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Acute versus delayed reverse total shoulder arthroplasty for proximal humerus fractures in the elderly: Mid-term outcomes

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ABSTRACT

Background: Treatment of proximal humerus fractures (PHFs) via reverse total shoulder arthroplasty (RTSA) has shown early promise when compared to historical treatment modalities. Ideal surgical timing remains unclear. The purpose of this study was to compare the outcomes of early versus delayed RTSA for PHF. We hypothesized that acute RTSA would display superior outcomes compared to those receiving delayed surgical intervention.
Methods: This multicenter study retrospectively analyzed 142 patients who underwent RTSA for fracture. Patients treated within 4 weeks of injury were placed in the acute group (n = 102), and patients treated longer than 4 weeks after injury were placed in the chronic group (n = 38). A comprehensive panel of patient reported outcome measures, VAS pain scores, range of motion, and patient satisfaction were evaluated.
Results: The acute group had significantly better final follow-up SPADI scores (20.8 ± 23.9 vs. 30.7 ± 31.7) ($p<0.05$). No further differences were detected in other postoperative range of motion measurements, subjective outcomes, or VAS scores.
Conclusions: Our results suggest that patients treated acutely display similar mid-term outcomes to those who receive delayed treatment. With this in mind, surgeons may first give consideration to a period of nonoperative treatment.
Level of evidence: Level II.

Institutional Review Board approval was received from Western IRB (#1133601).

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Optimal operative treatment for proximal humerus fractures (PHFs) in the elderly is controversial. [12] Traditional surgical techniques, including hemiarthroplasty (HA) and open reduction internal fixation (ORIF), have previously demonstrated unpredictable effects on patient outcomes and increased need for revision surgery. [1,6,17,24] Accordingly, reverse total shoulder arthroplasty (RTSA) has been utilized more recently for this patient population [7,12,14,19,21] and has demonstrated equal or better clinical results than HA and ORIF. [3,5,15] Because many PHFs can achieve clinical success non-operatively, these injuries are often treated nonoperatively first. However, if these patients go on to fail non-operative treatment, delayed RTSA surgery frequently becomes recommended. In general, the influence of acute versus delayed treatment of PHFs treated via RTSA remains unclear.

The purpose of this study was to compare patient-reported and clinical outcomes of RTSA interventions for PHF injuries based on surgical timing. We hypothesized that elderly patients treated acutely would display superior outcomes compared to those receiving delayed surgical intervention.

1. Materials and methods

A retrospective review was performed using a multi-center, surgical research database compiled by 17 fellowship-trained shoulder surgeons between August 2007 and August 2016. Patients presented to clinic and were initially selected for either nonoperative or operative management by each surgeon at his/her respective site based on radiographic findings and evidence of fracture. In the case of nondisplaced fractures, a nonoperative management was trialed first. In cases of significant or worsening displacement, patients were referred to operative management. All patients over the age of 65 who underwent RTSA as a treatment for PHF were considered for inclusion in the study. Exclusion criteria included previous, same-side procedures to treat their PHF and lack of follow-up at or exceeding one year postoperatively. These patients were subsequently sorted into one of two groups based upon timing of RTSA procedure after injury. Patients who received RTSA for an acute PHF (less than 4 weeks from injury to time of surgery) were placed in the acute group, while those treated with RTSA for the sequelae of PHF (greater than 4 weeks from time of injury to surgery) were placed in the chronic group. Patient demographics including age, body mass index (BMI), and history of previous shoulder surgery were recorded, as well as pertinent comorbidities. Surgical variables including component size, intraoperative blood loss, and complications were also recorded. Patients were excluded if there was incomplete data, or lack of 2-year follow-up. All patients gave informed consent to participate and the study was approved by an Institutional Review Board.

A wide variety of previously-validated outcomes measures were collected, including the modified American Shoulder and Elbow Surgeons (ASES) shoulder score, Simple Shoulder Test-12 (SST-12), University of California-Los Angeles (UCLA) shoulder rating scale, Constant shoulder score (Constant), visual analog scale (VAS), and Shoulder Pain and Disability Index (SPADI). Additionally, patient satisfaction was included at final follow-up as a self-reported categorical rating (much worse, worse, unchanged, better, much better). Active range of motion parameters including forward elevation, abduction, and external rotation were measured in degrees. Internal rotation was recorded based on the most proximal vertebral level that could be reached by the patient's thumb.

1.1. *Surgical technique*

All surgeries were performed via a deltopectoral approach. The greater tuberosity was repaired according to surgeon preference. Postoperative protocols with regards to duration of immobilization and initiation of therapy varied by surgeon and that information was not collected for this study.

1.2. *Data analysis*

Data analysis was conducted using SPSS® (IBM, Armonk, NY, USA) to calculate descriptive statistics. Continuous data is described as means with ranges or standard deviations. Categorical data is described as counts and percentages. Means were compared between the two groups using a two-sided *t*-test. Univariate analysis was used to compare group and time interactions among patients. Statistical significance for all analyses was set at $P < 0.05$.

2. Results

A total of 161 patients were enrolled in the database. However, 14 patients (11.9%) in the acute group and 4 (9.5%) in the chronic group were lost to follow-up. An additional patient was excluded for previous ORIF. Therefore, the acute group contained 104 PHF's, while the chronic group included 38. All but two patients received the Equinoxe® Fracture Reverse Implant; two patients received the Equinoxe® Standard Reverse Implant (Exactech, Gainesville, FL, USA). In the chronic group, 22 patients had a diagnosis of malunion and 11 patients had a nonunion of the proximal humerus. The remaining 5 chronic patients were indicated for RTSA by worsening displacement, defined by change in fracture alignment on consecutive radiographs indicating grater displacement. Patients in the chronic group had surgery significantly later than patients in the acute group (0.2 ± 0.2 vs 55.9 ± 105.3 months, $p < 0.0001$) (Table 1).

There was no significant difference in final follow-up time between the two groups. The acute and chronic group displayed similar final follow-up time (45.1 ± 19.1 vs 51.8 ± 28.1). The average age of our cohort was 74.0 ± 7.8 years. Of note, the acute group was significantly older than the chronic group on average (75.4 ± 7.0 vs. 69.0 ± 8.0, $p < 0.05$). Average BMI was 27.9 ± 5.3 and not significantly different between the two groups. Significantly more acute patients had cemented stems than the delayed group (92.1% vs. 39.4%, $p < 0.001$). Demographics are shown in Table I.

Radiographic analysis found 5 patients with scapular notching (2 with Grade I, 3 with Grade II). In total, 22 total patients showed radiographic lucency in one of eight

Table 1 – Patient demographics.

		Acute (n = 104)	Chronic (n = 38)	P-value
Age (years)		75.4*	69.0*	<0.0001
BMI		27.9	28.3	0.701
Comorbidities	*Heart Disease*	25	3	0.061
	Diabetes Mellitus	14	8	0.106
	Tobacco Use	5	2	0.822
Sex	*Female*	89	31	0.724
	Male	15	7	
Final Follow-up Time (Months)		45.1	51.8	0.138
Blood Loss (cc)		325.7	363.9	0.582
Cemented Prosthesis		94*	15*	<0.001
Time between Fracture and RTSA (months)		0.2	55.9	<0.0001

The table shows patient-centric factors, compared between the acute and chronic group. While most factors were similar between groups, acute patients were significantly older and received cemented prostheses significantly more than their chronic counterparts (p<0.05).
Abbreviations: BMI- Body mass index, RTSA- Reverse total shoulder arthroplasty

humeral standardized zones [20]. No differences were detected between these groups (Table 2).

When fractures were classified according to the Neer system, significant differences were detected between the acute and chronic group. Significantly more 2-part fractures were present in the chronic group, while significantly more 3- and 4-part fractures were found in the acute group ($p < 0.0001$). (Table 3).

Postoperatively, the acute group had significantly lower SPADI scores (20.8 ± 23.9 vs. 30.7 ± 31.7, p<0.05) than the chronic group (Table 4). All other final follow-up range of motion, pain, and patient-reported outcome scores were not significantly different (Table 5).

Patient overall self-reported satisfaction was favorable, with 83.1% of patients experiencing ‘better’ or ‘much better’ results. A similar high rate of satisfaction was achieved in the acute group versus the chronic group (81.3% vs. 84.2 %) (Table 6).

2.1. Complications

Overall, 10 patients reported postoperative complications; 2 of these patients required revision surgery. The acute and chronic group exhibited similar rates of complications (6.9% vs 7.9%), and revisions (1.0% vs 2.6%). The acute group had 1 wound infections, 1 acromial stress fracture, 2 instances of unexplained pain and stiffness, and 1 instance of algodystrophy. Additionally, this group had 2 humeral fractures from a fall, one of which required revision. The chronic group had 1 axillary nerve injury, and 1 infection. Additionally, 1 chronic patient sustained a humeral shaft fracture following a fall; this RTSA had to be revised.

Table 3 – Comparison of fracture types between groups.

Fracture Type	Acute (%)	Chronic (%)
1-part	0 (0)	0 (0)
2-part	5 (4.8)	18 (47.4)
3-part	39 (37.5)	7 (18.4)
4-part	60 (57.7)	13 (34.2)

Table comparing Neer-fracture type between the two groups. While no 1-part fractures were present in either group, we found more 2-part fractures in the chronic group, and more 3- and 4-part fractures in the acute group.
P value<0.0001.

3. Discussion

As the incidence of PHF in the elderly continues to rise [10], so too does the importance of proper and timely treatment. The efficacy of RTSA as a treatment for PHF has already been

Table 2 – Radiographic lucency and scapular notching.

	Lucency									Scapular Notching
	Any	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	*Zone 6*	*Zone 7*	*Zone 8*	
Acute (n = 108)	18	9	8	7	4	7	8	13	5	4
Chronic (n = 32)	4	1	2	3	1	2	1	1	1	1
P-value	0.396	0.292	0.966	0.508	0.976	0.503	0.387	0.188	0.801	0.801

Radiographic lucency in each of eight standardized zones, and scapular notching was assessed in both patient groups, and plotted in a table. The acute and chronic group displayed similar occurrences of radiographic lucency in each zone, as well as similar instances of scapular notching.

Table 4 – Final follow-up outcome scores.

	ASES	Constant	SST	SPADI	UCLA	VAS
Acute	81.4 ± 17.4	66.5 ± 12.5	9.6 ± 2.7	20.8 ± 23.9	28.6 ± 4.5	1.3 ± 2.0
Chronic	79.2 ± 22.0	63.0 ± 15.5	9.1 ± 3.3	30.7 ± 31.7	28.6 ± 6.9	1.5 ± 2.4
P-val	0.59	0.32	0.36	0.05	0.99	0.57

This table compares range of motion scores between the two groups postoperatively. At final follow-up, only SPADI score was significantly different between the groups ($p < 0.05$). ASES, SST, UCLA, Constant, and VAS were not significantly different.
Abbreviations- ASES- American Shoulder and Elbow Surgeons Shoulder score, SST- Simple shoulder test, UCLA- University of California-Los Angeles shoulder score, Constant-Murley score, SPADI- Shoulder pain and disability index, VAS- Visual analogue scale.

demonstrated in the literature [3–5,7,12,14,15,19,21]; however, there lacks clarity on the influence surgical timing has on RTSA outcomes in this population. The purpose of this study was to compare mid-term outcomes of acute versus delayed RTSA for PHF using a comprehensive panel of outcome and ROM measures in a large retrospective cohort. Our study found that final follow-up values were very similar between the two groups, refuting our hypothesis. However, the acute group significantly outperformed the chronic group in final follow-up SPADI score ($p < 0.05$). Interestingly, the difference in SPADI scores between the two groups is much lower than the minimum clinically important difference (MCID) reported by Simovitch et al. [18] (9.9 vs. 20.0). This may indicate that the difference in SPADI scores does not represent a clinically significant difference, although the difference was statistically significant.

The SPADI score is a subjective questionnaire that asks about pain and function, with no objective component. The other scores we collected either ask questions about function (SST) or incorporate some objective component (RoM, strength, or stability). The unique nature of the SPADI score may explain why a difference was detected in this score, but not the others, however this result may be due to randomness.

Our results suggest that final follow-up VAS pain score does not differ based on time between treatment and surgery. Boileau et al. [2] treated 41 PHF patients with RTSA operation occurring more than 3 months after injury. These authors reported a final follow-up mean VAS score of 2.6 in their cohort, which was similar to our chronic group. This study adds credibility to the VAS scores we found in our chronic group.

Table 5 – Final follow-up range of motion.

	AA	FE	AER	IR Score
Acute	111.1 ± 29.0	131.0 ± 25.9	32.8 ± 15.9	4.2 ± 1.6
Chronic	117.1 ± 41.5	130.0 ± 34.9	37.1 ± 22.3	4.2 ± 1.8
P-value	0.39	0.89	0.34	0.99

This table compares range of motion scores between the two groups postoperatively. At final follow-up, only PER was significantly different. The acute group displayed higher PER ($p < 0.05$).
Abbreviations: AA- active abduction, FE- forward elevation, AER- active external rotation, IR score- internal rotation score.

There have been many studies which evaluated patient-reported outcomes in cohorts treated acutely with RTSA for PHF. [4,8,12] Bufquin et al. [4] reported a final follow-up Constant score of 44 in a cohort of 41 patients who underwent RTSA within 15 days of injury. Additionally, the study found active forward elevation, abduction, and external rotation values of 97, 86, and 30, respectively. For all common values, our acute group outperformed their cohort: Forward elevation (131.0 vs 97), abduction (111.1 vs 86), and external rotation (32.8 vs 30). This may partially be explained by the older age population compared to our study (78 vs 74.3 years). Interestingly, our average follow-up time was much higher (44.2 vs. 22 months) than this study. It is possible that our relatively higher range of motion measures are due to the acute fracture patients being followed longer thus potentially gaining additional range of motion compared to the cohort of patients in the study by Bufquin et al. which had shorter follow-up.

A previous study found that increased age can decrease the mobility component of the Constant score in patients undergoing RTSA for PHF [13]. Additionally, these authors used a Grammont-style implant, which may have contributed to differences in outcomes between our cohorts. In 20 patients undergoing RTSA within 41 days of injury, Klein et al. [12] reported mean final follow-up Constant (67.8 ± 13.5) and modified ASES (52.5 ± 10.9) scores, as well as average active abduction of 112.5 ± 38.1 degrees and forward elevation of 122.6 ± 32.8 degrees. The only significant difference found was in the ASES score; our cohort displayed higher scores (81.4 ± 17.1 vs. 52.5 ± 10.9, p<0.0001).

Martinez et al. [16] treated 44 patients with RTSA for proximal humerus fracture at an average of 12 months following injury. The authors noted a Constant score of 58, which was lower than the reported score of our chronic group (63.0 ± 15.5). The study also reported mean, final follow-up active forward elevation (100 degrees), abduction (95 degrees), and external rotation (35 degrees). Our chronic group outperformed their cohort in mean, final follow-up active forward elevation, abduction, and active external rotation. The patients in the Martinez study all received Grammont-style implants (medial glenoid-medial humeral center of rotation design) whereas our patients received a sit on top humeral design (medial glenoid – lateral humeral center of rotation design), which again may have caused variability in final follow-up measures. Of interest, our chronic group had a longer time between injury and RTSA compared to these authors' cohort (55.9 vs. 12.0 months). Perhaps there exists an interaction between time to surgery and outcome scores when only

Table 6 – Comparison of patient satisfaction between acute and chronic group.

		Acute	Chronic
Answer (%)			
	Much Worse	0 (0)	0 (0)
	Worse	1 (0.9)	2 (5.3)
	Unchanged	18 (17.6)	4 (10.5)
	Better	18 (17.6)	8 (21.0)
	Much Better	65 (63.7)	24 (63.2)

Patient satisfaction was collected at the final follow-up visit for each group. Patients rated their satisfaction similarly in each group, according to a Chi squared analysis ($p = 0.80$).

looking at a chronic fracture group. However, further studies would be necessary to fully study this observation.

In 26 patients, Dezfuli et al. [8] reported no significant difference in subjective outcome measures between patients treated acutely with RTSA for PHF compared to those treated with RTSA for PHF following failed, nonoperative initial treatment. Our data aligns well with this study. In a much larger cohort, we showed similar final follow-up patient-reported outcome scores in all but SPADI scores. Our acute group displayed better final follow-up SPADI score than the chronic group. Dezfuli et al. [8] also noted no significant differences in final follow-up range of motion values between the acute and chronic groups. However, the authors did show that acute RTSA's had 10 degrees greater forward elevation compared to the failed, initial nonoperative treatment group. We detected no significant differences in the objective range of motion parameters between groups. While our data aligns well with this study, it is possible that the authors lacked sufficient sample size to detect significant differences between their groups.

Torchia et al. [22] conducted a meta-analysis in which they compared outcomes in acute and delayed RTSA treatment for PHF. Similar to our study, they placed patients in their acute group if they were operated on within 4 weeks of injury, and placed patients who received surgical intervention 4 or more weeks after surgery in their delayed treatment group. The authors report no differences between groups in final follow-up ASES, UCLA, Constant, and SST scores, however they did not include SPADI scores in their outcomes. Additionally, their aggregated delayed group displays significantly higher active external rotation compared to their acute group. Of all commonly-investigated measures, our results agree with the authors' in all but active external rotation, where we found no significant difference in final follow-up values.

Ernstbrunner et al. [9] recently reported range of motion and Constant scores for patients undergoing RTSA for massive irreparable rotator cuff tears (miRCT's). In a systematic review of 365 shoulder, they reported lower final follow-up Constant (59 vs 65.7), active external rotation (24 vs. 33.8), and forward elevation (127 vs. 130.8) compared to our entire cohort. The authors reported similar final follow-up abduction (113 vs. 112.4) compared to our cohort. PHF patients may experience similar or exceed mid and long-term outcomes to those to those undergoing RTSA for miRCT.

Our study captured no 1-part fractures (minimally displaced fractures) according to the Neer classification system. This may be a result of our study not capturing any patients treated nonoperatively, as a majority of 1-part fractures are treated nonoperatively [11,23]. We also found significantly more 3- and 4-part fractures in the acute group, and more 2-part fractures in the chronic group. These data may reflect surgeon bias regarding timing of surgery. It is possible that 3- and 4-part fractures are seen as more severe, and surgeons deem it necessary to operate earlier rather than first trialing nonoperative options. Additionally, if acute 2-part fractures proceed with operative treatment, it is more likely that they will receive ORIF than RTSA. This is another possible explanation for the differential fracture distribution.

We also noted that significantly more acute patients had cemented stems than the delayed group (92.1% vs. 39.4%, $p < 0.001$). One possible explanation is that the fracture stems used by the study's surgeons are intended to be used with cement, while the primary reverse stems are not. However, only two patients in our cohort received the primary stem. Therefore, it is unlikely that the differences in stem type would account for the difference in cementation. We are unsure of both the cause and effect of this phenomenon. A study with longer-term follow-up may be more apt to elucidate the reasons for and consequences of these differences.

Based on our data, it appears to be safe for surgeons to give a trial of nonoperative treatment without the concern of losing long term range of motion or pain improvement.

3.1. Limitations

Our study was limited by its retrospective nature. Specifically, nearly all of our patients lacked preoperative ROM values. However, it would be difficult to collect preoperative range of motion values on an acute fracture patient. Our cohort was operated on by multiple surgeons, with variable surgical preferences and therapy requirements. However, this fact may also make the data more generalizable. Our study also failed to capture outcomes in patients treated nonoperatively. In the future, a large-sample study with fewer confounding factors, such as surgeon selection bias and differential surgical techniques is warranted.

A significant age difference was detected between the acute and chronic group, which may affect the applicability of our results to all patients with PHF. Additionally, this may suggest a possible selection bias for surgeons on personal operative indications. While we had a larger sample size than previous studies, there were many more patients in the acute group

Table 7 – Type of fractures included in each of the studies with which we drew comparisons.

Study	Fractures included
Boileau et al.	Not reported
Bufquin et al.	Neer 3- and 4-part
Klein et al.	OTA type B2, C2, C3
Martinez et al.	Not reported
Dezfuli et al.	Not reported

than the chronic group which may also be related to inherent surgeon bias for intent to treat. It is possible more severe fractures (3 or 4 part) are operated on more aggressively than 2-part fractures.

We would have preferred to compare fractures of the same type across the two groups, for example comparing acute 2-part fractures to chronic 2-part fractures. However, we lacked the appropriate sample size to adequately detect differential outcomes in this manner. As such, future studies should attempt to obtain enough patients to conduct this type of analysis. Additionally, the studies that we referenced in the discussion included varying types of fractures, making the comparisons challenging (Table 7).

While we studied the largest cohort available to date, it is possible that our groups were still not large enough to detect differences between groups. Additionally, while we only included patients with two or more years of postoperative follow-up, further differences between the groups may be present further from the date of surgery.

4. Conclusion

The mid-term outcomes are remarkably similar in elderly patients treated acutely with RTSA versus those undergoing delayed treatment. As inherent risks exist with surgery, surgeons may give consideration to initial nonoperative treatment with the knowledge that mid-term outcomes are very similar.

Disclaimer

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