Comparison of Early Range of Motion in Reverse Shoulder Arthroplasty Based on Indication: A Single Center Retrospective Review

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Abstract

Background: Reverse shoulder arthroplasty (RSA) is commonly used in the treatment of rotator cuff arthropathy. Indications for RSA have expanded to include complex proximal humerus fractures. Studies directly comparing outcomes between traumatic and traditional elective indications are limited. The purpose of this study was to compare early active range of motion (aROM) within the first two years postoperatively between traumatic and non-traumatic primary RSA, as well as compare ASES scores, and patient satisfaction at final follow-up.

Methods: A retrospective analysis was conducted of all RSA performed by a single surgeon between January 2000 and December 2018. Patients were grouped by indication into traumatic and non-traumatic elective groups. Demographics, surgical data, and routine aROM data were collected. aROM was compared at 3, 6, 12, and 24 months. American Shoulder and Elbow Surgeons (ASES) score and patient satisfaction were determined at the time of this investigation.

Results: 367 RSA procedures were performed by the senior author during the study period, 88 for fracture (24%), and 279 for non-traumatic elective indications (76%). Forward elevation and external rotation were inferior in the fracture group at all time points in the first two years. Internal rotation was equivalent throughout the first two years. Final ASES scores were 77.6 versus 83.5 in the fracture and non-fracture groups, respectively ($p = .33$).

Conclusion: Patients undergoing RSA for fracture had statistically significant inferior aROM in forward elevation and external rotation throughout the first two years. Despite having inferior aROM, ASES scores and patient satisfaction at final follow-up were statistically equivalent.

Level of Evidence: Level III; Retrospective Cohort Comparision; Prognosis Study

Introduction

Reverse shoulder arthroplasty (RSA) was introduced to restore function in rotator cuff deficient shoulders, but indications have since expanded to include irreparable RCT, rotator cuff repair failure, rotator cuff tear in elderly, primary osteoarthritis, complex fractures, instability arthropathy, or HA or TSA failure. Reported outcomes after reverse shoulder arthroplasty have been excellent, with high rates of pain relief and improvements in functional scores and range of motion (ROM) reported throughout the literature.

RSA for management of both acute non-reconstructable fractures of the proximal humerus and the chronic sequela of fracture has gained popularity, especially in the treatment of elderly patients.[1,2] With the increasingly active elderly population expanding, the utilization of RSA in the acute trauma setting continues to rise. In comparing RSA to open reduction and internal fixation (ORIF) in the management

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of acute proximal humerus fractures, similar final aROM has been reported, with higher rate of re-operation in ORIF group.[3,4] RSA has also been reported to have a lower overall cost when compared to ORIF, with higher initial implant costs being offset by additional rehab and physical therapy costs and higher revision rates in the ORIF group.[5]

Two meta-analyses of the literature on RSA for fracture patients reported on quality of life scores and average aROM of 113–122°, 97°, 12–18°, and 38° in forward flexion (FF), abduction (Ab), external rotation (ER), and internal rotation (IR) respectively.[5,6] Two NSQIP database studies found fracture indication for RSA to be associated with longer operative time, longer hospital length of stay, increased discharge to skilled care facilities, increased blood transfusions, and increased thromboembolic events.[7,8] RSA for treatment of fracture was deemed a more complex episode of care. However, no comment could be made on ROM or patient reported outcomes due to the design of these studies.

Little has been written to date directly comparing clinical outcomes of RSA for fracture and non-fracture indications, and the results of these few studies have been discordant. Two studies report no difference in final aROM or patient reported outcomes scores.[9,10] One study reports a difference in forward elevation, as well as early differences in functional scores which become equivalent around 6 months to 1 year.[11] Two describe a statistical difference in aROM and patient reported outcomes only in chronic fracture sequela subgroups.[12,13] All authors evaluated aROM at a single time point at final follow-up which ranged from 40–101 months postoperatively. Acutely managed fractures were generally poorly represented in these studies.

The purpose of this investigation was to determine whether early aROM throughout the first two years after RSA differed based on indication. We hypothesized that patients undergoing RSA for traumatic indications, both acute and chronic, would have inferior outcomes compared to elective non-traumatic patients.

Materials and Methods

This study is a retrospective review of all primary RSA done at a single center between January 2000 and December 2018 performed by the senior author. After institutional review board approval, patients were identified and categorized by indication—fracture related versus non-fracture related. Patients with at least 3 months of clinical and radiographic follow-up were included. Patients treated for tumor, prior infection, or undergoing revision arthroplasty were excluded. Indications were further subcategorized within the two groups. Within the fracture group, patients were further subcategorized as acute fracture (treated <6 weeks post injury) and chronic sequela (treated >6 weeks post injury). Within the non-fracture group, patients were subcategorized as primary rotator cuff arthropathy (RCA), primary osteoarthritis, massive rotator cuff tear with pseudoparalysis, and inflammatory arthritis. Inflammatory arthropathy was not included in subgroup analysis due to a small number of patients.

Demographic data and injury characteristics were collected from charts including age, sex, comorbid medical conditions, and fracture characteristics. Fractures were classified by both the Neer classification scheme as well as that described by Boileau et al[14] in the chronic setting. Displacement of the greater tuberosity was measured by maximum displacement in the coronal, sagittal, or axial plane as measured on routine preoperative CT scan. Surgical information was collected from preoperative clinic notes as well as operative dictations.

Postoperative aROM data was collected at 3, 6, 12, and 24 months. The senior author's standard practice included goniometer measurement of aROM at all follow-up visits. FE and ER were measured in degrees, and IR was estimated by standard anatomic landmarks. As fracture patients did not have any preoperative aROM data recorded, this variable was not collected in this investigation. American Shoulder and Elbow Society (ASES) scores were collected via a phone survey at the time of this investigation. Additionally, at the time of survey, patients were asked to rate their overall satisfaction: very satisfied, satisfied, neutral/uncertain, or dissatisfied, which were scored as 1–4 numerically for analysis. Postoperative complications were identified by review of clinic notes and review of all subsequent postoperative radiographs.

Primary outcome measures included aROM in 3 planes (Forward Elevation, External Rotation, Internal Rotation) between fracture and non-fracture patients. Two-tailed T-tests were used to compare these values. A post hoc power analysis was performed, assuming means with equal variance with an alpha of 5% and power of .80, revealed 31 patients per group required to detect a 20 degree difference in aROM. Patients with final aROM in FE less than 90 degrees were classified an "unsatisfactory result." Chi-squared tests were used to compare the incidence of unsatisfactory results within each group. Secondary outcomes included ASES scores, patient satisfaction, revision rates, and subgroup comparisons within the indications groups previously mentioned.

All operations were performed by the senior author utilizing a standard deltopectoral approach. The Delta Xtend Reverse Shoulder System (DePuy, Raynham, MA) was used through July 2016, and the Zimmer Biomet Comprehensive Reverse Shoulder System (Zimmer Biomet, Warsaw, IN) was used from July 2016 to present. In non-fracture indications, a micro-stem was routinely utilized. The subscapularis tendon was sub periosteally dissected off the lesser tuberosity and was routinely not repaired. In the fracture group, a long or intermediate stem was routinely used, with or without cement at the discretion of the senior author based on intraoperative bone quality assessment.

Tuberosity repair was performed with suture in the absence of significant comminution and in the absence of significant tendon retraction. In the majority of cases the tuberosities were resected. All patients underwent the same postoperative protocol: non-weight bearing for six weeks, the use of a sling, aROM as tolerated, but no active internal rotation behind the back for six weeks.

Results

A total of 367 RSA procedures were completed by the senior author during the study period—24% for traumatic indications (88 patients), and 76% non-traumatic indications (279 patients). In the traumatic group, 73 RSA were done for acute fractures and 15 for chronic fracture sequela. In the acute fracture group 66 patients had 3 or 4-part fractures and 7 presented with head split patterns. 16 patients initially presented with anterior dislocation. Tuberosity repair was performed in 24% of the traumatic group. In the non-traumatic group, 142 patients had a diagnosis of rotator cuff arthropathy, 90 primary osteoarthritis, 45 irreparable rotator cuff tear, and 2 inflammatory arthropathy. There were no statistical differences between study groups in age, duration of follow-up, smoking status, or Charlson Comorbidity Index. The fracture group was predominantly

females, which was statistically different from the non-fracture group. Full demographic data is shown in Table 1.

Active range of motion in FE and ER was inferior in the traumatic group at all time points compared to the non-traumatic group, while IR was equivalent at all time points. Figures 1–3 display aROM in flexion, external rotation, and internal rotation, respectively. Subgroup analysis within the fracture patients revealed no statistical difference between the acute fracture and chronic fracture sequela groups in any plane of motion at any time point. Initial presentation with dislocation, initial degree of greater tuberosity displacement, and tuberosity repair status were all not associated with inferior aROM. Complete primary aROM analysis and subgroup analysis are seen in Tables 2 and 3, respectively. In the fracture group, the percentage of patients available at 3, 6, 12, and 24 months was 100%, 73% (64/88), 55% (48/88), and 33% (29/88), respectively. In the non-fracture group, follow up at 3, 6, 12, and 24 months was 100%, 67% (187/279), 57% (159/279), and 27% (74/279), respectively.

Despite differences in aROM between groups, ASES scores and patient reported satisfaction scores were equivalent (Table 4). 17 patients (18%) in the fracture group were available for survey completion at an average of 53.1 months, compared to 47 patients (17%) in the non-fracture group at 56.6 months post operatively. Patients in the fracture group reported average ASES score of 77.6 compared to 83.5 in the non-fracture group ($p = .33$). Average patient reported satisfaction was 1.24 in the fracture group compared to 1.32 in the non-fracture group ($p = .069$). In the fracture group, 14 reported being very satisfied, 2 somewhat satisfied, and 1 neutral or dissatisfied. In the non-fracture group, 39 were very satisfied, 3 somewhat satisfied, and 5 neutral or dissatisfied. As a surgeon reported satisfactory outcome, we decided upon active forward elevation to at least 90 degrees. At 1 year follow up, 32/49 patients (65%) in the fracture group were

Table 1. Demographic Data in the Fracture and non-Fracture Indications Groups.

	Fracture (n = 88)	Non-Fracture (n = 278)	p
Age (years)	69.7 ± 9.0	69.5 ± 9.4	.85
Female	72	139	<.001
DM	17	46	.63
Smoking	10	22	.39
Average CCI	3.7	3.8	.27
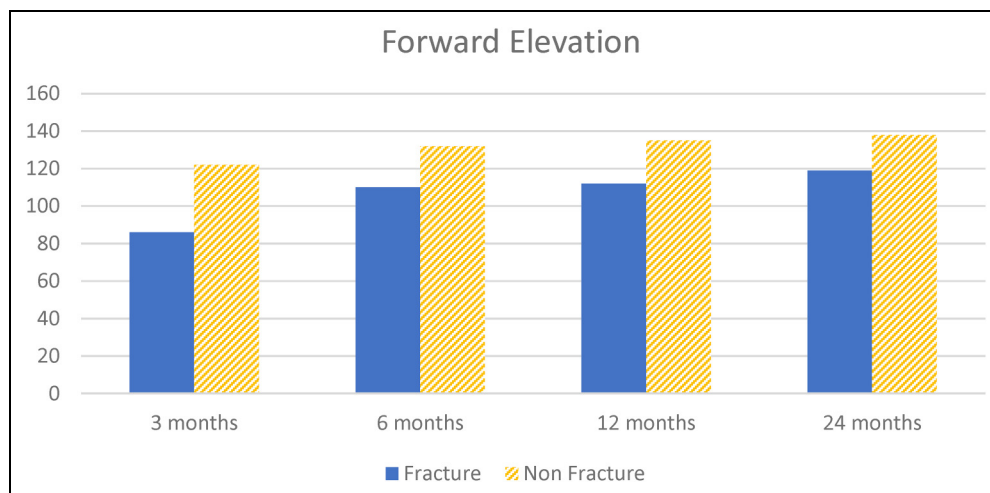
Figure 1. Forward elevation (in degrees) at 3-, 6-, 12-, and 12-months postoperative.
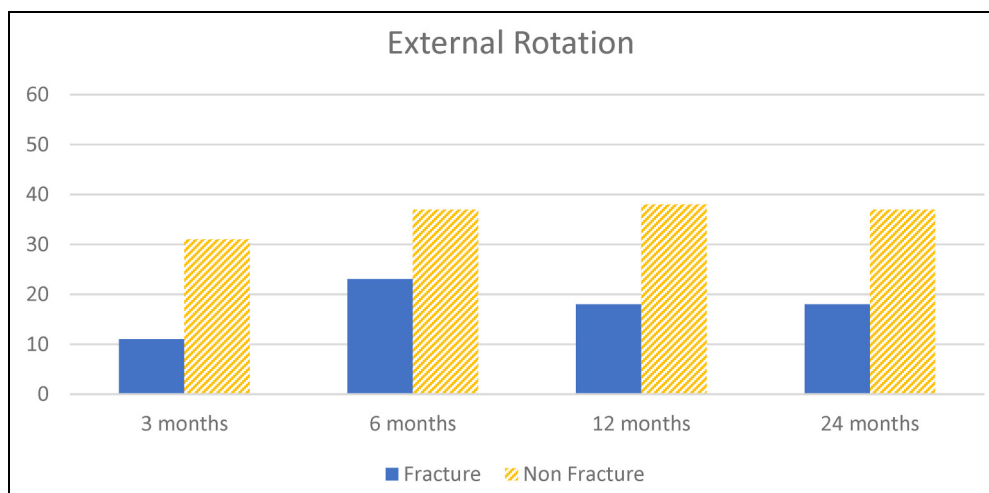
Figure 2. External rotation (in degrees) at 3-, 6-, 12-, and 12-months postoperative.
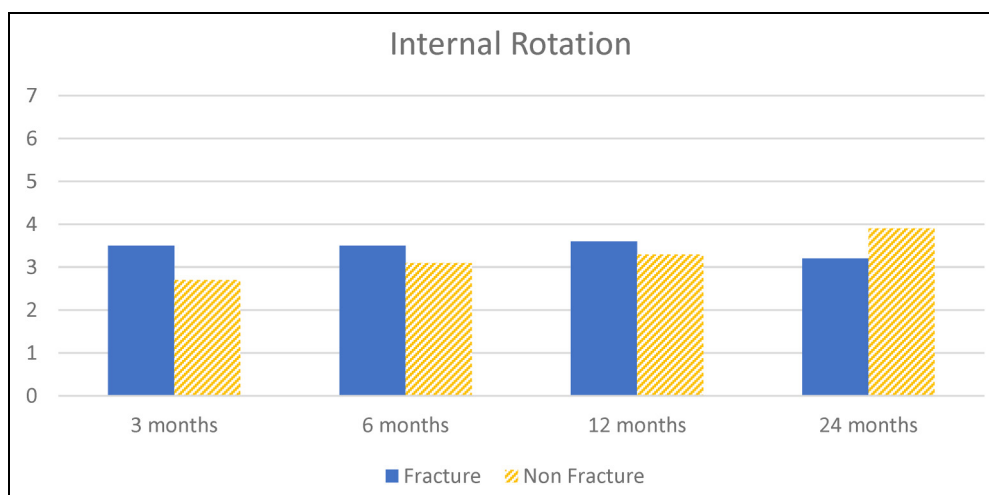
Figure 3. Internal rotation at 3-, 6-, 12-, and 12-months postoperative. Internal rotation scored as the following: 1 = greater trochanter, 2 = sacrum, 3 = iliac crest, 4 = L3, 5 = L2, 6 = L1, 7 = T12, 8 > = T11.

able to achieve this as compared to 120/143 (84%) in the non-fracture group ($p = .005$). By 2 year follow up, 20/24 patients (83%) in the fracture group could achieve this benchmark compared to 52/62 (84%) in the non-fracture group ($p = .95$).

Three revisions occurred in each group. In the fracture group, two were for instability with dislocation, and one was for infection. In the non-fracture group, two were for acromial fractures, and one was for aseptic loosening of the humeral component.

Discussion

The literature comparing RSA outcomes by indication is currently limited. Few studies exist in the literature directly comparing traumatic and non-traumatic indications. These series report aROM in RSA for fracture compared to non-traumatic comparison groups. However, the differences in aROM often fail to reach statistical significance. Moreover, traumatic indications are underrepresented in most of these series, particularly RSA for acute management of proximal humerus fractures.

One prior study reported statistically inferior active FE in acute traumatic RSA, with an acute fracture group representing 6% of the series.[11] Two series found a statistical inferiority in aROM in chronic fracture patients compared to non-traumatic indications, but not in acute fractures managed with RSA.[12,13] However, one of these series had less than 3% acute proximal humerus fractures, and the other included only 1% acute fractures. This may account for the lack of significant findings in the acute fracture group. Another series demonstrated a trend towards inferiority in active FE in a sizable acute fracture group, but this did not reach statistical significance.[10] The final series found no

Table 2. Range of Motion Results at 3-, 6-, 12-, and 24-Months Postoperative.

	3 months (mean ± SD)	6 months (mean ± SD)	12 months (mean ± SD)	24 months (mean ± SD)
Fracture Group, Total (n)	88	64	48	29
Forward Elevation (°)	86 ± 38 **	110 ± 33**	112 ± 35**	119 ± 27**
External Rotation (°)	11 ± 14**	23 ± 17**	18 ± 18**	18 ± 15**
Internal Rotation (φ)	3.5 ± 1.7	3.5 ± 1.8	3.6 ± 2.3	3.2 ± 2.5
Non-Fracture Group, Total (n)	279	187	159	74
Forward Elevation (°)	122 ± 29	132 ± 24	135 ± 18	138 ± 18
External Rotation (°)	31 ± 16	37 ± 16	38 ± 18	37 ± 17
Internal Rotation (φ)	2.7 ± 1.3	3.1 ± 1.5	3.3 ± 1.8	3.9 ± 2.3

Number of patients with available follow up data at each time point is reported. Forward elevation and external rotation measured in degrees. Internal rotation (φ) scored as the following: 1 = greater trochanter, 2 = sacrum, 3 = iliac crest, 4 = L3, 5 = L2, 6 = L1, 7 = T12, 8 > = T11. Statisical significance: * $p < .05$, ** $p < .01$.

Table 3. Range of Motion Subgroup Analysis.

		3 months (mean ± SD)	6 months (mean ± SD)	12 months (mean ± SD)	24 months (mean ± SD)
Fracture Group (Subgroups)					
Acute Fracture	FE (°)	91.4 ± 37.8**	110.2 ± 34.6**	114.4 ± 37.1**	122.5 ± 25.7*
(n = 73)	ER (°)	11.1 ± 16.3**	24.8 ± 18.4*	19 ± 18.7**	19.6 ± 12.3**
	IR (φ)	3.7 ± 1.8	3.4 ± 1.8	3.4 ± 2.0	2.8 ± 1.4
Chronic Fracture	FE (°)	84.3 ± 41.9*	106.9 ± 23.7	101.9 ± 18.9**	104 ± 31.5
(n = 15)	ER (°)	10.6 ± 9.8**	18.3 ± 11.3*	16 ± 18.5	23 ± 22.8
	IR (φ)	2.5 ± 0.8	3.7 ± 2.0	4.8 ± 3.3	5.8 ± 3.9
Non-Fracture Group (Subgroups)					
Primary OA	FE (°)	126.9 ± 26.7	136.2 ± 16.1	137.9 ± 15.8	141.7 ± 13.6
(n = 142)	ER (°)	32.7 ± 15.5	37.7 ± 15.7	38.7 ± 18.2	40.1 ± 18.0
	IR (φ)	2.5 ± 1.0	3.1 ± 1.6	3.5 ± 1.9	3.7 ± 2.4
RCA	FE (°)	113 ± 30*	124 ± 32.5*	128.8 ± 20.6	126.7 ± 26.1
(n = 90)	ER (°)	25.9 ± 17.7	34.7 ± 17.2	32.2 ± 21.8	28.5 ± 15.8
	IR (φ)	3 ± 1.7	3.3 ± 1.6	3.1 ± 1.7	4.4 ± 2.0
Irreparable Cuff	FE (°)	125.4 ± 27.2	134.4 ± 20.8	138 ± 12.2	143.4 ± 10.2
(n = 45)	ER (°)	35.3 ± 13.7	38.1 ± 13.9	41.1 ± 10.7	42.1 ± 11.3
	IR (φ)	2.6 ± 1.1	2.7 ± 0.92	3.4 ± 1.5	4.5 ± 2.2

Internal rotation (φ) scored as the following: 1 = greater trochanter, 2 = sacrum, 3 = iliac crest, 4 = L3, 5 = L2, 6 = L1, 7 = T12, 8 > = T11. Statisical significance: * $p < .05$, ** $p < .01$.
Forward elevation and external rotation measured in degrees.

difference in aROM based on indication, but only evaluated 5 patients with chronic fracture sequela, and included no acute fractures.[9]

In addition, these prior studies focus on evaluation of aROM at a single time point at final follow-up, typically several years post operatively. The current study recorded aROM at multiple time points up to two years. Our study demonstrates inferior active FE and ER in the fracture group as compared to the non fracture group. This was true for both the acute fracture and chronic fracture sequela subgroups. These findings persist throughout the first two years postoperatively.

The current study has some important differences compared to the previously mentioned investigations. The first difference is a more balanced distribution of indications, with 24% of our series being treated for fracture related indications, and the majority being acute fractures. This represents the second largest series to date of RSA for acute fracture-related indication with a direct non-fracture comparison group. With the increasing popularity of RSA in this setting, this warrants further investigation. The current investigation is also the first to track patients' ROM longitudinally over time during the early follow-up period, rather than evaluate patients at a single time point several years postoperatively. The investigation by Crespo et al. showed agreement with the current study that forward elevation is inferior in the fracture indications group.[11] While this was only measured at a single time point by Crespo et al., they did track functional scores over time which were inferior throughout early follow-up and are influenced by ROM.

There are several possible explanations why other similar studies did not find significant differences in ROM by

Table 4. Outcomes Scores (ASES and Subjective Satisfaction) and Revision Rates.

	Fracture Group	Non-Fracture Group	p
ASES Score (mean ± SD)	77.6 ± 16.1	83.5 ± 22	.33
Subjective Satisfaction (mean ± SD)	1.24 ± 0.56	1.32 ± 0.78	.069
Very Satisfied	14/17	39/47	
Somewhat Satisfied	2/17	3/47	
Neutral	1/17	3/47	
Dissatisfied	0/17	2/47	
1 Yr Satisfactory FE	32/49	120/143	.005
2 Yr Satisfactory FE	20/24	52/62	.95

indication. The prior studies may have been underpowered to demonstrate a statistically significant difference in ROM, particularly in their acute fracture cohorts. Alternatively, given that prior studies all relied on a single measurement of ROM at long term follow-up, it is possible that patients undergoing RSA for non-traumatic indications may lose their advantage over time due to deltoid fatigue. Deltoid lengthening is known to be associated with improved ROM due to the biomechanics of the prosthesis;[15] however, this leads to non-physiologic stress on the muscle and fatigue over time. Long-term longitudinal studies have shown significant decrease in ROM over time,[16] with functional scores dropping off after an average of 6–8 years. Loss in overhead ROM has been reported to start as early as 1 year postoperatively.[17]

In the largest series to date, Crespo et al. reported on a retrospective review of a prospective database of RSA outcomes for 108 acute fractures compared to 1876 elective cases at a mean follow-up 3.5 years.[11] Final aROM reported at a single time point showed FE to be inferior in the fracture group (138° vs. 132°, $p = .036$), with IR and ER equivalent between groups. While aROM was not explicitly recorded over time, this is the only series to our knowledge to report on functional outcomes longitudinally throughout the follow-up period. Their results show the fracture group had slower recovery in the first 6 months as shown by inferior functional outcomes scores in ASES, SST, and Constant Scores, which all became equivalent by 1 year.

Lindbloom et al described the outcomes 699 RSA patients based on classification into one of eight possible indications.[12] Several outcomes scores and aROM were compared at a single follow-up visit (mean 47 months postoperatively). Only 18 patients (2.6%) were indicated for acute proximal humerus fracture, 37 (5.3%) for malunion which included post traumatic degenerative changes, and 17 (2.4%) for nonunion. Compared to the RCA group as a reference, there was no difference in ASES or aROM in any plane in the acute fracture group. Abduction was found to be inferior in the non-union group (42° vs. 75°, $p < .05$). Female patients with chronic malunion had inferior FE (114° vs. 136°, $p < .05$).

Sebastia-Forcada et al described the only prospective study of RSA outcomes by indication, comparing 67 RSA for acute proximal humerus fractures to 64 RSA for RCA, with a minimum 5-year follow-up (mean 8.4 years).[10] aROM in all four planes trended toward inferiority in the fracture group, but did not reach statistical significance. Visual analog scale satisfaction was statistically lower in the fracture group (6.2 vs. 7.0, $p = .002$) but of unclear clinical significance. Wall et al reported on 196 consecutive RSA patients with an average 40 month follow-up.[13] 28 patients (14.3%) were classified as posttraumatic arthritis, and only 2 patients (1.0%) were indicated for acute fracture. The acute fracture group was not included in subsequent analysis due to the negligible number of patients in this group. FE at final follow up was inferior in the chronic fracture sequela group. This did reach statistical significance (115° vs. 142° vs. 143°, $p = .001$).

The current study does have significant limitations, starting with its retrospective design. We did not include patient-reported outcome data over time, as this data was not routinely collected during follow up. One quarter of the patients were available for 2 year follow-up, which was similar in both groups. This patient dropout may potentially bias the reported results. However, given the equivalent rates, the effect of this is likely felt in a balanced manner between the two groups. Additionally, the single center single surgeon patient population mitigates other potential confounders.

Conclusion

Reverse shoulder arthroplasty for proximal humerus fractures is associated with decreased early aROM within the first two years postoperatively when compared to non-fracture patients. RSA for traumatic indications is still an excellent option in elderly patients with acute non-reconstructable proximal humerus fractures, or for delayed management of unsatisfactory results. Final patient satisfaction scores and ASES scores are similar between fracture and non fracture patients. While the ROM may be inferior to non-traumatic patients, the vast majority do achieve at least 90 degrees of forward elevation and high rates of patient satisfaction are reported.

Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Informed Consent

Not applicable, because this article does not contain any studies with human or animal subjects.

Declaration of Conflicting Interests

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