Clinics of Surgery

Research Article

ISSN 2638-1451 | Volume 4

Does Adding Muscle Transfers to Reverse Shoulder Arthroplasty Improve Functional Outcomes of the Shoulder? A Multicenter Study

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Received: 24 Oct 2020
Accepted: 20 Nov 2020
Published: 27 Nov 2020

Citation:

Miyoshi N, Does Adding Muscle Transfers to Reverse Shoulder Arthroplasty Improve Functional Outcomes of the Shoulder? A Multicenter Study. Clinics of Surgery. 2020; 4(2): 1-6.

Keywords:

Reverse shoulder arthroplasty (RSA); Rotator cuff reconstruction; Tendon transfer; Clinical outcomes

1. Abstract

1.1. Background: One of the authors has added rotator cuff reconstruction with tendon transfers to RSA, expecting that it will not only obtain better function, but also reduce complications. The aim was to compare the clinical outcomes with and without tendon transfers in RSA in a multicenter study.

1.2. Methods: 67 shoulders were treated with RSA with or without tendon transfers. The average age was 76.4 years, and the average follow-up period was 22.8 months. In 35 shoulders without tendon transfers (Group C), just the subscapularis tendon was repaired, and 32 shoulders were treated with tendon transfers (Group M), Clinical outcomes were assessed by ROM, JOA/UCLA score, and complications.

1.3. Results: Flexion (Group C/M) improved from 50.4/47.3° to 115.1/131.4° postoperatively. ER improved from 17.7/21.6° to 19.2/29.2°. The JOA score improved from 47.7/45.4 preoperatively to 79.0/80.1 points postoperatively, UCLA scores improved from 11.6/11.4 preoperatively to 26.3/27.4 postoperatively. Complications occurred in 4/35 (1 infection, 2 acromial fractures, 1 ulnar nerve palsy) in group C and 3/32(1 dislocation, 1 scapular spine fracture, 1 ulnar nerve palsy) in group M.

1.4. Conclusion: Adding tendon transfers to RSA provided better functional outcomes, improving both elevation and ER, compared to conventional RSA. We expected that tendon transfers associated with RSA could improve stability to prevent dislocation, as well as decrease the load on the deltoid muscle. However, dislocation and scapular spine fracture occurred in cases with tendon transfer; therefore, further evaluation of the long-term course is necessary to clarify the efficacy of tendon transfers for reducing complications.

Level III

2. Introduction

An irreparable massive rotator cuff tear with osteoarthritis is one

of the most difficult shoulder joint disorders to treat. Reverse shoulder arthroplasty (RSA) has been reported to show good clinical outcomes in the short and mid-terms in many studies and is, therefore, now performed worldwide [1-6]. However, there are also many reports that the range of motion (ROM) of external rotation after surgery improves insufficiently, and many complications such as deltoid muscle rupture, loosening, infection, nerve injury, acromial fracture, dislocation, and a scapular notch have occurred following RSA [4-6]. Levy [7] reported that there is a limit to the improvement of postoperative ROM of RSA compared with anatomic total shoulder arthroplasty (TSA). Recently, some studies [8-10] have reported the clinical outcomes of latissimus dorsi (LD)/teres major (TM) tendon transfers for improvement of external rotation. One of the authors has added rotator cuff reconstruction with tendon transfers even with RSA, expecting that it will not only obtain better function, but also reduce the complication rate by preventing infection through reduction of dead space, improving stability, and decreasing long-term deltoid muscle damage by reducing deltoid muscle load. The aim of the present study was to compare the clinical outcomes with and without tendon transfers in RSA and to clarify the efficacy of tendon transfers for functional outcomes and prevention of complications.

3. Materials and Methods

A total of 67 shoulders of patients over 70 years of age (males, 25; females, 42) with cuff tear arthropathy or irreparable re-tear after rotator cuff repair were treated with RSA with or without tendon transfers by 7 surgeons at 8 hospitals during the period from April 2014 to March 2018, and they were followed-up for more than 12 months after surgery. All of them could not elevate their shoulder more than 100° preoperatively. The average age at the time of surgery was 76.4 years (range, 70 – 88 years), and the average follow-up period was 22.8 months (range, 12 – 49 months). Delta XTEND (Depuy synthes, Warsaw, IN, USA) was used in 5 shoulders, Comprehensive Reverse and Trabecular Metal Reverse (Zimmer-Biomet, Warsaw, IN, USA) were used in 21 shoulders and 26 shoulders, respectively, Ascend Flex and Aequalis Reverse (Tornier, Bloomington, IN, USA) were used in 7 shoulders and 3 shoulders, respectively, and SMR reverse (Lima, San Daniele, Italy) was used in 5 shoulders. In 35 shoulders treated without tendon transfers (Group C), just the subscapularis tendon was repaired using the delto-pectoral approach. In 32 shoulders with tendon transfers (Group M), both the delto-pectoral approach and the superior deltoid splitting approach between the anterior and middle fibers were used. In cases in which the subscapularis remained intact, the intact subscapularis tendon was detached subperiosteally and transferred antero-superiorly after the implant was inserted. If any cuff defect remained at this point, tendon transfers were added. The criteria for selecting tendon transfers were as follows:

(1) if there were supraspinatus, infraspinatus, and teres minor tendon tears, and external rotation function was impaired and the external rotation lag sign (ER lag sign) [11] was positive, posterior LD/TM transfers were selected. Our procedure of posterior LD/TM transfers involves transferring LD/TM tendons to the posterior part of the greater tuberosity referring to Hertzberg's report [12] to regain more external rotation function, and it is different from the L'Episcopo procedure; (2) if the ER lag sign was negative and external rotation function remained, and subscapularis tendon was torn, PM transfer was performed; and (3) if the anterior superior part of the subscapularis and supraspinatus tendon were torn, and the subscapularis tendon could be transferred to the superior defect, the anterior defect that did not extend beyond the upper end of the lesser tubercle could be reconstructed by LD/TM anterior transfer [13]. According to the aforementioned indication, 32shoulders of Group M were treated with 14 modified Cofield's transfers (partial transfer of subscapularis), 9 pectoralis major (PM) transfers, 3 anterior LD/TM transfers, 5 posterior LD/TM transfers, and 1 both PM and posterior LD/TM transfers, according to the indication demonstrated below.

Clinical outcomes were assessed by active ROM, Japanese Orthopaedics Association (JOA) scores (Table 1), the University of California at Los Angeles shoulder (UCLA) score, and complications such as dislocation, infection, fracture, and nerve injury.

Table 1: Japanese Orthopaedics Association (JOA) score

I PAIN (30 Points)	
None	30
Tenderness or minimal pain in sports or heavy labor	25
Minimal pain in ADL	20
	15
Moderate and tolerable pain (Analgetic needed, occasional night pain)	10
Severe pain (ADL limited, frequent night pain)	5
Totally incapacitated bacause of pain	0
II FUNCTION (20 POINTS)	
Strength in Abduction (5 Points)	**Endurance (5 Points)**

(To be measured at 90 degrees of abduction or at possible abduction level.)	Normal	5	(Time seconds of holding 1kg dumbell horizontally with elbow extended and forearm pronated)	More than 10 seconds	5
	Excellent	4		More than 3 seconds	3
	Good	3		More than 2 seconds	1
	Fair	2		Zero	0
	Poor	1			
	Zero	0			
Activities of Daily Living (10 Points)					
Combing hair	1		Reaching opposite axilla	1	
Making knot in back	1		Open and close sliding door	1	
Reaching mouth	1		Reaching overhead shelf	1	
Sleep on involved side	1		Self-hygienic care	1	
Reaching side pocket (jacket)	1		Wearing jacket	1	
Subtract one point from above for each activity that cannot be carried out, specify;					
1.	2.	3.			

III RANGE OF MOTION (30 Points)					
Elevation (15 Points)		**Exertal Rotation (9 Points)**		**Interal Rotation (6 Points)**	
More than 150 degrees	15	More than 60 degrees	9	Above T12 spinous process	6
More than 120 degrees	12	More than 30 degrees	6	Above L5 spinous process	4
More than 90 degrees	9	More than 0 degrees	3	Gluteal	2
More than 60 degrees	6	More than -20 degrees	2	Below Gluteal	0
More than 30 degrees	3	Less than -20 degrees	0		
0 degrees	0				

IV ROENTGENOGRAPHIC EVALUATION (5 Points)	
Normal	5
Moderate changes or subluxation	3
Advanced change or disclocation	0
V JOINT STABILITY (15 Points)	
Normal	15
Slight instability or apprehension	10
Severe instability or history or state of subluxation	5
Relevant history or state of dislocation	0

4. Statistics

Statview software (Version 4.54) was used for all statistical analyses. Preoperative and postoperative data were analyzed using the non-paired t-test and the Wilcoxon signed-rank test for dependent data. The paired t-test and the Mann-Whitney U test for nonparametric independent data were used for comparisons between the 2 groups. The significance level was set at P<.05.

5. Results

The mean age at surgery was 75.9 years (range, 70-88 years) in group C and 77.2 years (range, 70-88 years) in group M, and the follow-up period was 22.1 months (range, 12-45 months) in group C and 24.7 months (range, 12-49 months) in group M. Both were not significantly different between the groups.

Preoperative forward flexion, external rotation, and internal rotation score were not significantly different between Group C and Group M (P= 0.361, 0.372, and 0.219, respectively). In group C, active forward flexion improved from 50.4° (range, 0-110°) to 115.1° (range, 90-170°) (improvement 64.7°) (Figure 1), external rotation improved from 17.7° (range, -20-80°) to 19.2° (range, -30-70°) (improvement 1.5°) (Figure 2), and the internal rotation score of the JOA score (range; 0-6 points) was 3.9 points (range, 0-6 points) preoperatively and 3.9 points (range, 2-6 points) postoperatively. Active forward flexion was significantly improved (P<.001), but external and internal rotation were not significantly changed in group C (P=0.73, 0.135, respectively). In group M, active forward flexion improved from 47.3° (range, 0-110°) to 131.4° (range, 90-165°) (improvement 84.1°) (Figure 1), external rotation improved from 21.6° (range, -20-60°) to 29.2° (range, 0-80°) (improvement 7.6°) (Figure 2), and the internal rotation score improved from 3.6 points (range, 0-6 points) to 3.9 points (range, 2-6 points) postoperatively. Active forward flexion (P<.001) and external rotation (P=.032) were significantly

improved, and internal rotation (P=0.227) was not significantly changed in group M. Active forward flexion (P=.0029) and external rotation (P=.0022) were significantly difference in group M between the groups postoperatively. Internal rotation improved in 6 shoulders (17.1%) and deteriorated in 7 shoulders (20.0%) of the 35 shoulders in group C, whereas it improved in 13 shoulders (40.6%) and deteriorated in 7 shoulders (21.9%) of the 32 shoulders in group M, showing a higher rate of improvement in group M (Figure 3). Regarding clinical scores, both preoperative JOA score and UCLA score were not significantly different between Group C and Group M (P=0.424, 0.802, respectively). In Group C, the JOA score improved from 47.7 points (range, 25-77.5 points) (score: pain 12.1 (range, 5-30), ROM 11.8 (range, 3-19)) to 79.0 points (range, 50-95 points) (score: pain 25.3 (range, 15-30), ROM 18.1(range, 11-28)) points postoperatively (improvement 31.3 points) (Figure 4), and the UCLA score improved from 11.6 (range, 5-17) preoperatively to 26.3 (range, 17-33) points postoperatively (improvement 14.7 points) (Figure 5). In group M, the JOA score improved from 45.4 points (range, 20-66) (score: pain 10.7 (range, 5-25), ROM 11.3 (range, 3-19)) to 80.1 points (range, 51-93) (score: pain 25.4 (range, 15-30), ROM 20.7 (range, 14-28)) points postoperatively (improvement 35.7 points) (Figure 4), and the UCLA score improved from 11.4 (range, 4-16) preoperatively to 27.4 (range, 22-35) points postoperatively (improvement 16.0 points) (Figure 5). The JOA score and the UCLA score were significantly improved (P<.001) postoperatively in both groups. However, both scores were not significantly different between the groups postoperatively (P=0.65, 0.159, respectively). Complications occurred in 4/35 cases (11.4%) (2 cases of acromial fracture, 1 case of infection, and 1 case of ulnar nerve palsy) in group C, and in 3/32 cases (9.4%) (1 case of dislocation, 1 case of scapular spine fracture and 1 case of ulnar nerve palsy) in group M. In the case of dislocation, two years after surgery, the patient felt instability for the first time when she held a heavy object, and it then recurred several times. Displacement of the os acromiale and advanced bone resorption of the greater tubercle were seen on the X-ray.

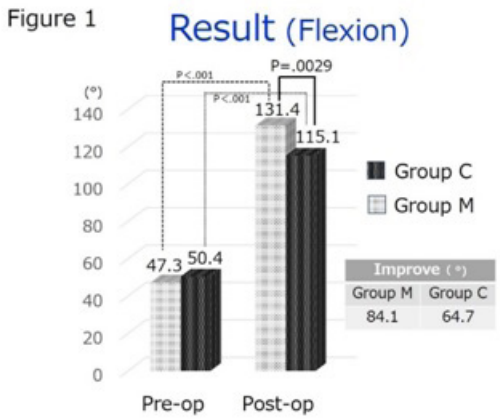

Figure 1. Pre- and postoperative ROM of flexion Pre-op, preoperatively; Post-op, postoperatively.

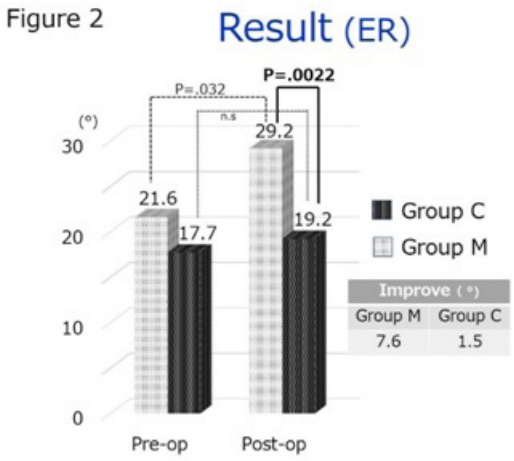

Figure 2. Pre- and postoperative ROM of external rotation.

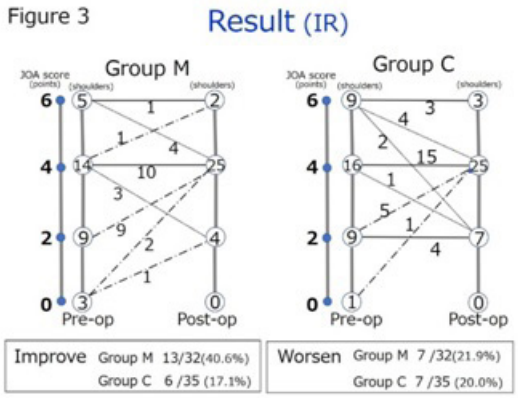

Figure 3. Pre- and postoperative change of the internal rotation score of the JOA score.

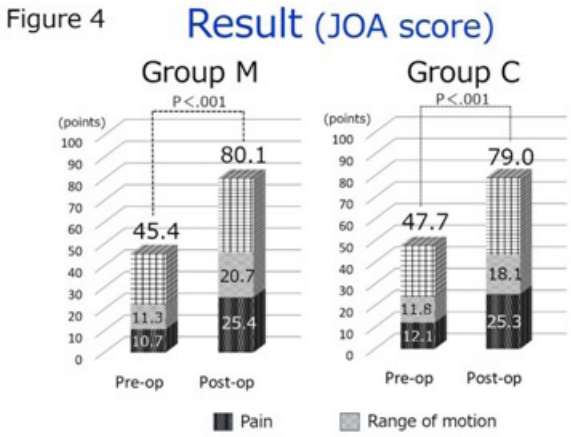

Figure 4. Pre- and postoperative JOA scores.

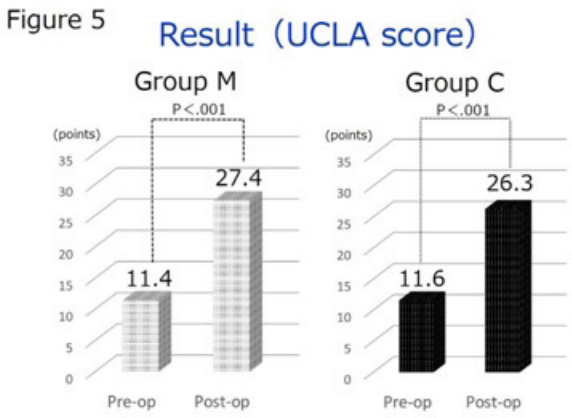

Figure 5. Pre- and postoperative UCLA scores.

6. Discussion

RSA has been reported to provide good improvement in forward flexion and is performed worldwide. On the other hand, many reports have found insufficient improvement of external rotation after surgery. Recently, some studies [8-10] have reported the clinical outcomes of LD/TM tendon transfers for improvement of external rotation. Puskas [10] reported that external rotation was improved from 4° to 27° (improvement of 23°), and forward flexion was improved from 82° to 138° (improvement of 56°) in RSA with LD transfer. Henseler [9] reported that RSA with LD transfer improved external rotation from 23° to 51° (improvement of 28°) and forward flexion from 94° to 123° (improvement of 29°). Although external rotation with LD transfer showed good improvement compared to the reports of RSA without transfer [1-6] forward flexion was not very different. Furthermore, few reports compared RSA with and without tendon transfer in the same study, so that we have conducted the current multiple center study to evaluate the effect of tendon transfers on functional outcomes after RSA.

We expected that adding rotator cuff reconstruction with tendon transfers to RSA would improve not only clinical outcomes, but also reduce complications. In the present study, external rotation was significantly improved, as well as flexion, with tendon transfers. In our view, both external rotation and forward flexion were improved by re-tensioning of the remaining cuff tendons and reconstruction of the power source in addition to the deltoid. On the other hand, there were no significant changes in the JOA and UCLA scores in the groups. This may be because the level of satisfaction was high for most patients regarding pain after RSA, and the change in the scores for ROM was relatively small in both scoring systems compared to the change in those of pain, which improved remarkably after surgery in the current patients. In particular, the score of forward flexion increased by just 3 points in the JOA score and 1 point in the UCLA score with an improvement of 30°, and the score of external rotation also increased by just 3 points in the JOA score with an improvement of 30°, and it did not affect the UCLA score at all. So even if there were significant differences in forward flexion (115.1° in Group C/131.4° in group M) and external rotation (19.2° in group C / 29.2° in group M) postoperatively, they did not appear to have much effect on the two scores.

Regarding complications, we expected that improved stability following rotator cuff reconstruction with tendon transfer would prevent dislocation and reduce the risk of neuropathy by avoiding excessive extension of the arm length for improving stability. Furthermore, reducing the dead space by the transferred tendon was expected to decrease the risk of infection, and reducing the load on the deltoid muscle was expected to prevent scapular fracture and deltoid rupture over the long-term. However, dislocation and acromial fracture occurred even when tendon transfer was performed in this study. The cause of dislocation in the present study was a displaced os acromiale and bone resorption of the greater tuberosity. There are reports [14] that the inferior inclination of os acromiale has no effect postoperatively, but in the present case, advanced bone resorption of the greater tuberosity also occurred. There is a report that bone resorption of the greater tuberosity causes instability by decreasing the deltoid wrapping effect, so the advanced bone resorption of the greater tuberosity might have caused the dislocation in the present case. For acromial fractures, some studies reported that the fractures occurred due to acromial stress from implants [15, 16], and Wong [16] reported that lateralization of the glenoid side increased acromial stress. In the present case, the scapular spine fracture in the M group was treated by lateralization with the angled bony increased offset, so the fracture might have been caused by the stress of the implant. Thus, it may be difficult to prevent dislocation and acromial fracture due to the characteristics of RSA itself.

RSA with tendon transfer did not cause infection or neuropathy in the present study. However, the effect of tendon transfers on reducing the complication rate was not clearly demonstrated in the current study. In the future, it will be necessary to increase the number of cases and follow patients for a longer term to evaluate complications that can occur later over the long term.

There are several limitations of this study. First, the follow-up period was short. The complications of RSA can occur later; therefore, it is important to continue observation. Second, the number of cases was small; we plan to study more cases. Third, this was a retrospective study, not a prospective randomized study. Fourth, 7 surgeons performed RSA in this study; though the overall concept and indications for the treatment were standardized, differences among the surgeons might have affected the outcomes. Fifth, six prostheses were used for RSA, and there may be differences among the prosthesis groups; thus, a detailed analysis of each prosthesis is needed and will be possible with the study of more shoulders.

7. Conclusion

Adding tendon transfers to RSA provided better functional outcomes, improving both elevation and ER, compared to conventional RSA. We expected that tendon transfers associated with RSA could improve stability to prevent dislocation, as well as decrease the load on the deltoid muscle. However, dislocation and scapular spine fracture occurred in cases with tendon transfer; therefore, further evaluation of the long-term course is necessary to clarify the efficacy of tendon transfers for reducing complications.

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