

Figure 1 (**a**) After the tenotomy, the tendon is flat and reinserted onto the footprint of the supraspinatus. Three metallic markers are placed into the tendon every 2 cm from the tip. (**b**) Ruptured tendon transfer: radiograph 3 months postoperatively. The distance between the metallic markers M2 and M3 is the same as it was immediately postoperatively, but the distance between M1 and M3 increased from 2 cm to 6 cm. This is a proximal rupture of the tendon.

attempt at partial or complete repair); 2 ruptured tendons with at least 1 tendon retracted to the glenoid that could not be pulled to the greater tuberosity after bursal débridement and capsular release; magnetic resonance imaging showing a massive irreparable tear of the posterosuperior rotator cuff with fatty infiltration of grade III or higher according to the Goutallier classification[22] on at least 1 of the 2 torn tendons; and a minimum follow-up of 24 months.

Patients were not eligible for this procedure if they had associated irreparable tear of the subscapularis; cuff tear arthropathy with glenohumeral arthritis stage IV or V according to Hamada classification[24]; associated complete and permanent axillary nerve palsy; a pseudo-paralytic shoulder[9] (active forward flexion [FF] $<45°$ despite 3 months of physiotherapy); and a stiff shoulder (limitation of passive range of motion despite 3 months of physiotherapy).

Surgical technique

Patients were operated on following a surgical technique described by Kany et al.[28] All surgeries were performed in the beach chair position under general anesthesia and an interscalene nerve block. A 5-cm incision was performed along the anterior (axillary) border of the scapula. The LD (the first visible muscle) was separated from the muscle belly of the teres major, and its neurovascular bundle was identified. Once the muscle belly had been released from its surrounding structures, the aponeurotic band leading to the LD tendon was identified and carefully followed until its humeral insertion. The LD tendon was then cut on its axillary attachments and detached from the humerus. The tendon was left flat and 3 metal clips (Suturpack 2/0; Ethicon, Somerville, NJ, USA) were placed systematically inside at a fixed distance of 2 cm (M1), 4 cm (M2), and 6 cm (M3) from the tendon tip as described previously[27] (Fig. 1, *a*). The subcutaneous space was then released under the posterior deltoid and behind the long head of the triceps using blunt scissors from the insertion site of the LD to the subacromial space to prepare the most direct route for the transfer. Arthroscopic débridement of the subacromial space was performed and the long head of the biceps, when present, was tenodesed with an anchor into its groove. The subscapularis was repaired at the same time in case of combined partial lesion. The plane between the teres minor, when intact, and the deltoid was developed to allow the passage of the transfer. The free sutures of the flat LD tendon were retrieved through this newly created space under arthroscopic visualization. Fixation was achieved using 2 knotless anchors (Versalok; DePuy Mitek, Raynham, MA, USA) implanted close to the upper part of the bicipital groove and a third absorbable 5.5-mm anchor (ArthroVfix; Vims Inc., Toulouse, France) implanted at the junction between the footprints of the supra- and infraspinatus to enhance compression of the flat tendon. At the end of the procedure, the first metallic marker was located 2 cm distally from the Versalok anchors, that is, at the junction between the insertion of the supra- and infraspinatus (Fig. 1, *a*). We did not perform any additional posterior partial repair of the remaining cuff.

Postoperative care

Patients were placed in a 30° abduction and a neutral-rotation sling for 6 weeks. Pendulum exercises were recommended immediately after the surgery. At 6 weeks, the sling was removed and passive full range of motion was authorized. Patients were allowed to begin active assisted range of motion exercises in every direction for a minimum of 3 months associated with bio-feedback exercises to stimulate the transfer.

Outcome measures

Preoperative age-adjusted Constant-Murley score (aCMS)[13] and Subjective Shoulder Value (SSV)[20] were collected from patients' records. All patients underwent a preoperative and postoperative radiologic evaluation of the shoulder with assessment of the subacromial distance (SAD) and the grade of glenohumeral arthritis according to the Hamada classification[24] on standard true anteroposterior radiographs in neutral rotation. All patients underwent either a preoperative CT arthrogram or magnetic resonance imaging to assess tendon retraction according to Patte[38]; fatty infiltration of the subscapularis, supraspinatus, infraspinatus, and teres minor according to Goutallier et al[22]; and the number of involved tendons according to Collin classification.[12]

Postoperative pain, function, and physical findings were assessed using the aCMS,[13] the SSV,[20] the Simple Shoulder Test (SST),[45] the Activities of Daily Living requiring active External Rotation (ADLER) score,[5] and the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score.[41] Subjective satisfaction was assessed by self-questionnaire before and after surgery and divided into 4 categories to assign a rating of very satisfied, satisfied, disappointed, or unsatisfied. Anatomic integrity of the transferred tendon was analyzed on plain radiographs thanks to the metallic markers implanted into the transferred tendon at fixed intervals. As previously reported, an increased distance (up to 2 cm) between 2 metallic markers meant rupture of the transferred tendon[27] (Fig. 1, *b*). When none of the 3 markers had migrated by at least 2 cm, the transfer was considered to be intact. Finally, an electromyographic (EMG) study using needle electrodes was carried out to demonstrate contractions of the LDT with both active forward flexion and active external rotation at the side (ER1).

Statistical analysis

The primary objective of the study was to find out if the outcomes of the surgery were different between the 2 age groups. A between-group comparison of postoperative outcomes was performed as the primary statistical analysis. In addition, a within-group comparison of the preoperative vs. postoperative outcome measures were also done to establish if both groups improved postoperatively. *t* tests and Wilcoxon signed-rank tests were used to test the statistical significance of this comparison.

As a secondary objective, regression analysis was done to understand if the postoperative outcomes were predicted by the age of the patients. Regression analyses also included other preoperative factors, including patient characteristics (sex, smoking, type of work, compensation) and injury characteristics (number of involved tendons, infraspinatus fatty infiltration, subscapularis repair, SAD, Hamada stage, and Collin classification). As a secondary analysis, relative risk and odds ratio were calculated for all the preoperative factors, especially age, to understand their influence on patient satisfaction; a chi-square test was performed to understand the statistical significance of the relationship.

A statistical significance level was set at .05, and all the analysis were performed by an independent statistician not involved in the documentation of outcomes. The statistical software package SPSS, version 20.0 (IBM, Armonk, NY, USA), was used for the statistical analysis.

Results

Demographic and perioperative results

Sixty-six patients met the inclusion criteria (global series; see Table I). Four patients were lost to follow-up (6%) after 1 year and were excluded, which meant that 62 patients with complete follow-up were available for the study. One patient died 3 years after the surgery from an independent cause and was kept for the study. The mean follow-up period was 32 months (range 24-69 months). There were 35 male and 27 female patients, with a mean age of 64 years at the time of surgery (range 43-83 years). The dominant arm was involved in 55 cases. The mean duration of symptoms before the surgical procedures was 24 months (range 3-108 months). For 27 patients, the LDT was the first surgical procedure. Thirty-five patients had already undergone 1 or more previous operations including arthroscopic cuff repair (27 patients) and open cuff repair (8 patients). In 47 patients, 2 tendons were involved in the tear (supra- and infraspinatus). In 15 patients, 3 tendons were involved in the tear, among which 3 subscapularis tears were considered significant enough to be repaired, which was done during the procedure. Therefore, there were 3 patients at Collin stage C (supraspinatus, infraspinatus, and upper part of the subscapularis involved), 47 patients at Collin stage D (supra- and infraspinatus involved), and 12 patients at Collin type E (supraspinatus, infraspinatus, and teres minor involved), with 3 Hornblower signs. The mean fatty infiltration stage of the supraspinatus was 3.7 (range 3-4), the mean fatty infiltration stage of the infraspinatus was 3.5 (range 2-4), and the mean fatty infiltration stage of the subscapularis was 0.4 (range 0-2).

Entire group

The aCMS improved significantly from a mean of 41 $\pm$ 11.3 preoperatively to 86 $\pm$ 25.8 postoperatively ($P <.001$) with all the parameters of the Constant score also improving significantly ($P =.001$) (Table II). The SSV improved significantly from a mean of 23% $\pm$ 9.7% preoperatively to 64% $\pm$ 23.9% postoperatively ($P =.001$). The preoperative and postoperative data on range of motion and strength are detailed in Table II. Fifty patients (81%) were satisfied or very satisfied with the surgical procedure and 12 (19%) were disappointed or unsatisfied. There were 18 ruptured transfers (29%). EMG studies revealed active and normal contractions of the LDT in both FF and ER1 in 24 cases (39%); active and normal contractions in FF but weak in ER1 in 18 cases (28%); active but weak

Table I Patient demographics

Patient characteristics	No. of patients (n=62)
Work style	
Sedentary	23
Manual work	39
Previous surgery	
No	27
Once	31
Twice	3
3 times	1
Management of LHB	
LHB absent (previous surgery)	34
LHB tenotomy/ tenodesis	28
Workers' compensation	
Yes	18
No	44
Type of previous surgery	
Open cuff repair	8
Arthroscopic cuff repair	27
Collin classification	
Type C	3
Type D	47
Type E	12

LHB, long head of the biceps.

contractions in both FF and ER1 in 16 cases (27%); no contractions at all in 4 cases (6%).

Risk factors of poorer outcome

Baseline characteristics were analyzed as potential predictor risk factors of poorer outcome. Univariate odds ratio and relative risks were calculated for patient satisfaction and preoperative subject and clinical characteristics (Table III). With odds ratio greater than 1, both groups of patients, ≤55 and ≥75 years old, reported greater satisfaction levels at the last follow-up. Patient satisfaction was also better when the number of involved tendons was less than 3 (but more than 1), when the SAD was less than 6 mm, when the infraspinatus fatty infiltration was less than Goutallier stage 3, and when the rupture was Collin type D (supra- and infraspinatus involved but normal teres minor). Poor satisfaction was reported in patients with previous surgery and/ or subscapularis repair. However, none of those factors were found to statistically have significant influence. We did not find any statistical result regarding smoking status because their proportions in the 2 groups were different and quite small. Although those results can be found to be clinically significant, we could not obtain a statistical significance for all the parameters owing to variability in sample size for each parameter.

A simple linear regression was undertaken to understand if age predicted the postoperative outcomes in all the patients who underwent surgery (entire group). The regression analysis revealed a statistically significant model for age and the analyzed outcome measures ($R^2 = 0.67$, $F[11, 25] = 4.75$, $P = .001$). Individual analysis of the outcome measures revealed that age predicted the aCMS score $B = 0.76$ (95% CI 0.44-1.0, $P = .001$) and SST score $B = 2.2$ (95% CI 0.4-4.3, $P = .04$) significantly, with no statistical significance achieved for other outcome measures (Table IV).

Complication and failure rates

There were 10 complications in the global series (16%). Six patients sustained a hematoma localized on the lateral thoracic side that healed uneventfully with nonoperative treatment. Two patients had a superficial infection but did not need any revision surgery. Treatment with oral antibiotics for those 2 cases resulted in very satisfied and intact LDT for one and satisfied but ruptured LDT for the second. One patient had to undergo revision surgery for a deep infection (*Staphylococcus aureus*). Local débridement and intravenous antibiotic therapy followed by oral antibiotics for this infected case resulted in an unsatisfying result (disappointed and ruptured LDT). One patient sustained a fall 1 month after the procedure, leading to an anterosuperior escape of the humeral head with a bad result (disappointed and ruptured LDT), but the patient has had no desire for any revision surgery so far. There were no neurovascular lesions.

Primary outcome (group A vs. group B)

The baseline preoperative characteristics (Table V) were similar across both groups with comparable scores in potential predictors of surgical outcomes such as the number of ruptured tendons and Hamada stage. There were no significant mean differences in the preoperative aCMS and SSV scores. However, there were more smokers in group A (6;20%) than in group B (1;3.3%).

Group 1: Patients ≤55 years of age. Thirty-one of the 62 patients (50%) with a mean age of 52 years (range, 43-55) at the time of surgery were reviewed at last follow-up (average 33 months, range 24-69). Statistically significant difference in all postoperative outcome measures except for ER1 (mean difference 3.3° ± 18°; $P = .41$) was reported as compared to the preoperative scores. Of those 31 patients, 25 (81%) were satisfied or very satisfied with the surgical procedure. Pre- and postoperative data on scores, range of motion, strength, SAD, and Hamada stage are detailed in Table II. Ten LD tendon ruptures (33%) were observed at the second control postoperatively. Finally, 2 patients underwent revision surgery among those 31 patients ≤55 years of age who turned from a Hamada stage 2 before surgery to a Hamada stage 4 at 24 and 72 months postoperatively. They were revised with a reverse shoulder arthroplasty. Intraoperative findings during these revision surgeries revealed that the tendon was no longer visible in the joint.

Table II Clinical results

Clinical data	Preoperative			Review			P value, preoperative review		
	Global	Group A	Group B	Global	Group A	Group B	Global	Group A	Group B
Constant score	31.1 ± 7.7	32.2 ± 7.5	29.9 ± 7.9	65.3 ± 17.9	64 ± 17.9	66.6 ± 18	<.001*	<.001*	<.001*
Constant subscore									
Pain	0.2 ± 0.9	0.2 ± 0.9	0.2 ± 0.9	12.3 ± 3.2	11.8 ± 3.2	12.9 ± 3.1	.001*	.001*	.001*
Activity	6.7 ± 1.6	6.7 ± 1.5	6.8 ± 1.6	15.2 ± 4.2	14.8 ± 4.2	15.6 ± 4.1	.001*	.001*	.001*
Mobility	22.9 ± 7	23.9 ± 6.9	22 ± 7	32 ± 9.4	31.3 ± 9.7	32.7 ± 9.2	.001*	.001*	.001*
Strength	1.3 ± 1	1.5 ± 1.1	1 ± 0.7	5.6 ± 4.2	5.3 ± 4.2	5.9 ± 4.3	.001*	.001*	.001*
aCMS	40.8 ± 11.3	38.4 ± 9.1	43.1 ± 12.8	85.6 ± 25.9	75 ± 22.4	96.3 ± 25	.001*	.001*	.001*
SSV, %	23 ± 9.7	20.2 ± 6	25.5 ± 11.6	63.8 ± 24	60.9 ± 24.5	66.7 ± 23.6	.001*	.001*	.001*
Active FF, degrees	124.5 ± 34.2	127.4 ± 32.9	121.6 ± 31.8	148 ± 41.5	149 ± 43.3	146.8 ± 40.4	.001*	.004*	.004*
Active abduction, degrees	82.1 ± 42.4	82.7 ± 42.1	81.4 ± 45.4	128 ± 44.5	125.5 ± 48.3	130.3 ± 41	.001*	.001*	.001*
Active ER at side (ER1), degrees	23.9 ± 14.9	25.6 ± 17	22.1 ± 12.5	33 ± 18.5	31.6 ± 18	36.6 ± 14.1	.001*	.410*	.003*
Active IR vertebral level	6.2 ± 1.9	6.2 ± 2.1	6.2 ± 1.8	7.9 ± 2.3	7.6 ± 2.1	8.2 ± 2.4	.001*	.001*	.001*
VAS score	NA			2.5 ± 2.7	2.8 ± 2.2	2.2 ± 2.5	NA		
SST score	NA			7.3 ± 3.4	6.2 ± 3.2	8.3 ± 3.4	NA		
ADLER score	NA			24.7 ± 8.6	22.9 ± 7.8	26.4 ± 9.2	NA		
ASES score	NA			66.6 ± 23	64.4 ± 22.8	72.4 ± 23.1	NA		
Patient satisfaction, n (%)									
Very satisfied	NA			33 (53.2)	14 (45.2)	19 (61.3)	NA		
Satisfied	NA			17 (27.4)	11 (35.5)	6 (19.3)	NA		
Disappointed	NA			7 (11.3)	5 (16.1)	2 (6.5)	NA		
Unsatisfied	NA			5 (8.1)	1 (3.2)	4 (12.9)	NA		
SAD, mm	7.5 ± 2.4	7.4 ± 2.7	7.5 ± 2.2	7.2 ± 2.4	7.4 ± 2.5	7.1 ± 2.3	.001*	.001*	.001*
Hamada stage	1.6 ± 0.6	1.4 ± 0.5	1.7 ± 0.6	2 ± 0.9	1.8 ± 0.8	2 ± 0.8	.001*	.001*	.001*
EMG, n (%)									
Active FF and ER1	NA			24 (39)	11 (36)	13 (42)	NA		
Active FF but weak ER1	NA			18 (28)	11 (36)	7 (23)	NA		
Weak FF and ER1	NA			16 (27)	8 (26)	8 (26)	NA		
Inactive	NA			4 (6)	1 (2)	3 (9)	NA		

aCMS, age-adjusted Constant-Murley score; *SSV*, Subjective Shoulder Value; *FF*, forward flexion; *ER*, external rotation; *IR*, internal rotation; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ADLER*, Activities of Daily Living requiring active External Rotation; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SAD*, subacromial distance; *EMG*, electromyography; *NA*, not applicable.
Unless otherwise noted, values are mean ± standard deviation.
Group A: patients ≤55 years of age (n=31); group B: patients beyond 55 years of age (n=31).
* Statistically significant.

Table III Univariate odds ratios and risk ratio for patient satisfaction

Subject factors	Odds ratio	Risk ratio	95% CI of odds ratio	*P* value
Smoker*	—	—	—	—
SAD <6 mm	2.17	1.6	0.51, 9.1	.23
No. of tendons involved <3	1.75	1.1	0.38, 7.9	.36
IS Goutallier stage <3	1.64	1.29	0.46, 5.8	.32
Collin classification	1.46	1.09	0.33, 6.5	.44
Age ≤ 55 yr	1.3	1.1	0.36, 4.4	.47
Age ≥ 75 yr	1.0	1.0	0.28, 3.5	.62
Male gender	0.90	0.96	0.25, 3.2	.57
Manual worker	0.81	0.93	0.21, 3.0	.52
Hamada stage <2	0.78	0.88	0.46, 1.6	.47
Previous surgery	0.52	0.78	0.14, 2.0	.27
Worker's compensation	0.49	0.62	0.13, 1.8	.23
Subscapularis repair	0.39	0.36	0.04, 2.1	.24

SAD, subacromial distance; *IS*, infraspinatus; *CI*, confidence interval.
Odds ratio less than 1: factor associated with lower patient satisfaction; odds ratio greater than 1: factor associated with higher patient satisfaction.
* Smoker status ratio could not be calculated because their proportionate number was very low.

Table IV Regression analysis model summary age at surgery vs. postoperative outcomes

Postoperative outcome	Beta value	95% CI of Beta	Significance
Constant	−0.44	−0.98, 0.10	.10
SSV	−0.13	−0.41, 0.15	.34
Forward flexion	−0.13	−0.31, 0.06	.18
Abduction	−0.17	−0.36, 0.02	.08
External rotation	0.01	−0.19, 0.22	.90
Internal rotation	−0.53	−2.66, 1.51	.59
VAS score	0.54	−3.39, 4.47	.78
SST score	2.21	0.04, 4.36	.04*
ADLER score	−0.27	−0.80, 0.26	.30
ASES score	−0.02	−0.61, 0.57	.94
aCMS	0.77	0.44, 1.09	.001*

SSV, Subjective Shoulder Value; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ADLER*, Activities of Daily Living requiring active External Rotation; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score; *aCMS*, age-adjusted Constant-Murley score; *CI*, confidence interval.
* Statistically significant.

Group B: Patients ≥75 years of age. Thirty-one of the 62 patients (50%) with a mean age of 77 years (range, 75-83) at the time of surgery were reviewed at last follow-up (average 31 months; range, 24-53). Statistically significant difference was observed in all postoperative outcome measures including ER1 as compared to preoperative scores. Twenty-five patients among those 31 (81%) were satisfied or very satisfied with the surgical procedure. Pre- and postoperative data on range of motion, strength, SAD, and Hamada stage are detailed in Table III. Eight tendon ruptures (26%) were observed at the second control postoperatively. No RSA was performed among those 31 patients ≥75 years of age.

Secondary outcomes: relation between age and clinical outcomes

Within-group comparisons reveal that both group scores significantly improved the aCMS, with group B, the elderly population (53 ± 23.5; P = .001), reporting better improvements from the preoperative levels compared with group A, the younger population (36 ± 17.4; P = .001)

Table V Preoperative group characteristics

	Group A: 31/62 patients (age ≤ 55 yr)	Group B: 31/62 patients (age ≥ 75 yr)
Age at surgery (yr), mean (range)	52 (43-55)	77 (75-83)
Smoking status, n (%)	6 (20)	1 (3)
Involved tendons, n	2.1 ± 0.3	2.2 ± 0.4
Constant score	32.2 ± 7.5	29.9 ± 7.9
Constant subscore		
Pain	0.2 ± 0.9	0.2 ± 0.9
Activity	6.7 ± 1.5	6.8 ± 1.6
Mobility	23.9 ± 6.9	22.0 ± 7.0
Strength	1.5 ± 1.1	1 ± 0.7
aCMS	38.5 ± 9.1	43.1 ± 12.8
Active FF, degrees	127.4 ± 32.9	121.6 ± 31.8
Active abduction, degrees	82.7 ± 42.1	81.4 ± 45.4
Active ER at side (ER1), degrees	25.6 ± 17	22.1 ± 12.5
SSV	20.2 ± 6	25.5 ± 11.6
SAD, mm	7.5 ± 2.7	7.5 ± 2.2
Hamada stage	1.5 ± 0.5	1.7 ± 0.6

aCMS, age-adjusted Constant-Murley score; *FF*, forward flexion; *ER*, external rotation; *SSV*, Subjective Shoulder Value; *SAD*, subacromial distance.
Unless otherwise noted, values are mean ± standard deviation.

(Table II). Analysis of the postoperative aCMS scores revealed statistically significant difference between the 2 groups (21 ± 36.5; $P = .006$) (Table VI). Overall, we found that functional outcome measures for parameters such as mobility, more specifically the ER range of motion, VAS, SST, SSV, ADLER, and ASES scores, were equal for both groups. Nonparametric tests did not reveal any significant differences in the postoperative outcomes for each of the variables of both groups except the SST score.

Discussion

We can confirm our hypothesis: LDT can be as effective in the elderly (≥75 years of age) as in the younger population (≤55 years of age) for the treatment of irreparable posterosuperior RCT. Nevertheless, patients older than 70 years have been considered not to be eligible for such a procedure because of significant muscle weakness, low capacity of healing, and poor ability to activate the transfer.[14,18,25,46] However, these studies have demonstrated good to excellent outcomes in younger patients, especially those for whom the transferred tendon healed successfully.[27] We found only 3 reports that enrolled patients older than 75 years,[23,36,47] but no cut-off age has been defined in those studies. In our series, the functional outcome measures for parameters such as range of motion (and more specifically ER1-ER2 [active external rotation at 90° of abduction]), VAS, SST, SSV, ADLER, ASES, and patient's satisfaction scores were in general equal in both groups.

Tendon transfers have revolutionized the treatment of nonrecovering nerve palsies in the upper limb such as radial nerve palsy at the hand even in the elderly population.[1,42] We have considered that a tendon transfer could work actively in the elderly at the shoulder as it works at the hand and could be proposed in irreparable posterosuperior RCT. Three points have to be highlighted in the elderly group from this study: at first both the age-adjusted Constant-Murley score and the SST are significantly better (96 vs. 75 points; $P = .001$); second, the rate of the transferred tendon rupture is lower (26% vs. 33%); and third, no patient had to be revised to an RSA. Our previous study suggests a strong correlation between the functional scores and the status of the transfer, intact or ruptured, [28] with a better Constant score when the LDT heals. The rate of rupture seems correlated to (1) the type of fixation into (tunneled tendon) or onto "over-the-top" the humeral head and (2) the applied tension on the tendon—the higher the tension, the higher the rate of rupture. A more posterior fixation is now recommended[29] to decrease the rate of rupture. In this series, we fixed the tendon flat onto the humeral head, which could explain our high rate of rupture in both groups (29%). Since 2018, we have been performing a full-arthroscopic LD transfer technique[46] with a more posterior fixation (onto the footprint of the infraspinatus) to improve the rate of tendon healing and is currently being investigated.[30] Finally, a tendon transfer could be a better option than RSA in the elderly population regarding potential drawbacks of a reverse. These include high complication rates, incomplete restoration of satisfactory rotation, and a higher cost. Moreover, a tendon transfer does not cut the bridges to an RSA in case of failure.[48]

Our EMG study shows a dynamic forward flexion effect of the transferred tendon in 42 of the 62 cases (67%), including 20 aged patients, which suggests the LDT not only acts passively with a tenodesis effect but also could act as an active tool for rebalancing humeral head muscular horizontal biodynamics when healed.[8] Thirty-four patients (55%) had a weak EMG with ER1 that could be explained by the fact that the transferred LD has a different line of pull from that of the infraspinatus when the elbow is on the side but similar to that of the teres minor when the arm is abducted. This result confirms publication from Clavert et al, [10] who report electrical activity in abduction and external rotation suggesting that the LDT transfer acts as an active muscle transfer and not only as a muscle tenodesis that covers the humeral head.

Our patients had a higher risk of being less satisfied with their results in case of prior rotator cuff repair (relative risk [RR] 0.78) and/or combined subscapularis repair—Collin type C cuff tear (RR 0.36). Conversely, our patients had a higher chance of being more satisfied with their results in

Table VI Comparison of clinical results between group A and group B

	Group A: 31/62 patients (age ≤ 55 yr)	Group B: 31/62 patients (age ≥ 75 yr)	*P* value: group A vs. B
Follow-up, mo	33 ± 13	31 ± 9.6	NA
Constant score	64 ± 17.9	66.6 ± 18	.56
aCMS	75 ± 22.4	96.3 ± 25	.001*
SSV, %	60.9 ± 24.5	66.7 ± 23.6	.22
Pain	11.8 ± 3.2	12.9 ± 3.1	.18
Activity	14.8 ± 4.2	15.6 ± 4.1	.50
Mobility	31.3 ± 9.7	32.7 ± 9.2	.56
Strength	5.3 ± 4.2	5.9 ± 4.3	.53
Active forward flexion, degrees	149 ± 43.3	146.8 ± 40.4	.84
Active abduction, degrees	125.5 ± 48.3	130.3 ± 41	.68
Active ER1, degrees	31.6 ± 18	36.6 ± 14.1	.56
Active ER2, degrees	41.5 ± 22.7	48.5 ± 22.2	.03*
Active internal rotation (vertebral level)	7.6 ± 2.1	8.2 ± 2.4	.31
VAS score	2.8 ± 2.2	2.2 ± 2.5	.54
SST score	6.2 ± 3.2	8.3 ± 3.4	.001*
ADLER score	22.9 ± 7.8	26.4 ± 9.2	.24
ASES score	64.4 ± 22.8	72.4 ± 23.1	.44
Very satisfied, n (%)	14 (45.2)	19 (61.3)	NA
Unsatisfied, n (%)	1 (3.2)	4 (12.9)	NA
Transfer rupture, n (%)	10 (33)	8 (26)	NA

aCMS, age-adjusted Constant-Murley score; *SSV*, Subjective Shoulder Value; *ER1*, active external rotation at the side; *ER2*, active external rotation at 90° of abduction; *VAS*, visual analog scale; *SST*, Simple Shoulder Test; *ADLER*, Activities of Daily Living requiring active External Rotation; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score; *NA*, not applicable.
Unless otherwise noted, values are mean ± standard deviation.
* Statistically significant

case of SAD less than 6 mm (RR 1.6), infraspinatus fatty infiltration lower than Goutallier stage 3 (RR 1.29), number of involved ruptured tendons fewer than 3, and Collin type D cuff tear (supra- and infraspinatus involved but normal teres minor) (RR 1.09). These data might be helpful to consider elderly patients with large 2-tendon tears, and suggest the LDT may not be indicated in cases where the teres minor is involved (3 tendons). In such cases of extended irreparable posterosuperior cuff tear but without pseudoparalytic shoulder, either a lower trapezius transfer or a L'Episcopo procedure could be a better option. As a result, we have moved and limited our LDT indications to patients with a painful loss of active elevation or painful shoulder as described by Boileau et al[6] with Collin type D. We have turned to the lower trapezius transfer in cases of isolated loss of active external rotation according to Boileau et al,[4] that is, a non pseudo-paralytic shoulder with a positive Hornblower sign, a positive external lag sign, and a Collin type E cuff tear. We still consider that RSA remains the only option to restore active elevation in pseudoparalytic shoulders.[26]

Limitations

There are several limitations to this study, including a short-term follow-up period. However, it has been reported that failures always occur between the first and third months postoperatively without any symptoms,[28] and the results are stable with time[18] without significant clinical worsening. Moreover our study was performed in a single center, without any interobserver reliability assessment. However, the procedures were performed within a short but continuous period of time by a senior shoulder surgeon with significant experience in arthroscopically assisted LDT and the statistical results were analyzed by an independent observer (P.S.).

Conclusion

Posterior transfer of latissimus dorsi is an effective surgical option for the treatment of massive irreparable posterosuperior cuff tears in the elderly (≥75 years of age) and has similar results as in younger patients (≤55 years of age).

Acknowledgments

The authors thank Ramsay-GDS for providing English editing services, and Marie Vigan, MD, for participation in statistical analysis.

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. Altintas AA, Altintas MA, Gazyakan E, Gohla T, Germann G, Sauerbier M. Long-term results and the disabilities of the arm, shoulder, and hand score analysis after modified Brooks and D'Aubigne tendon transfer for radial nerve palsy. J Hand Surg 2009; 34:474-8. https://doi.org/10.1016/j.jhsa.2008.11.012
2. Anastasopoulos PP, Alexiadis G, Spyridonos S, Fandridis E. Latissimus dorsi transfer in posterior irreparable rotator cuff tears. Open Orthop J 2017;11:77-94. https://doi.org/10.2174/1874325001711010077
3. Bachman D, Nyland J, Krupp R. Reverse-total shoulder arthroplasty cost-effectiveness: a quality-adjusted life years comparison with total hip arthroplasty. World J Orthop 2016;7:123-7. https://doi.org/10.5312/wjo.v7.i2.123
4. Boileau P, Baba M, McClelland WB, Thélu CÉ, Trojani C, Bronsard N. Isolated loss of active external rotation: a distinct entity and results of L'Episcopo tendon transfer. J Shoulder Elbow Surg 2018;27:499-509. https://doi.org/10.1016/j.jse.2017.07.008
5. Boileau P, Chuinard C, Roussanne Y, Neyton L, Trojani C. Modified latissimus dorsi and teres major transfer through a single delto-pectoral approach for external rotation deficit of the shoulder: as an isolated procedure or with a reverse arthroplasty. J Shoulder Elbow Surg 2007;16:671-82. https://doi.org/10.1016/j.jse.2007.02.127
6. Boileau P, McClelland WB, Rumian AP. Massive irreparable rotator cuff tears: how to rebalance the cuff-deficient shoulder. Instr Course Lect 2014;63:71-83.
7. Boileau P, Watkinson DJ, Hatzidakis AM, Balg F. Grammont reverse prosthesis: design, rationale, and biomechanics. J Shoulder Elbow Surg 2005;14:147S-61S. https://doi.org/10.1016/j.jse.2004.10.006
8. Burkhart SS, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. Arthroscopy 1994;10:363-70.
9. Burks RT, Tashjian RZ. Should we have a better definition of pseudoparalysis in patients with rotator cuff tears? Arthroscopy 2017;33:2281-3. https://doi.org/10.1016/j.arthro.2017.07.024
10. Clavert P, Arndt J, Daemgen F, Kempf JF. Long-term outcomes of latissimus dorsi transfer for irreparable rotator cuff tears. Int Orthop 2020;44:905-10. https://doi.org/10.1007/s00264-020-04540-x
11. Coe MP, Greiwe RM, Joshi R, Snyder BM, Simpson L, Tosteson AN, et al. The cost-effectiveness of reverse total shoulder arthroplasty compared with hemiarthroplasty for rotator cuff tear arthropathy. J Shoulder Elbow Surg 2012;21:1278-88. https://doi.org/10.1016/j.jse.2011.10.010
12. Collin P, Matsumura N, Lädermann A, Denard PJ, Walch G. Relationship between massive chronic rotator cuff tear pattern and loss of active shoulder range of motion. J Shoulder Elbow Surg 2014;23:1195-202. https://doi.org/10.1016/j.jse.2013.11.019
13. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop 1987;214:160-4.
14. 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
15. Ernstbrunner L, Suter A, Catanzaro S, Rahm S, Gerber C. Reverse total shoulder arthroplasty for massive, irreparable rotator cuff tears before the age of 60 years: long-term results. J Bone Joint Surg Am 2017;99:1721-9. https://doi.org/10.2106/JBJS.17.00095
16. Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. J Bone Joint Surg Am 1998;80:832-40.
17. Gerber C, Maquieira G, Espinosa N. Latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. J Bone Joint Surg Am 2006; 88:113-20. https://doi.org/10.2106/JBJS.E.00282
18. 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
19. 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 1988;232:51-61.
20. Gilbart MK, Gerber C. Comparison of the subjective shoulder value and the Constant score. J Shoulder Elbow Surg 2007;16:717-21. https://doi.org/10.1016/j.jse.2007.02.123
21. Grammont PM, Baulot E. Delta shoulder prosthesis for rotator cuff rupture. Orthopedics 1993;16:65-8.
22. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clin Orthop 1994;304:78-83.
23. Grimberg J, Kany J, Valenti P, Amaravathi R, Ramalingam AT. Arthroscopic-assisted latissimus dorsi tendon transfer for irreparable posterosuperior cuff tears. Arthroscopy 2015;31:599-607.e1. https://doi.org/10.1016/j.arthro.2014.10.005
24. Hamada K, Fukuda H, Mikasa M, Kobayashi Y. Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop Relat Res 1990:92-6.
25. 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
26. Kany J. Tendon transfers in rotator-cuff surgery. Orthop Traumatol Surg Res 2020;106:S43-51. https://doi.org/10.1016/j.otsr.2019.05.023
27. Kany J, Grimberg J, Amaravathi RS, Sekaran P, Scorpie D, Werthel JD. Arthroscopically-assisted latissimus dorsi transfer for irreparable rotator cuff insufficiency: modes of failure and clinical correlation. Arthroscopy 2018;34:1139-50. https://doi.org/10.1016/j.arthro.2017.10.052
28. Kany J, Kumar H, Chang V, Grimberg J, Garret J, Valenti P. Mini invasive axillary approach and arthroscopic humeral head interference screw fixation for latissimus dorsi transfer in massive and irreparable posterosuperior rotator cuff tears. Tech Shoulder Elb Surg 2010;11:8-14.
29. Kany J, Sekaran P, Grimberg J, Amavarathi RS, Valenti P, Elhassan B, et al. Risk of latissimus dorsi tendon rupture after arthroscopic transfer for posterior superior rotator cuff tear: a comparative analysis of 3 humeral head fixation techniques. J Shoulder Elbow Surg 2020;29:282-90. https://doi.org/10.1016/j.jse.2019.06.019
30. Kany J, Selim HA. Combined fully arthroscopic transfer of latissimus dorsi and teres major for treatment of irreparable posterosuperior rotator cuff tears. Arthrosc Tech 2020;9:e147-57. https://doi.org/10.1016/j.eats.2019.09.008
31. Mall NA, Lee AS, Chahal J, Sherman SL, Romeo AA, Verma NN, et al. An evidenced-based examination of the epidemiology and outcomes of traumatic rotator cuff tears. Arthroscopy 2013;29:366-76. https://doi.org/10.1016/j.arthro.2012.06.024
32. Meyer AC, Drefahl S, Ahlbom A, Lambe M, Modig K. Trends in life expectancy: did the gap between the healthy and the ill widen or

close? BMC Med 2020;18:41. https://doi.org/10.1186/s12916-020-01514-z
33. Mihata T, McGarry MH, Pirolo JM, Kinoshita M, Lee TQ. Superior capsule reconstruction to restore superior stability in irreparable rotator cuff tears: a biomechanical cadaveric study. Am J Sports Med 2012;40:2248-55. https://doi.org/10.1177/0363546512456195
34. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: from mass-screening in one village. J Orthop 2013;10:8-12. https://doi.org/10.1016/j.jor.2013.01.008
35. Moosmayer S, Lund G, Seljom US, Haldorsen B, Svege IC, Hennig T, et al. At a 10-year follow-up, tendon repair is superior to physiotherapy in the treatment of small and medium-sized rotator cuff tears. J Bone Joint Surg Am 2019;101:1050-60. https://doi.org/10.2106/JBJS.18.01373
36. 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
37. Mulieri P, Dunning P, Klein S, Pupello D, Frankle M. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. J Bone Joint Surg Am 2010;92:2544-56. https://doi.org/10.2106/JBJS.I.00912
38. Patte D. Classification of rotator cuff lesions. Clin Orthop Relat Res 1990:81-6.
39. Petriccioli D, Bertone C, Marchi G. Recovery of active external rotation and elevation in young active men with irreparable posterosuperior rotator cuff tear using arthroscopically assisted latissimus dorsi transfer. J Shoulder Elbow Surg 2016;25:e265-75. https://doi.org/10.1016/j.jse.2015.12.011
40. Renfree KJ, Hattrup SJ, Chang YH. Cost utility analysis of reverse total shoulder arthroplasty. J Shoulder Elbow Surg 2013;22:1656-61. https://doi.org/10.1016/j.jse.2013.08.002
41. Richards RR, An KN, Bigliani LU, Friedman RJ, Gartsman GM, Gristina AG, et al. A standardized method for the assessment of shoulder function. J Shoulder Elbow Surg 1994;3:347-52.
42. Ropars M, Dréano T, Siret P, Belot N, Langlais F. Long-term results of tendon transfers in radial and posterior interosseous nerve paralysis. J Hand Surg Br 2006;31:502-6. https://doi.org/10.1016/j.jhsb.2006.05.020
43. Savarese E, Romeo R. New solution for massive, irreparable rotator cuff tears: the subacromial ‘‘biodegradable spacer’’. Arthrosc Tech 2012;1:e69-74. https://doi.org/10.1016/j.eats.2012.02.002
44. Sevivas N, Ferreira N, Andrade R, Moreira P, Portugal R, Alves D, et al. Reverse shoulder arthroplasty for irreparable massive rotator cuff tears: a systematic review with meta-analysis and meta-regression. J Shoulder Elbow Surg 2017;26:e265-77. https://doi.org/10.1016/j.jse.2017.03.039
45. Tashjian RZ, Deloach J, Green A, Porucznik CA, Powell AP. Minimal clinically important differences in ASES and simple shoulder test scores after nonoperative treatment of rotator cuff disease. J Bone Joint Surg Am 2010;92:296-303. https://doi.org/10.2106/JBJS.H.01296
46. Valenti P, Kalouche I, Diaz LC, Kaouar A, Kilinc A. Results of latissimus dorsi tendon transfer in primary or salvage reconstruction of irreparable rotator cuff tears. Orthop Traumatol Surg Res 2010;96:133-8. https://doi.org/10.1016/j.rcot.2010.02.018
47. Valenti P, Maqdes A, Werthel JD. Clinical and radiological outcomes after reverse shoulder arthroplasty in patients with failed deltoid or latissimus dorsi transfers. A review of ten cases. Int Orthop 2017;41:2143-8. https://doi.org/10.1007/s00264-017-3520-4
48. Warner JJ. Management of massive irreparable rotator cuff tears: the role of tendon transfer. Instr Course Lect 2001;50:63-71.
49. Warner JJ, Parsons IM. Latissimus dorsi tendon transfer: a comparative analysis of primary and salvage reconstruction of massive, irreparable rotator cuff tears. J Shoulder Elbow Surg 2001;10:514-21.
50. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg 2010;19:116-20. https://doi.org/10.1016/j.jse.2009.04.006