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Strength Assessment After Reverse Shoulder Arthroplasty

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Abstract

Objective: The main objective was to evaluate the anterior flexion force (AFF) and the lateral abduction force (LAF) of patients who underwent reverse shoulder arthroplasty (RSA) and to compare the measured force with that in a similar-age control group. The secondary objective was to identify prognostic factors for muscle strength recovery.
Methods: Forty-two shoulders that underwent primary RSA between September 2009 and April 2020 met the inclusion criteria and were called the arthroplasty group (AG). The control group (CG) consisted of 36 patients. The mean AFF and the mean LAF were evaluated with a digital isokinetic traction dynamometer.
Results: The average AFF found in the AG was 15 N, while in the CG, the average AFF was 21 N ($P < .001$). The average LAF in the AG was 14 N (standard deviation [SD] 8 N), while in the CG the average LAF was of 19 N (SD 6 N) ($P = .002$). All prognostic factors studied in the AG showed no statistical significance: dominance (AFF 0.697/LAF 0.883), previous rotator cuff repair surgery (AFF 0.786/LAF 0.821), Hamada radiological classification (AFF 0.343/LAF 0.857), magnetic resonance imaging (MRI) pre-operative evaluation of the quality of the teres minor (AFF 0.131/LAF 0.229), suture of the subscapularis at the end of the arthroplasty procedure (AFF 0.961/LAF 0.325) and postoperative complications (AFF 0.600/LAF 0.960).
Conclusion: The mean AFF was 15 N, and the mean LAF was 14 N. The comparison of AFF and LAF with a CG showed a 25% reduction in muscle strength. It was not possible to demonstrate prognostic factors for muscle strength recovery after RSA.

Keywords

Reverse shoulder arthroplasty, flexion strength and abduction strength

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Introduction

The results of reverse shoulder arthroplasty (RSA) have evolved over the years with the research and development of new implants,[1,2] the improvement of the surgical technique,[3,4] and increased knowledge of patient rehabilitation.[5–7]

Several studies have assessed patient outcome expectations and the objective outcomes achieved after RSA. It is important to know patients' expectations and the limitations that exist on achieving them and thus to align expectations between the surgeon and the patient.

Regarding the functional outcome, Parsons et al[8] looked for risk factors for failure after RSA. They found that patients with coronary heart disease, diabetes and previous joint surgery were more likely to have worse functional outcomes, although they were not correlated with the pre-operative expectations of these patients.

Regarding patient expectations, Rauck et al[9] showed that elderly patients undergoing RSA were satisfied with the re-establishment of the ability to perform some everyday activities. Regarding the expectation of functional results,

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both younger patients and patients who had better preoperative function seem to be more demanding. The same findings were verified by Werner et al[10] when they analyzed the clinical relevance of the American Shoulder & Elbow Surgeon score to the functional evaluation during the postoperative period of RSAs.

Rauck et al[9] found that, in addition to age, patients' expectations of results varied according to the pathology for which surgical treatment was indicated. Patients undergoing RSA due to glenohumeral arthrosis expected better functional results than patients undergoing RSA due to rotator cuff tear arthropathy (CTA). Lindbloom et al[11] also verified that patients operated on for different pathologies presented variability in their expectations of functional results.

Knowledge of muscle strength after the RSA procedure has not been widely researched in the literature. We consider the recovery of muscle strength to be an important step in the recovery of upper limb (UL) function; therefore, we decided to evaluate this item separately to verify its relevance in improving satisfaction among our patients.

The main objective of this research was to evaluate the anterior flexion force (AFF) and the lateral abduction force (LAF) of patients submitted to RSA and to compare the measured force with that in a control group of similar age. As a secondary objective, we identified prognostic factors for muscle strength recovery.

Methods

This study was a cohort study. The Ethics Committee of the institution issued a favorable opinion on performing the research (approval number 3,210,752). Patients included in the study were verbally informed of the painless nature of the test and consented to its performance.

A group of 88 shoulders (86 patients) that underwent RSA between September 2009 and April 2020 were evaluated using the Constant Score and the measurement of muscle strength.

For this study, 46 shoulders (44 patients) that underwent primary reverse arthroplasty for the treatment of rotator CTA at a minimum of 24 months postoperatively were selected. Three patients who had complications that compromised the assessment of muscle strength—1 patient with an acromion fracture, 1 patient with reflex sympathetic dystrophy undergoing treatment and another who had recently undergone thoracentesis—were excluded. One patient who required re-operation due to dissociation of the metallic glenosphere was also excluded.

A total of 42 shoulders (40 patients) met these inclusion criteria and were called the arthroplasty group (AG) for statistical comparison purposes.

The AG shoulders were classified according to Hamada et al.[12] The frequency of cases by the Hamada classification is listed in Table 1.

Table 1. Hamada Classification.

Hamada classification	Number of cases	Frequencies (%)
Type 2	14	33.3
Type 3	8	19
Type 4A	3	7.1
Type 4B	3	7.1
Type 5	14	33.3

The surgeries were performed by the author in the beach chair position. Deltopectoral access was used in 40 shoulders (95.2%), and anterosuperior access was used in the others. In 28 shoulders (66.6%), the prosthesis used was Exactech®; in 9, Tornier®; in 4, Zimmer Biomet®; and in 1, Depuy Synthes®.

The mean time spent in the procedure was 94.5 min, and blood transfusion was required in 6 patients (14.2%).

All patients were immobilized for 30 days with a padded sling, maintaining neutral rotation of the UL. When the subscapularis tendon was repaired, active anterior flexion, lateral rotation, and medial rotation exercises were started at 30 days postoperatively. In patients in whom the subscapularis was not repaired, these exercises were started on the 15th day. Isometric exercises to strengthen the deltoid and isotonic reinforcement of the scapula stabilizers were started at 30 days in all patients in a home orientation program. Clinical reviews performed by the surgeon were performed monthly until the 6th month, and subsequently, the patients were instructed to return to the service if they needed any guidance.

At the postoperative follow up, 5 problems (11.9%) and 5 complications (11.9%) were observed. The problems observed were 4 hematomas that required drainage and 1 allergic reaction near the surgical wound. The complications observed were 3 cases with neuropraxias, 2 of the axillary nerve, and 1 of the median nerve. All cases were spontaneously resolved until 6 months after the operation. There were 2 fractures of the humerus. One case was a traumatic fracture of the middle third of the humerus treated conservatively and 1 case was an incomplete humeral fracture distal to the cementless stem noticed on the postoperative radiography and required no special treatment.

Patients were called for evaluation at a mean of 46.9 months (standard deviation [SD] 26.8 months).

The strength assessment was performed by an independent examiner in an outpatient setting, following the safety rules required by the Research Ethics Committee. The assessment of muscle strength was measured in newtons (N) using an isokinetic digital traction dynamometer from the Marine Sports Digital Fish Scale® (MS08-00298), composed of 2 rigid adjustable straps, 1 end fixed next to the examiner's foot and the other at the end of the patient's UL. The device was adjusted to suit the patient's height.

Picture 1. Measurement of lateral abduction force.

Picture 2. Measurement of lateral abduction force.

For the measurement of AFF, the patient remained standing, with the shoulder in anterior flexion of 90° on the axis of the scapula and the forearm in a neutral position holding the dynamometer handle with a closed hand. Three consecutive measurements were performed with a mean interval of 10 s, and the mean was considered. The patient was allowed to lower the UL to rest between measurements for a maximum of 10 s (Picture 1).

For the measurement of LAF, the patient remained standing with the shoulder in lateral abduction of 90° and with the forearm in the prone position. The dynamometer handle was placed on the patient's wrist to prevent the hand dorsiflexion force from compromising the measurement. The measurements were obtained in the same manner as for the anterior flexion measurements. For patients who did not reach the position of 90° of abduction, the force noted was considered 0 (Picture 2).

Thirty-six patients were chosen for the control group (CG) with similar ages to the patients in the AG, without complaints of pain in the ULs, with normal range of motion of the shoulders and without a history of trauma or surgery in their ULs. Muscle strength was measured in the same way as for the AG in the dominant UL.

The following variables were searched in the AG patients' charts for statistical analysis: dominance, previous rotator cuff surgery, Hamada radiological classification, preoperative magnetic resonance imaging (MRI) evaluation of the quality of the teres minor, suture of the subscapularis at the end of the arthroplasty procedure and postoperative complications (Table 2).

The descriptive and statistical analysis was performed with R software (The R Foundation for Statistical Computing, https://www.r-project.org/, version 4.0.0, 2020-04-24). For the description of the sample, the mean and SD were used for variables with symmetrical distributions, the median and interquartile range (IQR) for variables with asymmetric distributions and percentages with 95% confidence intervals for categorical variables. In the comparison between 2 groups, Welch's two-sample t test was used, and Pearson's chi-square test was used for categorical variables. For all statistical tests, values of $P < .05$ were considered significant.

Results

The mean age of the 42 AG patients was 73 years old (SD 6), and 31 (73.8%) were women. In 31 patients (73.8%), the operated side was the right side and was the dominant side in 76.1% of the cases.

The mean age of the 36 patients in the CG was 68.8 years old (SD 7), and 26 (72.2%) were women. In 32 patients

(88.8%), the evaluated side was the right side, and in all cases, the UL evaluated was the dominant limb.

The groups were compared for sex and mean age (Table 2). They were considered similar in terms of the ratio of men to women (0.875). They were considered different for the mean age (0.015); however, this difference was not relevant from a clinical point of view because both groups consisted of seniors, and no person of the CG is under 60 years of age. The boxplots overlap in the IQRs (Picture 3).

The AG had an average active anterior flexion of 118.3° (minimum of 90° and maximum of 160°) and an average active lateral abduction of 87.3° (minimum of 50° and maximum of 90°). Four patients (9.5%) were unable to reach a minimum of 90° of lateral abduction for the measurement to be performed (Table 3).

An average AFF of 15 N (SD 8 N) was found in the AG, while in the CG, the average AFF was 21 N (SD 7 N). The difference was considered significant ($P < .001$).

Table 2. Prognostic Factors.

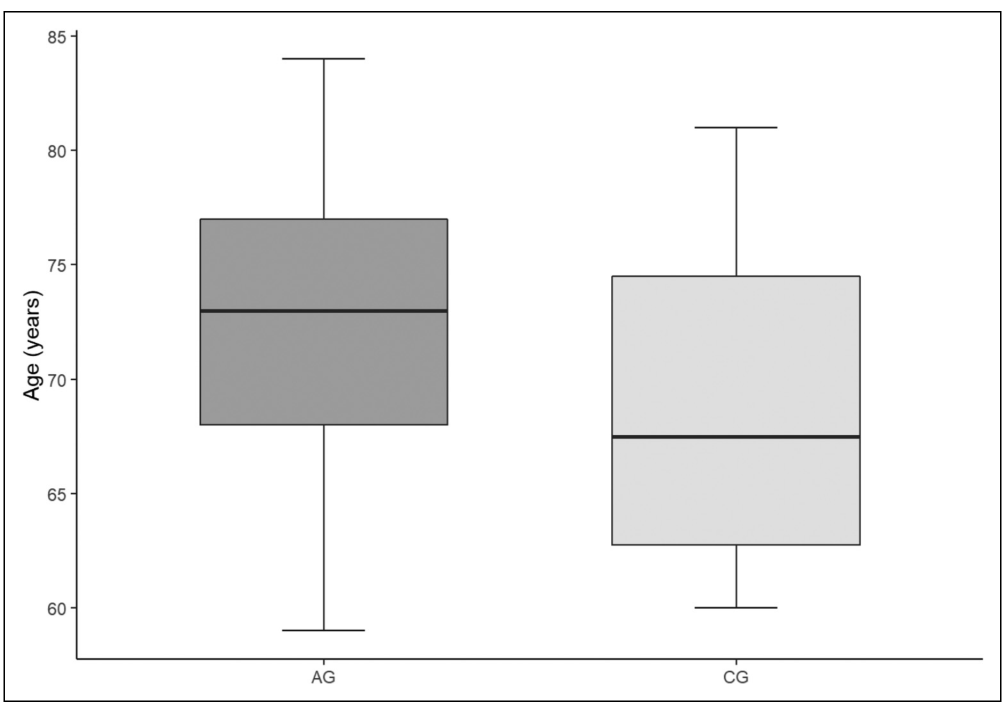
PF		Yes[a]	LBD[a]	No[a]	GBD[a]	*P* value[b]
Dominant upper limb	AFF	15(8)		14(8)		.697
	LAF	14(8)		13(8)		.883
Previous rotator cuff repair	AFF	16(10)		15(7)		.786
	LAF	14(9)		14(7)		.821
Hamada	AFF		16(8)		14(7)	.343
	LAF		14(8)		14(7)	.857
Teres minor quality	AFF	13(6)		16(9)		.131
	LAF	12(7)		15(8)		.229
Subscapularis sutured	AFF	15(9)		15(8)		.961
	LAF	11(9)		14(7)		.325
Complications	AFF	17(9)		15(8)		.600
	LAF	14(9)		14(8)		.960

[a]Mean (SD).
[b]Welch's two-sample t test.
Abbreviations: AFF, anterior flexion force; GBD, greater bone deformity; LAF, lateral abduction force; LBD, lesser bone deformity; SD, standard deviation.

Table 3. Group Comparison.

Characteristic	AG, n = 42[a]	CG, n = 36[a]	*P* value[b]
Age	73 (6)	69 (7)	.015
Sex, n (%)			.875
M	11 (26)	10 (28)	
F	31 (74)	26 (72)	

[a]Mean (SD); n (%).
[b]Welch's two-sample t test; Pearson's chi-square test.
Abbreviations: AG, arthroplasty group; CG, control group; F, female; M, male; SD, standard deviation.



Picture 3. Comparison of the ages of both groups. Abbreviations: AG, arthroplasty group; CG, control group.

An average LAF of 14 N (SD 8 N) was found in the AG, while in the CG, the average LAF was 19 N (SD 6 N). The difference was considered significant ($P = .002$).

The average Constant Score in the AG patients was 63.02. One case was classified as very good (2.3%), 11 cases as good (26.1%), 18 cases as regular (42.8%), and 12 cases as poor (28.5%).

The AFF and LAF of the AG were comparatively evaluated between the dominant and nondominant ULs. The 32 dominant shoulders presented an AFF of 15 N (DP 8 N), while the nondominant shoulders (10 shoulders) presented an AFF of 14 N (DP 8). The difference was not considered significant (0.697). The dominant shoulders had an LAF of 14 N (SD 8 N), while the nondominant shoulders had an LAF of 13 N (SD 8). The difference was not considered significant (0.883).

The AFF and LAF in the AG were comparatively evaluated between cases submitted or not to rotator cuff repair before progressing to arthroplasty. The 9 shoulders that had the rotator cuff tendons previously sutured had an AFF of 16 N (SD 10 N), while the others (33 shoulders) had an AFF of 15 N (SD 7). The difference was not considered significant (0.786). The 9 shoulders that had the rotator cuff tendons previously sutured had an LAF of 14 N (SD 9 N), while the others had an LAF of 14 N (SD 7). The difference was not considered significant (0.821).

The AG forces were evaluated according to the Hamada classification. The 22 cases of Hamada 2 and 3 (lesser bone deformity) were compared with the 20 cases of Hamada 4A, 4B, and 5 (greater bone deformity). Cases with less bone deformity had an AFF of 16 N (SD 8 N) and an LAF of 14 N (SD 8), while the cases with greater bone deformity had an AFF of 14 N (SD 7) and an LAF of 14 N (DP 7 N). The difference was not considered significant for AFF (0.343) or for LAF (0.857).

The AFF and LAF of the AG were evaluated among cases with a normal teres minor compared with cases with an absent teres minor or with fatty degeneration on preoperative MRI. The 17 shoulders with absence or fatty degeneration of the teres minor had an AFF of 13 N (DP 6 N), while the others (25 shoulders) had an AFF of 16 N (DP 9). The difference was not considered significant (0.131). The 17 shoulders with absence or fatty degeneration of the teres minor had an LAF of 12 N (SD 7 N), while the others had an LAF of 15 N (SD 8). The difference was not considered significant (0.229).

The AFF and LAF of the AG were comparatively evaluated between cases in which the subscapularis was sutured at the end of the arthroplasty procedure and cases in which suturing was not possible. The 7 shoulders with the sutured subscapularis had an AFF of 15 N (DP 9 N), while the others (35 shoulders) had an AFF of 15 N (DP 8). The difference was not considered significant (0.961). The 7 shoulders with the sutured subscapularis had an LAF of 11 N (DP 9 N), while the others had an LAF of 14 N (DP 7). The difference was not considered significant (0.325).

The AFF and LAF of the AG were comparatively evaluated between the cases that presented or did not present complications in their postoperative follow ups. The 5 shoulders that presented complications had an AFF of 17 N (SD 9 N), while the others had an AFF of 15 N (SD 8). The difference was not considered significant (0.600). The 5 shoulders that presented complications had an LAF of 14 N (SD 9 N), while the others had an LAF of 14 N (SD 8). The difference was not considered significant (0.960).

Discussion

After RSA, the deltoid muscle is primarily responsible for the range of motion. It is a triangular shape muscle that encompasses the anterior, lateral, and posterior portions of the shoulder. As the deltoid works together with the shoulder girdle, the isolated assessment of its function is a challenge.[13] According to Ziegler et al,[13] the best way to assess the strength of the deltoid is to position the measuring equipment handle close to its insertion in the humerus with the UL at 90° of abduction on the scapula plane. It should be noted that, since it is a multipennate muscle, it is easily fatigued, especially in elderly individuals. Alta et al,[14] in their study measuring the muscle strength of patients undergoing RSA, reduced the torque power of the test by a maximum of 60° of velocity due to the advanced age of the evaluated patients. In our study, we attempted to isolate the deltoid in the strength measurement tests in the most appropriate way possible and without causing pain or discomfort to the patients, following the recommendations of the American Society of Exercise Physiology.[15]

The AFF of 15 N and LAF of 14 N seem to be sufficient for daily activities, as suggested by other authors.[9,14,16] Alta et al[14] evaluated torque strength in patients undergoing RSA and compared the results with those in young individuals. They found that patients with RSA had limited muscle strength, especially in abduction and adduction. They suggested that this limitation could be responsible for some cases of incomplete recovery of the range of motion. Wang et al[17] evaluated torque strength in the postoperative period of RSA for different pathologies and verified that the recovery of greater amounts of internal rotation and anterior flexion strength was related to better sports performance and better subjective results on functional questionnaires (QuickDASH Score and Oxford Shoulder Score). Erşen et al[16] evaluated the isometric strength and resistance of the deltoid in cases of CTA that underwent RSA and found a correlation between the strength achieved and the humeroacromial distance measured on X-ray. In our study, we did not perform radiographic analysis of the patients. Müller et al[3] showed that an increase in glenosphere diameter led to significant increases in external rotation in adduction and abduction strength at the midterm follow up of RSAs.

There is a loss of muscle mass in healthy elderly patients, and in general, decreased muscle strength accompanies this loss with a decrease in power. Based on this premise, there was a concern about recruiting a CG of similar ages as the AG. There is also a tendency for men, because they have greater muscle mass, to present greater strength than women throughout all age groups, including among elderly individuals. The authors attempted to maintain a ratio between men and women in the CG similar to that in the AG, as suggested by Alta et al.[14]

The comparison of AFF and LAF evaluated between the groups found a 25% reduction in strength among patients operated on with RSA. It is important to point out that this 25% reduction is compared to normal, fully functional individuals of the same age. Initially visualized as a significant reduction, the final strength reached may be considered by some patients in this age group as a fantastic strength result. Further studies are suggested to verify whether the percentage found in the reduction of muscle strength affects daily activities.

The patients included in the AG followed an assisted home exercise program to recover range of motion and muscle strength, with serial visits to the service where they underwent surgery. According to Uschok et al,[5] the ability of physical therapy to modify the final result of the treatment in the medium-term and long-term follow up is debatable. In their study, they found that physical therapy seemed to influence the gain of the final range of motion without specifically improving the patients' muscle strength. In a systematic review published in 2020, Edwards et al[7] found no studies demonstrating the effectiveness of physical therapy programs in the postoperative period of RSA.

There is a concern in the literature about identifying the factors that influence the final result of RSA. Parsons et al[8] found that approximately 9% of patients who underwent primary RSA were dissatisfied with the result and that these cases were usually related to comorbidities, such as coronary disease, diabetes, and previous shoulder surgery.

In our study, we did not demonstrate interference of prognostic factors in the gain of deltoid muscle strength. Patients with nondominant UL surgery; patients receiving rotator cuff repair prior to arthroplasty; cases with greater bone destruction, absence or fatty degeneration of the teres minor; cases without subscapularis repair at the end of the arthroplasty procedure; and cases with postoperative complications did not present worse muscular strength in the evaluation.

The strengths and limitations of this review are as follows. There was a clear intention of the authors to render the evaluated groups as similar as possible in terms of age and the proportions of men and women. They also selected only patients operated on with RSA for CTA, thus bringing the most reliable results possible with the limited number of patients studied. We believe that the number of patients of the study limited the statistical analysis, especially in comparing prognostic factors. We consider the use of different brands and models of prostheses, as well as different glenosphere diameters, as a bias of the AG. In the CG, imaging tests were not performed to document the presence of possible asymptomatic rotator cuff injuries that could have compromised the muscle strength of these individuals.

Conclusion

The mean AFF in patients undergoing RSA for CTA was 15 N, and the mean LAF was 14 N. The comparison of AFF and LAF in a CG of similar ages showed a 25% reduction in muscle strength in patients undergoing RSA.

It was not possible to demonstrate prognostic factors for muscle strength recovery after RSA.

Declaration of Conflicting Interests

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