



# Reverse Shoulder Arthroplasty: Evaluation of the Clinical and Functional Outcomes per Etiology

## *Artroplastia reversa de ombro: Avaliação dos resultados clínicos e funcionais de acordo com a etiologia*

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### Abstract

**Objective** The present study aimed to evaluate the clinical outcomes of reverse shoulder arthroplasty to treat several conditions.

**Methods** Retrospective, longitudinal study analyzing the Constant and University of California at Los Angeles (UCLA) scores and range of motion of patients undergoing reverse shoulder arthroplasty.

**Results** In total, 28 patients were analyzed, with a mean age of 75.6 years old. The mean duration of follow-up was 45 months. Overall, there was a significant variation ( $p < 0.0001$ ) between the preoperative (10.2 points) and the postoperative UCLA scores (29.6 points), corresponding to a relative increase of approximately 200%. In addition, the mean Constant score was 67.8, and the complication rate was 17.8%. As for functional outcomes per etiology, fracture sequelae cases presented the best mean elevation (165°), Constant score (79 points), postoperative UCLA score (32.5 points), and absolute delta UCLA score increase (22 points), but with no statistical significance. However, cases operated for fracture sequelae showed significantly higher elevation ( $p = 0.027$ ) and Constant score ( $p = 0.047$ ) compared to rotator cuff arthropathy cases. In addition, the lowest mean postoperative Constant and UCLA scores were observed for the following etiologies: primary arthrosis, acute fracture, and arthroplasty revision.

**Conclusion** Reverse shoulder arthroplasty showed satisfactory functional outcomes and may be a treatment option not only for rotator cuff arthropathy but for several other conditions.

### Keywords

- ▶ arthropathy
- ▶ rotator cuff
- ▶ rupture
- ▶ arthroplasty, replacement, shoulder
- ▶ shoulder pain
- ▶ shoulder injuries
- ▶ shoulder prosthesis

\* Study developed at Hospital Ortopédico e Medicina Especializada (HOME), Instituto de Pesquisa e Ensino (IPEHOME), Brasília, DF, Brazil.

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## Resumo

**Objetivo** Avaliar os resultados clínicos da artroplastia reversa do ombro no tratamento de suas diversas indicações.

**Métodos** Estudo longitudinal retrospectivo que analisou os resultados dos escores Constant, UCLA e amplitudes de movimentos dos pacientes submetidos à artroplastia reversa do ombro.

**Resultados** Foram analisados 28 pacientes, a média de idade foi de 75,6 anos, com seguimento médio de 45 meses. No geral, obtivemos uma variação significativa ( $p < 0,0001$ ) entre o escore UCLA pré-operatório (10,2 pontos) e o escore UCLA pós-operatório (29,6 pontos), o que corresponde a um aumento relativo de aproximadamente 200%. Além disso, obtivemos pontuação média do escore Constant de 67,8 e uma taxa de complicações de 17,8%. Quanto aos resultados funcionais segundo as indicações, os casos de seqüela de fratura apresentaram as melhores médias de elevação ( $165^\circ$ ), escore Constant (79 pontos), escore UCLA pós-operatório (32,5 pontos) e aumento absoluto na variação do escore UCLA (22 pontos), sem significância estatística. Porém, identificou-se que os casos operados por seqüela de fratura apresentaram elevação ( $p = 0,027$ ) e pontuação no escore Constant ( $p = 0,047$ ) significativamente maiores em relação aos casos de artropatia do manguito rotador. Além disso, observamos que as menores médias dos escores Constant e UCLA pós-operatórios foram obtidos nas seguintes etiologias: artrose primária, fratura aguda e revisão de artroplastia.

**Conclusão** A artroplastia reversa de ombro apresentou resultados funcionais satisfatórios, podendo ser uma opção de tratamento não somente nos casos de artropatia do manguito rotador, mas também em várias outras patologias.

### Palavras-chave

- ▶ artropatias
- ▶ manguito rotador
- ▶ ruptura
- ▶ artroplastia do ombro
- ▶ dor de ombro
- ▶ lesões do ombro
- ▶ prótese de ombro

## Introduction

Reverse shoulder arthroplasty (RSA) was developed in 1985 by Grammont et al.<sup>1</sup> It is based on medialization and inferiorization of the rotational center of the glenohumeral joint, a mechanism that increases the lever arm and the deltoid force moment to compensate a rotator cuff (RC) deficiency.<sup>1,2</sup>

In addition to rotator cuff arthropathy (RCA),<sup>3-5</sup> RSA is currently indicated in extensive RC injuries,<sup>3,5,6</sup> fracture sequelae,<sup>3,7</sup> inflammatory arthropathies,<sup>3</sup> severe fractures of the proximal humerus,<sup>3,5</sup> primary arthroplasties revision,<sup>3,5</sup> and posttumor resection reconstruction.<sup>3,5</sup> Reverse shoulder arthroplasty is indicated mainly for elderly patients with decreased shoulder function and active anterior elevation lower than  $90^\circ$ ;<sup>3</sup> it is contraindicated in subjects with severe impairment or no deltoid contraction.<sup>3</sup>

Complications occur in rates ranging from 7.8 to 24% and include scapular notching, infection, instability, hematoma, component loosening, periprosthetic fractures, and neurovascular injuries.<sup>8-10</sup>

Therefore, RSA is a very useful procedure to treat several complex shoulder conditions, and outcomes and complications from each of these diseases have been increasingly studied. Our study aimed to evaluate the functional outcomes of RSA in the treatment of different etiologies. In view of the above and based on the literature,<sup>10</sup> we hypothesized that RSA functional outcomes would be better in patients with RC arthropathy when compared to other conditions.

## Methodology

### Study Design and Participants

This is a longitudinal, retrospective study. From 2011 to 2016, 35 patients underwent RSA. The study included patients with a minimum follow-up period of 24 months. Subjects who did not accept to participate in the research and those who were not able to contact were excluded from the sample. After applying the inclusion and exclusion criteria, 28 patients agreed to participate in the research and to visit the hospital for a reevaluation, totaling 28 shoulders.

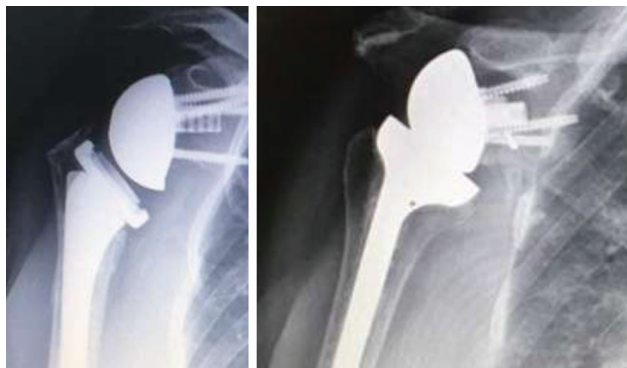
### Ethical Approval

All patients signed the informed consent form. The current study was submitted to evaluation and approval by the Committee for Ethics in Research on Human Beings, opinion number 2.430.846, CAAE 70804417.0.0000.0023.

### Surgical Procedure and Postoperative Rehabilitation

All procedures were performed by one of three surgeons. The implanted prostheses were Delta Xtend (DePuy Synthes, Warsaw, IN, USA) or Equinoxe Reverse Shoulder (Exactech, Inc., Gainesville, FL, USA) (– **Figure 1**).

The deltopectoral approach was chosen for all patients. The number of screws for base plate fixation was determined by the glenoid bone stock and the surgeon's preference. If intact, the subscapularis muscle was removed from the lesser



**Fig. 1** The two prosthesis models used in our cases (Equinoxe Reverse Shoulder [left] and Delta Xtend [right]).

tubercle and subsequently fixated using transosseous, non-absorbable sutures.

All patients followed the same standardized protocol for postoperative rehabilitation, using a sling for immobilization for 6 weeks; next, under the supervision of physical therapists, exercises for range of motion (ROM) gain started, initially with passive and active-assisted movements with a 90° limitation for abduction and frontal flexion. Muscle strengthening was stimulated from the 3<sup>rd</sup> postoperative month, and load was not advisable before then.

### Outcomes Analysis

Data collection during postoperative follow-up was carried out in two stages: 1–medical records review for demographic, surgical, and functional data collection; and 2–clinical evaluation, including functional variables and ROM data collection.

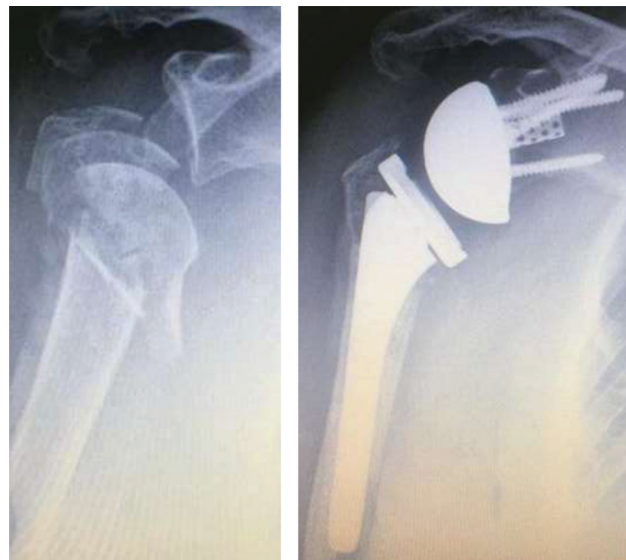
Collected data from medical records included age, follow-up duration, gender, operated shoulder side, diagnosis, complications, and preoperative University of California at Los Angeles (UCLA) score.<sup>11</sup> Since it is impossible to determine the preoperative UCLA score in subjects with acute proximal humeral fracture ( $n = 2$ ), this data was not obtained in two patients.

Diagnosis was determined as one of the following conditions: RC arthropathy (RCA); primary arthrosis associated with RC injury (elderly patients); acute, complex head-split fracture of the proximal humerus in elderly patients (► **Figure 2**); irreparable, extensive RC injury with chronic loss of limb elevation; arthroplasty revision; and fracture sequelae.

Rotator cuff injuries were deemed irreparable when: affecting more than one tendon; larger than 5 cm; or resulted in grade III or IV fatty degeneration of muscle bellies, according to the Goutallier et al.<sup>12</sup> classification system.

Functional shoulder analysis was performed by a trained researcher who was not part of the surgical team. At follow-up, Constant<sup>13</sup> and UCLA<sup>11</sup> scores were evaluated, along with active ROM for elevation, lateral rotation (LR), and medial rotation (MR), which were determined by goniometry.

In addition, ROM parameters, functional scores, and satisfaction in age, gender, and shoulder side subgroups were



**Fig. 2** Pre and postoperative acute, complex head-split fracture of the proximal humerus in an elderly patient.

compared, and any association between follow-up duration and age, ROM, and functional scores was verified.

The satisfaction survey proposed by the author was conducted by asking patients if they were very satisfied, satisfied, or not satisfied with treatment outcomes.

### Statistical Analysis

After data tabulation, a descriptive analysis was performed. Numerical data were expressed by appropriate central trend and dispersion measurements, whereas categorical data were expressed as frequency and percentage; in addition, the difference between post and preoperative UCLA score (delta UCLA) was calculated.

The statistical analysis was performed by an independent statistician and consisted of a Wilcoxon signed rank test to confirm UCLA score variation between the pre and postoperative period, except in patients with acute fractures; The Student t-test, Mann-Whitney, chi-squared, and Fisher exact tests were used to compare ROM parameters, functional scores, and satisfaction in age, gender, and shoulder side subgroups; and a Spearman's correlation coefficient determination to prove any association between follow-up duration, age, ROM, and functional scores.

A previous analysis was performed to ascertain data normality using the Shapiro-Wilk test and histogram analysis. A non-parametric test was used for variables with a non-Gaussian distribution. Significance level was set at 5%. The statistical analysis was processed using SAS System statistical software, version 6.11 (SAS Institute, Inc., Cary, NC, USA).

An extremely exploratory analysis was carried out to determine if the evaluated parameters presented a significant difference regarding the studied etiologies. This analysis was performed on an exploratory basis due to the very small sample for some categories ( $n = 2$ ), explaining why the interquartile range (IQR) has no upper limit (Q3).

Initially, the Kruskal-Wallis analysis of variance (ANOVA) was used to find out if there was a significant difference at a

5% level when the 6 conditions were compared simultaneously; the Mann-Whitney test was used only on an exploratory basis to identify trends in results.

## Results

### General Clinical and Functional Outcomes

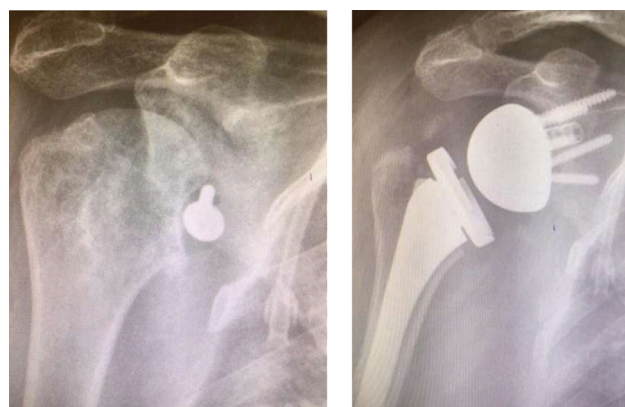
In total, this study evaluated 28 patients with a mean age of 75.6 years old (range, 58–86 years old). The mean follow-up duration was 45 months (range, 24–84 months). The sample was mostly female, with 89.3% of women. The most frequently affected shoulder was the right one, corresponding to 75% of the cases (►Table 1).

The most prevalent indication for the procedure was RCA (39.3%), followed by the irreparable, extensive RC injury (28.6%) and arthroplasty revision (10.8%). Each remaining indication accounted for 7.1% of the cases (►Table 1). Two patients presented fracture sequelae, including (1) an anterior glenoid fracture with anterior instability of the shoulder, progressing to anterior subluxation of the humeral head and implant-related arthropathy (►Figure 3); and (2) a complex proximal humeral fracture under non-surgical treatment for 5 years, which evolved to symptomatic glenohumeral arthrosis. On the other hand, patients from the arthroplasty revision group had undergone previous partial (one subject) or total (one subject) anatomical arthroplasty.

**Table 1** Clinical characterization of the sample

Variable		
Age (years old)		
mean ± SD (minimum–maximum value)	75.6 ± 6.4 (58–86)	
Age at surgery		
	N	%
> 75 years old	15	53.6
≤ 75 years old	13	46.4
Gender		
male	3	10.7
female	25	89.3
Follow-up (months)		
mean ± SD (minimum–maximum value)	45 ± 16.7 (24–84)	
Shoulder		
right	21	75.0
left	7	25.0
Condition		
Rotator cuff arthropathy	11	39.3
Primary arthrosis	2	7.1
Acute fracture	2	7.1
Extensive rotator cuff injury	8	28.6
Prosthesis revision	3	10.8
Fracture sequelae	2	7.1

Abbreviation: SD, Standard deviation.



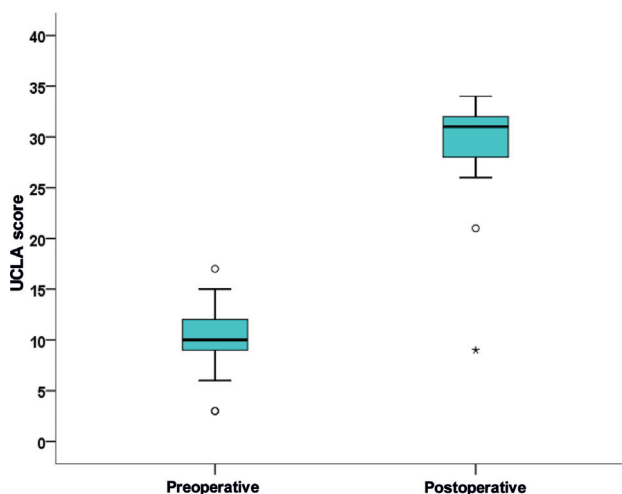
**Fig. 3** Pre and postoperative period from the fracture sequelae group.

Mean active ROMs were 137.6° for elevation, 16.7° for LR, and between L1 and L2 for MR (►Table 2).

Regarding functional scores, the median preoperative UCLA score ( $n = 26$ ) was 10 points, and median postoperative UCLA score ( $n = 26$ ) was 31 points, with a significant variation ( $p < 0.0001$ ) corresponding to a relative increase of approximately 200% ( $n = 26$ ), as shown in ►Figure 4.

An additional functional evaluation, the mean postoperative Constant score was 69.4 points (►Table 2).

As for satisfaction, only one patient reported being not satisfied; the remaining subjects declared themselves satisfied (39.3%) or very satisfied (57.1%) with the procedural outcomes (►Table 2). This patient, a 75-year-old woman, was submitted to a hemiarthroplasty revision; the original procedure was performed due to a complex fracture of the proximal extremity of the humerus, which progressed with RC rupture, severe pain, and significant ROM reduction. Her UCLA score was 3 points before reverse arthroplasty. At the functional evaluation, performed 24 months after RSA, the patient presented the following results: 50° of anterior elevation, 0° of LR, RC at the gluteus level, a Constant score of 28 points and an UCLA score of 9 points (►Figure 5).



**Fig. 4** Pre and postoperative University of California at Los Angeles (UCLA) score.

**Table 2** Functional score and satisfaction classification

Variable		
Constant score		
mean $\pm$ SD (minimum–maximum value)	67.8 $\pm$ 12 (28–93)	
Preoperative UCLA score*		
mean $\pm$ SD (minimum–maximum value)	10.2 $\pm$ 3.2 (3–17)	
Postoperative UCLA score*		
mean $\pm$ SD (minimum–maximum value)	29.6 $\pm$ 5.1 (9–34)	
Absolute delta UCLA		
mean $\pm$ SD (minimum–maximum value)	19.4 $\pm$ 5 (6–31)	
Delta (%) UCLA		
mean $\pm$ SD (minimum–maximum value)	228 $\pm$ 180.2 (86.7–1,033)	
Elevation (°)		
mean $\pm$ SD (minimum–maximum value)	137.6 $\pm$ 25.1 (50–165)	
Lateral rotation		
mean $\pm$ SD (minimum–maximum value)	16.7 $\pm$ 17.7 (0–60)	
Medial rotation (lumbar vertebrae)		
mean	L1/L2	
Satisfaction classification		
not satisfied	1	3.6
satisfied	11	39.3
very satisfied	16	57.1

Abbreviations: SD, standard deviation, UCLA, University of California at Los Angeles.

\*Not applicable to 2 patients ( $n = 26$ ).

### Clinical and Functional Outcomes Evaluation per Etiology

As for functional outcomes per etiology, the fracture sequela group presented the best results for elevation, LR, Constant score, postoperative UCLA score, and absolute increase in delta UCLA score (**Table 3**). The prosthesis revision group had the worst results for elevation, LR, Constant score, postoperative UCLA score, and delta UCLA score (**Table 3**). The Mann-Whitney test revealed that fracture sequelae cases showed significantly higher elevation ( $p = 0.027$ ) and Constant score ( $p = 0.047$ ) compared to RCA (**Table 4**). Patients who underwent a prior arthroplasty revision had significantly lower LR values compared to subjects operated for RCA, acute fracture, extensive RC injuries, and fracture sequelae (**Table 4**).

### Complications

Postoperative complications were observed in 5 patients (17.8%): (1) one case of periprosthetic humeral fracture during the surgical procedure, distal to the tip of the nail,



**Fig. 5** Pre and postoperative period from the primary arthroplasty revision group.

which was submitted to a non-surgical treatment and progressed to complete consolidation; (2) another case of periprosthetic fracture, which occurred due to a fall 19 months after reverse arthroplasty, treated with osteosynthesis and fixation with plate and screws (**Figure 6**); (3) 1 case of infection treated with surgical debridement and antibiotic therapy; (4) 1 case of radial nerve neuropraxia, with complete recovery in 3 months; (5) 1 case of prosthesis dislocation 2 months after RSA, treated with reduction under anesthesia, with no need for a new procedure.

The transoperative periprosthetic fracture and the radial neuropraxia were observed at the RCA group. The infection was identified in a patient with primary arthrosis, while the late periprosthetic fracture occurred in a subject with acute proximal humeral fracture. In addition, the prosthesis dislocation occurred in an arthroplasty revision case.

### Discussion

Currently, RCA is the most frequent indication for RSA, and the prevalence for other indications varies according to the author.<sup>4,5,14,15</sup> In our study, the most common indication for RSA was RCA (39.3%), followed by extensive RC injury (28.6%) and prosthesis revision (10.8%). Each remaining indication, that is, primary arthrosis, acute fracture, and fracture sequelae, accounted for 7.1% of the cases.

The indication type must be analyzed because etiology is related to success and complication rates.<sup>5</sup> In our analysis, fracture sequelae cases presented the best mean values for elevation (165°), Constant score (79 points), postoperative UCLA score (32.5 points), and absolute increase in delta UCLA score (22 points), with no statistical significance. However, cases operated due to fracture sequelae showed significantly higher elevation ( $p = 0.027$ ) and Constant score ( $p = 0.047$ ) compared to RCA.

Wall et al.<sup>16</sup> retrospectively evaluated 191 patients who underwent reverse arthroplasty for different etiologies. With

**Table 3** Clinical variable, functional score, and range of motion per etiology

Variable	Rotator cuff arthropathy		Primary arthrosis		Acute fracture		Extensive rotator cuff injury		Arthroplasty revision		Fracture sequelae	
	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean
<b>Clinical variables</b>	11		2		2		8		3		2	
Age at surgery (years old)		75.6		79		78.5		75.3		80		64.5
Follow-up (months)		45.5		53		25		46.5		33.3		65
<b>Range of motion</b>												
Elevation (°)		139.9		135		110		150.6		96.7		165
Lateral rotation (°)		19.5		0		10		24		0		20
Medial rotation (°; lumbar vertebrae)		13.5		17		16		14		15.5		14
<b>Functional scores</b>												
Constant score		69.5		61.5		59		73.4		49		79
Preoperative UCLA score		10.5		10.5		–		11.1		6		10.5
Postoperative UCLA score		31.1		28		30		30.6		20.7		32.5
Absolute delta UCLA		20.5		17.5		–		19.5		14.7		22

Abbreviation: UCLA, University of California at Los Angeles.

a mean follow-up period of 39.9 months, these authors showed that patients with RCA, primary arthrosis, and extensive RC injury had better results compared to subjects with posttraumatic arthrosis and arthroplasty revision indication. Similarly, Wellmann et al.<sup>17</sup> showed that RSA resulted in significantly higher Constant scores in patients with RCA compared to those requiring an arthroplasty revision.

Even though patients from the prosthesis revision group showed a functional improvement in the UCLA score similar to that of the remaining groups, they did not reach the same performance level. Wall et al.<sup>16</sup> also observed worse functional outcomes in arthroplasty revision patients, with 118° of shoulder elevation and a Constant score of 52.2 points.



**Fig. 6** Periprosthetic fracture treated with osteosynthesis using plate and screws.

Boileau et al.<sup>18</sup> compared reverse arthroplasty outcomes in patients with RCA, fracture sequelae, and arthroplasty revision, and also concluded that the three groups showed significant elevation and Constant score gains but with significantly lower values at the arthroplasty revision group.

Patients with RCA did not present the best UCLA and Constant scores in our study. However, when analyzed alone, these values were consistent with most of the literature,<sup>5,16,17</sup> confirming that RCA is a classic indication for RSA, with satisfactory functional outcomes.

Fávaro et al.<sup>8</sup> evaluated RSA outcomes in patients with RCA and observed a significant improvement in the preoperative (10.1) to the postoperative UCLA score (29.8). This finding was consistent with our study, which revealed a mean preoperative UCLA score of 10.2 and a significant difference ( $p < 0.0001$ ) compared to the mean postoperative UCLA score (29.6). On average, the absolute delta UCLA score increased in 19.4 points.

Another functional score assessed by our study was the postoperative Constant score, with a mean value of 67.8 points. Atalar et al.<sup>19</sup> observed an average Constant score ranging from 20.7 before the procedure to 58.9 points at the end of the follow-up. Amaral et al.<sup>20</sup> evaluated RSA outcomes in patients with RMA, revealing a mean Constant score of 60 points.

As for ROM, we found a mean elevation value of 137.6°, lower compared to reports from Atalar et al.<sup>19</sup> and Amaral et al.,<sup>20</sup> of 150° and 149°, respectively. Our patients presented a mean LR of 16.7°, slightly lower compared to these same authors, who found average values of 20° and 37°, respectively.<sup>19,20</sup> This difference may be due to the fact that both studies evaluated only patients operated for RCA and who

**Table 4** Descriptive level (*p*-value) of Kruskal-Wallis analysis of variance and Mann-Whitney test for each condition pair

Clinical variable	ANOVA	Comparison of paired conditions (Mann-Whitney test)														
		1 × 2	1 × 3	1 × 4	1 × 5	1 × 6	2 × 3	2 × 4	2 × 5	2 × 6	3 × 4	3 × 5	3 × 6	4 × 5	4 × 6	5 × 6
Age at surgery (years old)	0.31	0.43	0.49	1.00	0.43	0.11	1.00	0.69	1.00	0.12	0.23	0.56	0.12	0.15	0.064	0.083
Follow-up (months)	0.10	0.92	<b>0.029</b>	0.93	0.12	0.23	0.12	0.90	0.56	0.44	<b>0.036</b>	0.37	0.12	0.18	0.12	0.083
<b>Range of motion</b>																
Elevation	<b>0.005</b>	0.16	0.071	0.071	0.067	<b>0.027</b>	0.10	<b>0.035</b>	0.55	0.083	<b>0.036</b>	0.77	0.10	<b>0.018</b>	<b>0.035</b>	0.076
Lateral rotation	<b>0.022</b>	<b>0.027</b>	0.68	0.61	<b>0.009</b>	0.32	0.083	<b>0.034</b>	1.00	0.083	0.59	<b>0.046</b>	0.083	<b>0.013</b>	1.00	<b>0.046</b>
Medial rotation	0.16	<b>0.028</b>	0.11	0.36	0.23	0.92	0.32	0.060	0.32	0.10	0.35	0.68	0.22	0.50	0.60	0.44
<b>Functional scores</b>																
Constant score	<b>0.041</b>	0.058	0.073	0.53	0.10	<b>0.047</b>	1.00	<b>0.049</b>	0.56	0.12	0.067	0.56	0.12	0.15	0.36	0.083
Preoperative UCLA score	0.24	0.92	–	0.45	<b>0.040</b>	0.84	–	0.69	0.14	1.00	–	–	–	0.064	0.60	0.083
Postoperative UCLA score	0.18	0.069	–	0.80	0.13	0.42	–	0.18	0.55	0.10	–	–	–	0.17	0.23	0.14
Absolute delta UCLA	0.29	0.084	–	0.22	0.34	0.22	–	0.69	0.56	0.10	–	–	–	0.31	0.19	0.55

Abbreviations: ANOVA, analysis of variance; UCLA, University of California at Los Angeles.

1 - Rotator cuff arthropathy; 2 - primary arthrosis; 3 - acute fracture; 4 - extensive rotator cuff injury; 5 - arthroplasty revision; 6 - fracture sequelae. Bold indicates significant difference at a 5% level.

were younger than our patients. However, the mean MR in our sample was between L1 and L2, higher than the average described in these same studies.<sup>19,20</sup>

In our study, the complication rate was 17.8% (5 cases). Wall et al.<sup>16</sup> observed a 19.1% rate, reporting dislocation (7.5%) and infection (4%) as the most frequent complications. Similarly, for Boileau et al.<sup>18</sup> the complication rate after RSA was 24%, and dislocation and infection were the most common intercurrents.

The limitations of our study include its observational nature, small sample size, and disproportionate number of patients in each etiology group, making it difficult to compare their outcomes. Our strength lies on the postoperative analysis of several shoulder functionality parameters.

## Conclusion

Reverse shoulder arthroplasty resulted in satisfactory functional outcomes and may be a treatment option not only for RCA, but for several other conditions. The preoperative etiology influences the clinical outcomes of RSA, with patients undergoing arthroplasty revision presenting inferior outcomes compared to those with other indications.

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### Conflict of Interests

The authors declare no conflicts of interests.

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