J Shoulder Elbow Surg (2021) 30, 282–289

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Short-term outcomes of arthroscopic partial repair vs. latissimus dorsi tendon transfer in patients with massive and partially repairable rotator cuff tears

Laurent Pascal Baverel, MD[a,*], Nicolas Bonnevialle, MD, PhD[b], Thierry Joudet, MD[c], Philippe Valenti, MD[d], Jean Kany, MD[e], Jean Grimberg, MD[f], Floris van Rooij, MSc[g], Phillipe Collin, MD[a]

[a]*Institut Locomoteur de l'Ouest, Saint-Grégoire, France*
[b]*Chirurgie Orthopédique et Traumatologique, Hôpital Pierre-Paul Riquet, Toulouse, France*
[c]*Clinique du Libournais, Libourne, France*
[d]*Centre de Consultation de la Clinique Bizet, Paris, France*
[e]*Clinique De l'Union, St Jean, France*
[f]*IRCOS (Institut de Recherche en Chirurgie Osseuse et Sportive), Paris, France*
[g]*ReSurg SA, Nyon, Switzerland*

Background: There is limited evidence on clinical outcomes of arthroscopic partial repair (APR) and latissimus dorsi tendon transfer (LDTT) for posterosuperior massive rotator cuff tears (mRCTs). We aimed to compare clinical outcomes of APR and LDTT for partially repairable posterosuperior mRCTs and to determine whether outcomes differ among tears that involve the teres minor.

Methods: We retrieved the records of 112 consecutive patients with mRCTs deemed partially repairable due to fatty infiltration (FI) stage $\geq$3 in one or more rotator cuff muscles. Of the tears, 12 involved the subscapularis, 32 were managed conservatively, 14 were treated by reverse shoulder arthroplasty, and 7 were treated by stand-alone biceps tenotomy. Of the remaining 47 shoulders, 26 underwent APR and 21 underwent LDTT. At a minimum of 12 months, we recorded complications, active forward elevation, external rotation, the Constant-Murley score, American Shoulder and Elbow Surgeons (ASES) score, Subjective Shoulder Value (SSV), and Simple Shoulder Test (SST) score.

Results: No significant differences between the APR and LDTT groups were found in terms of follow-up (23.4 $\pm$ 3.5 months vs. 22.1 $\pm$ 4.1 months, $P = .242$), Constant-Murley score (64.8 $\pm$ 13.7 vs. 58.9 $\pm$ 20.0, $P = .622$), ASES score (78.3 $\pm$ 19.3 vs. 74.4 $\pm$ 14.5, $P = .128$), active forward elevation (158.1° $\pm$ 19.4° vs. 142.8° $\pm$ 49.1°, $P = .698$), or external rotation (33.3° $\pm$ 17.4° vs. 32.2° $\pm$ 20.9°, $P = .752$). By contrast, the APR group had a higher SSV (73.3 $\pm$ 17.5 vs. 59.5 $\pm$ 20.0, $P = .010$), and SST score (8.3 $\pm$ 2.4 vs. 6.4 $\pm$ 3.0, $P = .024$). Univariable analysis revealed that advanced FI of the teres minor compromised Constant-Murley scores ($\beta = -25.8$, $P = .001$) and tended to compromise ASES scores ($\beta = -15.2$, $P = .062$). Multivariable analysis corroborated that advanced FI of the teres minor compromised Constant-Murley scores ($\beta = -26.9$, $P = .001$) and tended to compromise ASES scores ($\beta = -16.5$, $P = .058$).

Institutional review board approval was received from Comité d'Ethique de Toulouse (study no. 04-415).

*Reprint requests: Laurent Pascal Baverel, MD, Rue Saint Jean 22, 1260 Nyon, France.

E-mail address: l.baverel@gmail.com (L.P. Baverel).

https://doi.org/10.1016/j.jse.2020.06.002

Conclusion: Both APR and LDTT granted similar early clinical outcomes for partially repairable posterosuperior mRCTs, regardless whether the teres minor was intact or torn. Advanced FI of the teres minor was the only independent factor associated with outcomes, as it significantly compromised Constant-Murley scores and tended to compromise ASES scores.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Rotator cuff tear; massive and irreparable cuff tear; latissimus dorsi tendon transfer; arthroscopic partial cuff repair; Constant-Murley score; teres minor; Collin classification

Massive rotator cuff tears (mRCTs) are defined as full-thickness lesions of ≥2 tendons and constitute up to 40% of all rotator cuff tears.[17,36] These tears can become irreparable due to degenerative muscle atrophy,[42] due to advanced fatty infiltration (FI),[21] or if tendons can no longer be restored to their anatomic footprints. If left untreated, mRCTs may lead to functional decline and progression of glenohumeral arthritis.[38]

Posterosuperior mRCTs without glenohumeral arthritis can be treated by reverse shoulder arthroplasty (RSA),[13,15] arthroscopic partial repair (APR),[24,28] latissimus dorsi tendon transfer (LDTT),[16,26,34,37] or lower trapezius transfer.[7,14] Although RSA has proved to grant reliable pain relief and functional improvement, it is invasive and complex to revise in cases of component loosening, often caused by impingement or scapular notching.[1,38] Both APR and LDTT provide satisfactory outcomes, with recent studies demonstrating adequate improvements in pain, strength, and function in the long term.[3,6,8,18] Lower trapezius transfer was recently described as a more physiological alternative to LDTT, by virtue of the orientation of its muscle fibers, and demonstrated promising clinical and biomechanical outcomes, albeit at limited follow-up.[7,14] There is, however, no clear consensus regarding the superiority of one procedure over the others for the treatment of irreparable posterosuperior mRCTs.[30,31]

There is limited evidence on the clinical outcomes of APR and LDTT for posterosuperior mRCTs that may not be completely repairable due to advanced FI or tissue degeneration. The purpose of this study was therefore to compare the clinical outcomes of APR and LDTT in patients with partially repairable posterosuperior mRCTs and to determine whether outcomes differ among tears that involve the teres minor (Collin type D vs. type E).[9] The null hypothesis was that the 2 procedures would render similar outcomes regardless whether the teres minor is involved.

Methods

We retrieved the records of a consecutive series of 112 patients with mRCTs deemed to be partially repairable due to stage 3 or 4 FI in one or more rotator cuff muscles. In this comparative multicenter study, all patients were treated between May 2015 and May 2016, by 8 surgeons, and provided informed consent for the use of their data and images for research and publishing purposes.

Of the initial 112 mRCTs, 12 involved the subscapularis tendon and 100 were posterosuperior tears; of the latter, we excluded 32 that had been managed conservatively, 14 treated by RSA, and 7 treated by stand-alone biceps tenotomy. The remaining 47 mRCTs were considered for analysis, of which 26 were treated by APR and 21 were treated by LDTT (Fig. 1). Four surgeons performed APR in all their cases, whereas 3 surgeons performed both APR and LDTT and 1 surgeon performed LDTT in all his cases. The choice of treatment depended on surgeon experience and preferences, as well as patient needs and characteristics, after patients were informed about the invasiveness and risks of each option. To evaluate the presence and extent of tears, FI, and tendon retraction in the subscapularis, supraspinatus, infraspinatus, and teres minor tendons, we assessed 9 patients by computed tomography arthrography, 31 by magnetic resonance imaging, and 7 by both methods. FI was evaluated according to the classification of Goutallier et al,[21] considering stages 0 and 1 "minor" and stages 2 and 3 "advanced."[2,12] Tendon retraction was classified as minor, moderate, or severe according to the classification of Patte.[36]

Surgical procedures

All procedures were performed with patients under general anesthesia with an interscalene block. For APR surgery, patients were operated on in the beach-chair position. All APR procedures were performed using the same technique, with a tenotomy or tenodesis of the long head of the biceps in cases in which the tendon was still present, as well as bursectomy, subacromial decompression, and tuberosity débridement. Intra- and extra-articular releases were performed to help restore tendons to their humeral footprints under low tension, using margin-convergence techniques,[4] cuff medialization, or multiple single-row medial suture anchors. For LDTT surgery, patients were operated on in either the lateral or beach-chair position, with 140° of shoulder forward flexion, slight adduction, and full internal rotation.[23] All LDTT procedures were performed using the same technique, with a tenotomy or tenodesis of the long head of the biceps in cases in which the tendon was still present. The skin was incised along the lateral aspect of the scapula, and the latissimus dorsi tendon was dissected and detached from the humeral insertion and was fixed with nonabsorbable sutures. A humeral tunnel was drilled using arthroscopy from the anterior cortex to the superoposterior aspect of the humeral head. The latissimus dorsi tendon was retrieved inside the joint, pulled inside the tunnel, and fixed with a cortical fixation device on the anterior humeral cortex (Fig. 2).

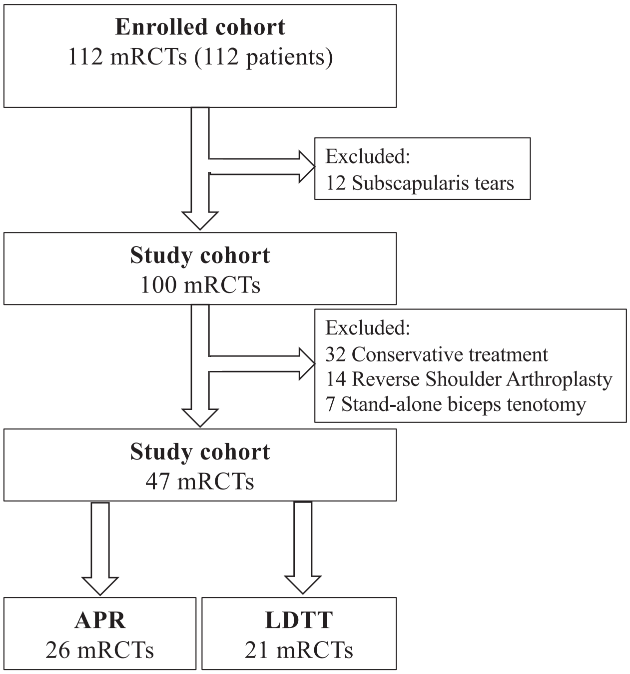

Figure 1 Study flowchart. *mRCTs*, massive rotator cuff tears; *APR*, arthroscopic partial repair; *LDTT*, latissimus dorsi tendon transfer.

Postoperative rehabilitation

All patients followed the same postoperative rehabilitation protocol. The shoulder was immobilized in 60° of abduction and neutral rotation for 6 weeks. Passive mobilization and pendulum exercises were allowed 4 weeks after surgery. A physiotherapy protocol with active-assisted range-of-motion (ROM) exercises was initiated 6 weeks after surgery, focusing on passive and active shoulder ROM and performing daily activities. A strengthening program with resistance exercises was allowed 12 weeks after surgery.

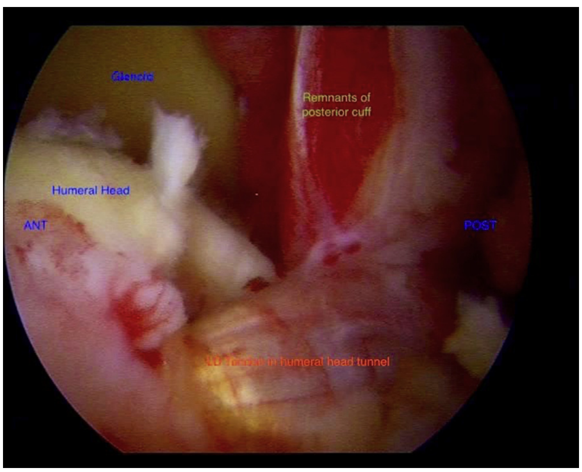

Figure 2 Arthroscopic view of latissimus dorsi *(LD)* tendon transfer fixation technique. *ANT*, anterior; *POST*, posterior.

Clinical evaluation

We retrieved all case notes to collect patient demographic characteristics, complications, active forward elevation, external rotation, and preoperative clinical scores, including the Constant-Murley score,[10] American Shoulder and Elbow Surgeons (ASES) score,[32] Subjective Shoulder Value (SSV),[17] and Simple Shoulder Test (SST) score. We also contacted all patients for postoperative assessment at a minimum follow-up of 12 months using the aforementioned ROM criteria and scores.

Statistical analysis

An a priori sample size calculation to ensure fulfillment of the principal goal of the study indicated that 21 patients per group were needed to determine the significance of the minimal clinically important difference in the Constant-Murley score of 10.4 points,[29] assuming equal standard deviations of 11.3 points,[8] with a statistical power of 0.90. The Shapiro-Wilk test was used to verify normality of distributions. Continuous variables were compared using unpaired *t* tests or Mann-Whitney tests. Categorical variables were compared using χ^2 tests or Fisher exact tests. Univariable and multivariable linear regression analyses were performed to determine associations of the postoperative Constant-Murley and ASES scores with 13 independent variables (age, follow-up, sex, dominant shoulder, smoking, Collin type, surgery type, FI of the supraspinatus, FI of the infraspinatus, FI of the teres minor, retraction of the supraspinatus, retraction of the infraspinatus, and retraction of the teres minor). Statistical analyses were performed using the R program (version 3.5.2; R Foundation for Statistical Computing, Vienna, Austria). $P < .05$ was considered statistically significant.

Results

Demographic characteristics

Of the study cohort of 47 patients, 26 underwent APR and 21 underwent LDTT (Table I). The APR and LDTT groups were similar in terms of age (65.8 ± 9.0 years vs. 65.4 ± 9.5 years, $P = .890$) and proportions of men (46% vs. 52%, $P = .772$), dominant shoulders (85% vs. 71%, $P = .264$), smokers (23% vs. 19%, $P = .735$), and Collin type E tears (23% vs. 52%, $P = .066$).

Clinical outcomes

No revisions were required in either group. There were no complications among patients who underwent APR, whereas among patients who underwent LDTT, 1 axillary hematoma, treated by lavage, occurred. No significant differences were found between the APR and LDTT groups in terms of follow-up (23.4 ± 3.5 months vs. 22.1 ± 4.1 months, $P = .242$), Constant-Murley score (64.8 ± 13.7 vs. 58.9 ± 20.0, $P = .622$), ASES score (78.3 ± 19.3 vs. 74.4 ± 14.5, $P = .128$), active forward elevation (158.1° ± 19.4°

Table I Demographic characteristics and preoperative data

Demographic characteristic	APR (n = 26)		LDTT (n = 21)		*P* value
	Mean ± SD or n (%)	Range	Mean ± SD or n (%)	Range	
Age, yr	65.8 ± 9.0	38-83	65.4 ± 9.5	52-84	.890
Male sex	12 (46)		11 (52)		.772
Dominant shoulder	22 (85)		15 (71)		.264
Smoking	6 (23)		4 (19)		.735
Collin type					.066
D	20 (77)		10 (48)		
E	6 (23)		11 (52)		

APR, arthroscopic partial repair; *LDTT*, latissimus dorsi tendon transfer; *SD*, standard deviation.

Table II Clinical assessment

	APR (n = 26)			LDTT (n = 21)			*P* value
	n	Mean ± SD	Range	n	Mean ± SD	Range	
Follow-up, mo	26	23.4 ± 3.5	16-29	21	22.1 ± 4.1	12-30	.242
Constant-Murley score							
Preoperative	26	36.7 ± 16.6	13-65	21	40.5 ± 10.2	16-54	.342
Postoperative	26	64.8 ± 13.7	34-87	21	58.9 ± 20.0	22-81	.622
Net change	26	28.1 ± 18.5	−7 to 71	21	18.4 ± 18.2	−28 to 41	.079
ASES score							
Preoperative	24	33.5 ± 16.4	10-68	21	37.5 ± 14.7	20-63	.295
Postoperative	26	78.3 ± 19.3	25-98	21	74.4 ± 14.5	45-97	.128
Net change	26	44.1 ± 23.1	5-85	21	37.0 ± 20.3	2-68	.276
SSV							
Preoperative	26	37.5 ± 15.4	10-65	21	34.8 ± 12.6	15-60	.507
Postoperative	26	73.3 ± 17.5	30-100	21	59.5 ± 20.0	15-85	.010*
Net change	26	35.8 ± 23.8	−20 to 75	21	24.8 ± 22.9	−15 to 65	.115
SST score							
Preoperative	23	3.5 ± 2.6	0-9	21	2.6 ± 1.3	0-6	.395
Postoperative	26	8.3 ± 2.4	3-12	21	6.4 ± 3.0	0-11	.024*
Net change	26	5.2 ± 3.3	−2 to 12	21	3.8 ± 2.8	−1 to 8	.294
Active forward elevation, °							
Preoperative	26	137.7 ± 30.5	80-180	21	136.9 ± 19.1	110-170	.915
Postoperative	26	158.1 ± 19.4	80-180	18	142.8 ± 49.1	30-180	.698
Net change	26	20.4 ± 32.3	−40 to 90	21	6.4 ± 49.5	−130 to 70	.201
External rotation, °							
Preoperative	26	29.2 ± 19.4	5-70	21	23.3 ± 24.3	−30 to 60	.372
Postoperative	26	33.3 ± 17.4	−20 to 70	18	32.2 ± 20.9	−20 to 60	.752
Net change	26	4.0 ± 25.3	−80 to 40	21	13.1 ± 15.7	−15 to 50	.379

APR, arthroscopic partial repair; *LDTT*, latissimus dorsi tendon transfer; *SD*, standard deviation; *ASES*, American Shoulder and Elbow Surgeons; *SSV*, Subjective Shoulder Value; *SST*, Simple Shoulder Test.
* Statistically significant ($P < .05$).

vs. 142.8° ± 49.1°, $P = .698$), or external rotation (33.3° ± 17.4° vs. 32.2° ± 20.9°, $P = .752$) (Table II). By contrast, the APR group had a significantly higher SSV (73.3 ± 17.5 vs. 59.5 ± 20.0, $P = .010$) and SST score (8.3 ± 2.4 vs. 6.4 ± 3.0, $P = .024$). It is worth noting, however, that the net changes in the SSV and SST score were not significantly different between the 2 groups.

Postoperative Constant-Murley scores and ASES were not related to the type of tear or treatment despite some differences in preoperative scores (Figs. 3 and 4). Univariable analysis revealed that advanced FI of the teres minor significantly compromised Constant-Murley scores ($\beta = -25.8$, $P = .001$) (Table III) and tended to compromise ASES scores ($\beta = -15.2$, $P = .062$) (Table IV).

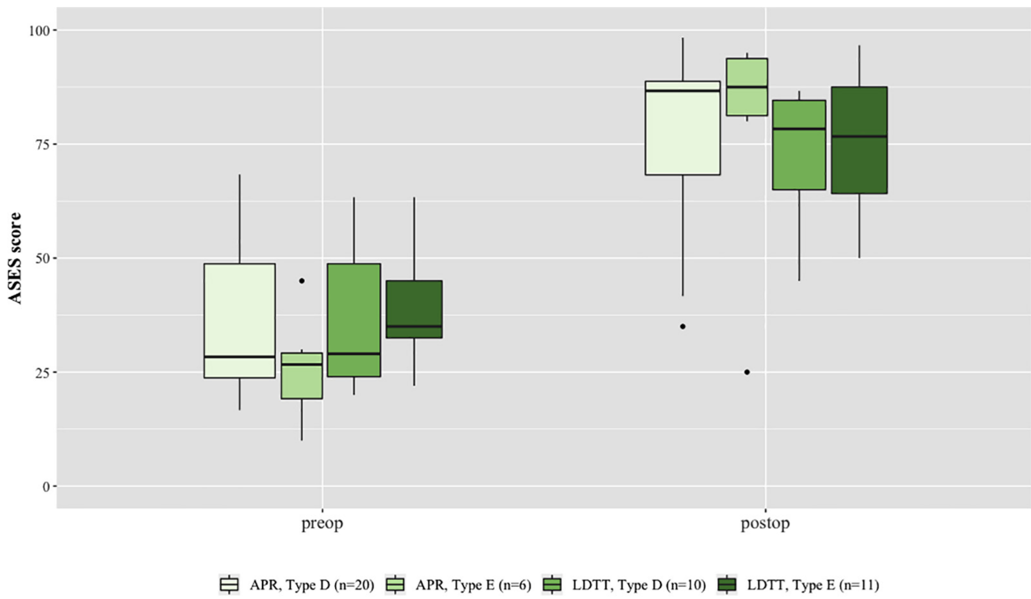

Figure 3 Preoperative *(preop)* and postoperative *(postop)* American Shoulder and Elbow Surgeons *(ASES)* scores divided by surgery and Collin types. *APR*, arthroscopic partial repair; *LDTT*, latissimus dorsi tendon transfer; *horizontal line*, median; *top and bottom of box*, third and first quartiles; *top and bottom of whiskers*, 95% confidence interval; *dots*, outliers.

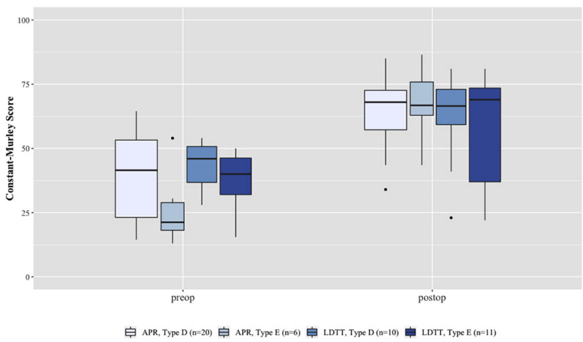

Figure 4 Preoperative *(preop)* and postoperative *(postop)* Constant-Murley scores divided by surgery and Collin types. *APR*, arthroscopic partial repair; *LDTT*, latissimus dorsi tendon transfer.

Multivariable analysis further corroborated that advanced FI of the teres minor significantly compromised Constant-Murley scores ($\beta = -26.9$, $P = .001$) and tended to compromise ASES scores ($\beta = -16.5$, $P = .058$).

Discussion

The most important findings of this study are that, at a minimum follow-up of 12 months, APR and LDTT grant similar clinical outcomes for partially repairable posterosuperior mRCTs, regardless whether the teres minor is intact or torn. These findings confirm the null hypothesis that the 2 procedures render similar outcomes in both Collin type D and type E tears. It is important to note, however, that advanced FI of the teres minor was the only independent factor associated with outcomes, as it significantly compromised Constant-Murley scores and tended to compromise ASES scores.

The literature reports minimal complications at 3 to 5 years following both APR and LDTT.[11,24,28,33] At a mean follow-up of 2 years, our study revealed that only 1 complication was noted in patients who underwent LDTT—an axillary hematoma, successfully treated by lavage—whereas no complications were noted in patients who underwent APR.

Posterosuperior mRCTs without glenohumeral arthritis can be treated by RSA,[13,15] APR,[24,28] LDTT,[16,26,34,37] or lower trapezius transfer.[14] Whereas RSA provides adequate pain relief and functional recovery, the procedure is invasive and challenging in case of revision.[1,38] Both APR and LDTT are less invasive procedures with proven long-term outcomes,[3,6,8,18] although there remains no consensus regarding the superiority of APR or LDTT.[30,31] APR attempts to re-create the force couple of the humeral head and to increase the distance between the acromion and humerus to reduce pain while improving function.[5] LDTT was introduced to treat patients with partially repairable posterosuperior mRCTs and was described to restore active forward elevation and external rotation in patients with sequelae of obstetric brachial plexus palsies.[19] Paribelli et al[35] corroborated this by presenting significantly greater active forward elevation for LDTT compared with APR, with no significant differences in external rotation. However, our study revealed no significant differences in active forward elevation or external rotation in patients treated by LDTT vs. APR. A recent systematic review on the clinical and biomechanical outcomes of lower trapezius transfer proved its safety and efficacy in the short term, but further

Table III Univariable and multivariable regression analyses to identify factors associated with postoperative Constant-Murley scores

	Univariable				Multivariable (n = 47)		
	n	β, points	95% CI	*P* value	β, points	95% CI	*P* value
Age	47	0.1	−0.5 to 0.6	.792			
Follow-up	47	5.4	−4.5 to 15.4	.275			
Female sex	23	−0.5	−1.8 to 0.8	.463			
Dominant shoulder	37	4.7	−8.1 to 17.6	.462			
Smoking	10	5.9	−6.4 to 18.2	.341			
Concomitant TM tear (type E)	17	−5.9	−15.8 to 4.1	.240	4.1	−6.1 to 14.3	.421
LDTT	21	−3.0	−13.4 to 7.4	.565	−5.3	−14.7 to 4.1	.261
FI of SSP: stages 2 and 3	40	1.9	−12.2 to 16.0	.788			
FI of ISP: stages 2 and 3	28	−0.8	−11.0 to 9.5	.882			
FI of TM: stages 2 and 3	5	−25.8	−40.2 to −11.5	.001*	−26.9	−42.1 to −11.7	.001*
Retraction of SSP: severe	25	3.6	−6.4 to 13.6	.474			
Retraction of ISP: severe	20	−0.1	−10.2 to 10.1	.992			
Retraction of TM: severe	1	−18.6	−52.9 to 15.8	.282			

CI, confidence interval; *LDTT*, latissimus dorsi tendon transfer; *FI*, fatty infiltration; *SSP*, supraspinatus; *ISP*, infraspinatus; *TM*, teres minor.
* Statistically significant ($P < .05$).

Table IV Univariable and multivariable regression analyses to identify factors associated with postoperative ASES scores

	Univariable				Multivariable (n = 47)		
	n	β, points	95% CI	*P* value	β, points	95% CI	*P* value
Age	47	0.3	−0.2 to 0.9	.225			
Follow-up	47	2.2	−8.1 to 12.4	.674			
Female sex	23	0.4	−0.9 to 1.8	.532			
Dominant shoulder	37	2.7	−10.5 to 15.8	.684			
Smoking	10	7.4	−5.1 to 19.8	.242			
Concomitant TM tear (type E)	17	−3.9	−14.1 to 6.4	.449	4.1	−7.4 to 15.5	.475
LDTT	21	−0.5	−11.2 to 10.2	.925	−4.0	−14.6 to 6.6	.450
FI of SSP: stages 2 and 3	40	8.5	−5.6 to 22.7	.232			
FI of ISP: stages 2 and 3	28	0.4	−10.1 to 10.8	.946			
FI of TM: stages 2 and 3	5	−15.2	−31.2 to 0.8	.062	−16.5	−33.6 to 0.6	.058
Retraction of SSP: severe	25	4.1	−6.1 to 14.3	.418			
Retraction of ISP: severe	20	0.0	−10.4 to 10.4	.997			
Retraction of TM: severe	1	−8.4	−43.9 to 27.0	.634			

ASES, American Shoulder and Elbow Surgeons; *CI*, confidence interval; *LDTT*, latissimus dorsi tendon transfer; *FI*, fatty infiltration; *SSP*, supraspinatus; *ISP*, infraspinatus; *TM*, teres minor.

comparative studies with longer follow-up are required before the procedure can be more widely adopted, as well as to evaluate the benefits of its greater mobility against the drawbacks of the technical challenges and the need for tendon grafting.[7,14]

Our study revealed a lower Constant-Murley score (58.9 ± 20.0) after LDTT than that in the literature, whereas active forward elevation (142.8° ± 49.1°) and external rotation (32.2° ± 20.9°) were comparable to those in the literature. Gerber et al[18] found LDTT to result in a Constant-Murley score of 64, active forward elevation of 132°, and external rotation of 33°. Castricini et al[6] found LDTT to result in a Constant-Murley score of 70, active forward elevation 160°, and external rotation of 43°. Finally, Yamakado[41] found LDTT to result in active forward elevation of 149° and external rotation of 32°. The clinical outcomes of our study in terms of the Constant-Murley score (64.8 ± 13.7), ASES score (78.3 ± 14.5), active forward elevation (158.1° ± 19.4°) and external rotation (33.3° ± 17.4°) are comparable to the literature on the outcomes of APR. Shon et al[39] found APR to result in an ASES score of 74 and SST score of 6.1. Holtby and Razmjou[25] found APR to result in an ASES score of 71, active forward elevation of 129°, and external rotation of 42°. Kim et al[28] found APR to result in a Constant-Murley score of 74 and SST score of 8.8.

Our study found that stage 2 or 3 FI of the teres minor is a major independent prognostic factor that can compromise clinical results in patients with posterosuperior mRCTs. In this series, postoperative Constant-Murley scores were negatively affected by stage 2 and 3 FI of the teres minor ($\beta = -23.0$, $P = .009$) whereas ASES scores were nearly significantly negatively affected ($\beta = -16.5$, $P = .058$). Several studies have evaluated the influence of FI of the supraspinatus and infraspinatus,[20,22] but to our knowledge, there are few studies that have reported the influence or effect of FI of the teres minor.[39,40] Shon et al[39] found that stage 2 or higher FI of the teres minor was correlated with outcome deterioration and poor satisfaction after APR. FI of the teres minor not only affects the outcomes of APR; Simovitch et al[40] have demonstrated that it also negatively affects the outcomes of RSA. The teres minor externally rotates and depresses the shoulder and, owing to its function, may be of great importance in mRCTs.[39,40]

This study has several limitations that must be taken into account. First, the patients were not randomized, and the surgical procedures were chosen according to the preference and experience of the shoulder surgeons. Second, the small subgroup sizes limit the statistical power of the findings. Third, the short follow-up does not allow conclusions regarding longevity of either treatment. Finally, improved LDTT techniques were recently introduced to decrease retear rates,[27] and the current findings apply only to the original technique without enhancements. A strength of this study was the direct comparison of 2 types of interventions for patients with partially repairable mRCTs, including the influence of FI and tendon retraction.

Conclusion

Both APR and LDTT granted similar early clinical outcomes for partially repairable posterosuperior mRCTs, regardless whether the teres minor was intact or torn. Advanced FI of the teres minor was the only independent factor associated with outcomes, as it significantly compromised Constant-Murley scores and tended to compromise ASES scores. These findings should reassure surgeons who opt for less invasive treatments for posterosuperior mRCTs and could help adjust patient expectations based on FI patterns.

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. Affonso J, Nicholson GP, Frankle MA, Walch G, Gerber C, Garzon-Muvdi J, et al. Complications of the reverse prosthesis: prevention and treatment. Instr Course Lect 2012;61:157-68.
2. Beeler S, Ek ET, Gerber C. A comparative analysis of fatty infiltration and muscle atrophy in patients with chronic rotator cuff tears and suprascapular neuropathy. J Shoulder Elbow Surg 2013;22:1537-46. https://doi.org/10.1016/j.jse.2013.01.028
3. Besnard M, Freychet B, Clechet J, Hannink G, Saffarini M, Carrillon Y, et al. Partial and complete repairs of massive rotator cuff tears maintain similar long-term improvements in clinical scores. Knee Surg Sports Traumatol Arthrosc 2020. https://doi.org/10.1007/s00167-020-05907-8. in press.
4. Burkhart SS, Athanasiou KA, Wirth MA. Margin convergence: a method of reducing strain in massive rotator cuff tears. Arthroscopy 1996;12:335-8.
5. Burkhart SS, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. Arthroscopy 1994;10:363-70.
6. Castricini R, De Benedetto M, Familiari F, De Gori M, De Nardo P, Orlando N, et al. Functional status and failed rotator cuff repair predict outcomes after arthroscopic-assisted latissimus dorsi transfer for irreparable massive rotator cuff tears. J Shoulder Elbow Surg 2016;25:658-65. https://doi.org/10.1016/j.jse.2015.08.043
7. Clouette J, Leroux T, Shanmugaraj A, Khan M, Gohal C, Veillette C, et al. The lower trapezius transfer: a systematic review of biomechanical data, techniques, and clinical outcomes. J Shoulder Elbow Surg 2020;29:1505-12. https://doi.org/10.1016/j.jse.2019.12.019
8. Collin P, Colmar M, Thomazeau H, Mansat P, Boileau P, Valenti P, et al. Clinical and MRI outcomes 10 years after repair of massive posterosuperior rotator cuff tears. J Bone Joint Surg Am 2018;100:1854-63. https://doi.org/10.2106/jbjs.17.01190
9. Collin P, Matsumura N, Ladermann 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
10. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987:160-4.
11. Cuff DJ, Pupello DR, Santoni BG. Partial rotator cuff repair and biceps tenotomy for the treatment of patients with massive cuff tears and retained overhead elevation: midterm outcomes with a minimum 5 years of follow-up. J Shoulder Elbow Surg 2016;25:1803-9. https://doi.org/10.1016/j.jse.2016.04.001
12. Dwyer T, Razmjou H, Henry P, Gosselin-Fournier S, Holtby R. Association between pre-operative magnetic resonance imaging and reparability of large and massive rotator cuff tears. Knee Surg Sports Traumatol Arthrosc 2015;23:415-22. https://doi.org/10.1007/s00167-013-2745-z
13. Ek ET, Neukom L, Catanzaro S, Gerber C. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: results after five to fifteen years. J Shoulder Elbow Surg 2013;22:1199-208. https://doi.org/10.1016/j.jse.2012.11.016
14. Elhassan BT, Wagner ER, Werthel JD. Outcome of lower trapezius transfer to reconstruct massive irreparable posterior-superior rotator cuff tear. J Shoulder Elbow Surg 2016;25:1346-53. https://doi.org/10.1016/j.jse.2015.12.006
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. Gerber C. Latissimus dorsi transfer for the treatment of irreparable tears of the rotator cuff. Clin Orthop Relat Res 1992:152-60.
17. Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Joint Surg Am 2000;82:505-15.
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 Relat Res 1988:51-61.
20. Godenèche A, Elia F, Kempf JF, Nich C, Berhouet J, Saffarini M, et al. Fatty infiltration of stage 1 or higher significantly compromises long-term healing of supraspinatus repairs. J Shoulder Elbow Surg 2017;26: 1818-25. https://doi.org/10.1016/j.jse.2017.03.024
21. 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 Relat Res 1994:78-83.
22. Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. J Shoulder Elbow Surg 2003;12:550-4. https://doi.org/10.1016/s1058-2746(03)00211-8
23. 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
24. Heuberer PR, Kolblinger R, Buchleitner S, Pauzenberger L, Laky B, Auffarth A, et al. Arthroscopic management of massive rotator cuff tears: an evaluation of debridement, complete, and partial repair with and without force couple restoration. Knee Surg Sports Traumatol Arthrosc 2016;24:3828-37. https://doi.org/10.1007/s00167-015-3739-9
25. Holtby R, Razmjou H. Relationship between clinical and surgical findings and reparability of large and massive rotator cuff tears: a longitudinal study. BMC Musculoskelet Disord 2014;15:180. https://doi.org/10.1186/1471-2474-15-180
26. 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
27. 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
28. Kim SJ, Lee IS, Kim SH, Lee WY, Chun YM. Arthroscopic partial repair of irreparable large to massive rotator cuff tears. Arthroscopy 2012;28:761-8. https://doi.org/10.1016/j.arthro.2011.11.018
29. Kukkonen J, Kauko T, Vahlberg T, Joukainen A, Aärimaa V. Investigating minimal clinically important difference for Constant score in patients undergoing rotator cuff surgery. J Shoulder Elbow Surg 2013; 22:1650-5. https://doi.org/10.1016/j.jse.2013.05.002
30. Malahias MA, Kostretzis L, Chronopoulos E, Brilakis E, Avramidis G, Antonogiannakis E. Arthroscopic partial repair for massive rotator cuff tears: does it work? A systematic review. Sports Med Open 2019; 5:13. https://doi.org/10.1186/s40798-019-0186-z
31. Memon M, Kay J, Quick E, Simunovic N, Duong A, Henry P, et al. Arthroscopic-assisted latissimus dorsi tendon transfer for massive rotator cuff tears: a systematic review. Orthop J Sports Med 2018;6: 2325967118777735. https://doi.org/10.1177/2325967118777735
32. Michener LA, McClure PW, Sennett BJ. American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form, patient self-report section: reliability, validity, and responsiveness. J Shoulder Elbow Surg 2002;11:587-94. https://doi.org/10.1067/mse.2002.127096
33. Mori D, Funakoshi N, Yamashita F. Arthroscopic surgery of irreparable large or massive rotator cuff tears with low-grade fatty degeneration of the infraspinatus: patch autograft procedure versus partial repair procedure. Arthroscopy 2013;29:1911-21. https://doi.org/10.1016/j.arthro.2013.08.032
34. Namdari S, Voleti P, Baldwin K, Glaser D, Huffman GR. Latissimus dorsi tendon transfer for irreparable rotator cuff tears: a systematic review. J Bone Joint Surg Am 2012;94:891-8. https://doi.org/10.2106/jbjs.K.00841
35. Paribelli G, Boschi S, Randelli P, Compagnoni R, Leonardi F, Cassarino AM. Clinical outcome of latissimus dorsi tendon transfer and partial cuff repair in irreparable postero-superior rotator cuff tear. Musculoskelet Surg 2015;99:127-32. https://doi.org/10.1007/s12306-015-0353-4
36. Patte D. Classification of rotator cuff lesions. Clin Orthop Relat Res 1990:81-6.
37. Petricciolli 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
38. Petrillo S, Longo UG, Papalia R, Denaro V. Reverse shoulder arthroplasty for massive irreparable rotator cuff tears and cuff tear arthropathy: a systematic review. Musculoskelet Surg 2017;101:105-12. https://doi.org/10.1007/s12306-017-0474-z
39. Shon MS, Koh KH, Lim TK, Kim WJ, Kim KC, Yoo JC. Arthroscopic partial repair of irreparable rotator cuff tears: preoperative factors associated with outcome deterioration over 2 years. Am J Sports Med 2015;43:1965-75. https://doi.org/10.1177/0363546515585122
40. Simovitch RW, Helmy N, Zumstein MA, Gerber C. Impact of fatty infiltration of the teres minor muscle on the outcome of reverse total shoulder arthroplasty. J Bone Joint Surg Am 2007;89:934-9. https://doi.org/10.2106/jbjs.F.01075
41. Yamakado K. Clinical and radiographic outcomes with assessment of the learning curve in arthroscopically assisted latissimus dorsi tendon transfer for irreparable posterosuperior rotator cuff tears. Arthroscopy 2017;33:2144-51. https://doi.org/10.1016/j.arthro.2017.06.015
42. Zanetti M, Gerber C, Hodler J. Quantitative assessment of the muscles of the rotator cuff with magnetic resonance imaging. Invest Radiol 1998;33:163-70.