



# Reverse shoulder arthroplasty for acute proximal humeral fractures: Postoperative complications at 7 days, 90 days and 1 year

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## ABSTRACT

**Background:** In the last decade, the biomechanics of reverse shoulder arthroplasty (RSA) for proximal humeral fractures in the elderly have led to more functional outcomes and greater pain relief. However, its use has also introduced a significant rate of complications. The purpose of this study is to assess the complication rate of RSA in these cases as well as the relationship to ASA score and basic disease history. **Methods:** We evaluate patients who underwent RSA due to acute proximal humeral fractures at three hospitals from 2010 to 2016. We analyze previous disease and anticoagulant treatment, American Society of Anesthesiologists (ASA) Physical Status Classification, and the transfusion rate to correlate these factors with major and minor postoperative complications at 7, 90, and 365 days.

**Results:** We include 103 patients (104 shoulders) over 65 years of age. Mean age is 77.31 years (62–91), 20 of which are male. The overall rate of complications is 25%, with 17.4% minor and 7.6% major complications. We observe a statistically significant relationship between a higher ASA score (3,4) and major complication at 90 days ( $p=0.024$ ) and a trend ( $p=0.072$ ) towards a higher ASA score with minor complication during the first week. Rheumatoid disease significantly increases major complications at 90 days ( $p=0.037$ ). The transfusion rate is 11.5%.

**Conclusions:** The overall major complication rate of RSA for acute fractures is low in the elderly population. Although, the patient's history (e.g. previous rheumatoid pathology, neurological diseases, or anticoagulant treatment) as well as their ASA score should be considered before RSA surgery. The higher the ASA score and the presence of rheumatoid disease, leads to a higher rate of major complications during the first 90 days after surgery.

**Level of evidence:** Level IV; Case series; Treatment study.

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## Introduction

Traditionally, hemiarthroplasty (HA) has been the “gold standard” for three and four-part proximal humeral fractures in older patients (>65 years). Despite a reduction in pain, this treatment leads to variable functional outcomes. Sufficient anatomic healing of the tuberosities is the key to achieving a functional result. In patients with osteoporotic and comminuted tuberosities, however, anatomic healing is neither reliable nor predictable [1].

Recently, another treatment option has become available, reversed shoulder arthroplasty (RSA). RSA can improve the range of motion, despite a massive rotator-cuff tear, by exploiting the deltoid muscle as a lever rather than relying on the damaged rotator cuff. Encouraging mid-term results [2,3] have been described for acute proximal humeral fractures, and are less dependent on tuberosity healing.

Despite the favorable outcomes of predictable pain relief and improved functional restoration in fractures treated with an RSA, the complication rates are not negligible. Some studies have measured a large complication range (10–75%) [4–6]. However, the definition of complications is an issue because the same events are not consistently identified as complications. For example, Zumstein et al. [7] defined “complication” as any intraoperative or postoperative event that affects the final outcome negatively

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(e.g. infection, dislocation, nerve problems, aseptic loosening, or disassociation of the components) while “problem” was defined as any adverse event not affecting the final outcome (e.g. hematoma, notching, heterotopic ossification, lucent lines, or intraoperative fracture).

The current literature has demonstrated that a higher American Society of Anesthesiologists (ASA) score (3–4) predicts more complications in hip and knee prostheses [8–10], but this relationship remains unclear for RSA in complex proximal humeral fractures because it has not been reported.

The main purpose of this study is to assess the minor and major complication rates of RSA in older adults for the treatment of proximal humeral fractures at 7, 90, and 365 days following treatment. Additionally, we study the relationship between complications to ASA score, basic disease history, and previous anticoagulant or antiplatelet treatment.

## Materials and methods

This is a multicentric retrospective study. From January 2010 to December 2016, 347 complex proximal humeral fractures were identified from three institutions.

Inclusion criteria for the study included displaced three- and four-part fractures, treated with RSA within three weeks of injury in patients over 65 years of age with a minimum clinical follow-up time of twelve months. The authors agreed to include all four-part fractures, and only grossly displaced 3-part greater tuberosity proximal humeral fractures considered to be non-re-constructible.

Exclusion criteria included fractures treated more than three weeks after injury, patients younger than 65 years of age, patients treated with open reduction and internal fixation (ORIF) or hemiarthroplasty, or a follow-up time less than one year. All operations were performed by one of four experienced shoulder surgeons. All patients were operated in a “beach chair” position under general and regional block anesthesia. In all cases, the humeral stem was cemented and the tuberosities were reinserted.

In the three centers the same prophylactic antibiotic protocol was used consisting in cefazolin 1 g/6 h (3 doses). The first dose was delivered 1 h before surgery, and the rest every 6 h during the postoperative period. The prophylactic antibiotic protocol was determined at each center by the Hospital Department of Infectious Diseases.

All patients included underwent the same Rehabilitation protocol based on immobilization with brace for three weeks followed by passive range of motion during the first 6 weeks. After that, active range of motion and progressive resistance exercises were introduced.

During follow-up, complications were identified at the first week, 90 days, and one-year post operation. Complications were recorded based on Zumstein definitions [7]: “problem” (hematoma, notching, heterotopic ossification, lucent lines, and intraoperative fracture) and “complication” (infection, dislocation, nerve problems, aseptic loosening, and disassociation of the components). Following these definitions, our postoperative complications are classified as “minor” (problem) and “major” (complication).

As an extension to the Zumstein definitions [7] in the present study “Neurological problems” are categorized into neuroapraxia (temporary impairment with spontaneous resolution) as a minor complication while nerve palsy (no recovery requiring surgery) as a major complication. We classify “Infection” as superficial (complete resolution with antibiotics) as a minor complication, and deep (requiring corrective surgery) as a major complication.

The ASA physical status score, age, gender, the presence of medical comorbidities (e.g. ischemic cardiopathy, neurological, rheumatic, psychiatric, or neoplastic diseases), and anticoagulant or antiplatelet treatment data were collected for all patients.

We analyze the data with the SPSSWIN (IBM, Armonk, NY, USA) and perform a descriptive analysis with different categories. We calculate an independent parametric Student's *t*-test to relate quantitative (age) and qualitative (complication) variables. To correlate ASA score with complication and transfusion ordinal variables, we calculate the nonparametric Mann-Whitney U test. To compare comorbidities with complications, we calculate a  $\chi^2$  Fisher test given that the event is infrequent. To test whether ASA score correlates with length of hospitalization we compute the nonparametric Spearman's Rho correlation. We consider a *p*-value of 0.05 or less to be statistically significant.

## Results

Of the 347 patients, 166 were treated with ORIF, 31 with hemiarthroplasty, 9 had total anatomical prostheses, and 141 with an RSA. The 141 patients treated with RSA due to complex proximal humeral fractures, 37 patients were excluded due to either age or follow-up time. We include the remaining 104 shoulders from 103 patients (one patient underwent 2 RSA procedures for complex fracture in both humeral heads). The patients are 84 women and 20 men with a mean age of 77.31 years (65–91).

During surgery, a standard deltopectoral approach was used in 76 patients (73.07%), while 28 patients (26.92%) had a superior standard approach. The implants for reverse total shoulder arthroplasties were either Delta Xtend™ (Depuy, Warsaw, IN; 78 cases) or Aequalis™ II (Tornier, Montbonnot, France; 26 cases) with a cemented humeral stem. In all the cases tuberosities were reinserted.

ASA classification of this cohort categorizes 5 patients as ASA 1 (4.8%), 61 patients as ASA 2 (58.7%), 37 patients as ASA 3 (35.6%), and 1 patient as ASA 4 (1%). Twenty-one patients show comorbidities, specifically, diabetes mellitus 2 (20.2%), psychiatric pathology (19.2%), neurological diseases (18.3%), neoplastic antecedents (14.4%), ischemic cardiopathy (9.6%) and rheumatoid diseases (8.7%). Seventy-eight patients (78.9%) were under treatment for AAS 100 mg, 15 patients (14.4%) were taking antiplatelet medication (AAS 300 mg, clopidogrel, prasugrel, or ticlopidine), and 7 patients (6.7%) were under anticoagulant treatment (acenocumarol or warfarin).

We observe an overall complication rate of 25%, with 17.4% minor (not affecting the final outcome) and 7.6% major (affecting the final outcome). The earliest follow-ups have a higher prevalence of minor complications, specifically 11.5% during the first week, 5.8% in the first 90 days, and with no major complications. This observation changes in the subsequent follow-ups. From 3 months to one-year, major complications (e.g. deep infection, dislocation, or periprosthetic fractures) are observed at a rate of 3.8% at 90 days to one-year postoperative with no minor complications (Table 1).

A higher ASA score significantly correlates with major complications at 90 days ( $p=0.024$ ). We observe a trend for minor complications to occur during the first week post operation ( $p=0.072$ ; Table 2). Rheumatoid disease correlates with an increase in major complications at 90 days ( $p=0.037$ ). The presence of a neurological pathology trends with minor complications at 90 days ( $p=0.073$ ). No other correlations are found between comorbidities and complications (Table 3).

Patients under no treatment or low antiplatelet (AAS 100 mg) medication have significantly lower rates of minor complications (3.7%) during the first week ( $p<0.001$ ). Patients under high antiplatelet or anticoagulant treatment show a significantly higher rate of minor complications, 33.3% and 42.9% respectively ( $p=0.009$  and  $p=0.025$ ; Table 3).

Age does not correlate with complication rate at any of the three hospitals ( $p=0.3$ ,  $0.5$ , and  $0.7$ ). Twelve patients (11.5%) underwent transfusions. This ratio varies among the different centers: 18.42%,

**Table 1**  
Summary of complications at follow-up.

COMPLICATIONS	7 day follow up	90 day follow up	1 year follow up
MINOR COMPLICATIONS	11.5 %	5.8 %	0 %
Medical complications	7 cases	6 cases	0 cases
Surgical complications	5 cases	0 cases	0 cases
	2 neuroapraxia		
	1 hematoma		
	1 edema		
	1 superficial infection		
MAJOR COMPLICATIONS	0 %	3.8 %	3.8 %
Surgical complications	0 cases	4 cases	4 cases
		2 deep infection	3 deep infections
		( <i>Proteus Mirabilis-Klebsiella Pneumoniae</i> )	( <i>Staph Epidermidis-Propioni - Aureus</i> )
		2 dislocation	1 periprosthetic fracture
	<b>11.5 %</b>	<b>9.6 %</b>	<b>3.8 %</b>

**Table 2**  
Minor and major complications by ASA<sup>a</sup> groups during follow-up.

Number Complications	7 days		90 days		1 year	
	Minor	Major	Minor	Major	Major	Major
ASA 1	1	0	0	0	0	0
ASA 2	3	0	4	0	0	2
ASA 3	6	0	2	4	4	2
ASA 4	1	0	0	0	0	0
	<b>11</b>	0	6	<b>4</b>	4	4
U Mann Whitney	<b>p = 0.072**</b>	p = 0.692	p = 0.987	<b>p = 0.024*</b>		p = 0.607

<sup>a</sup> American Society of Anesthesiologists.

\* Statistical significance.

\*\* Statistical trend.

**Table 3**  
Minor and major complications according to underlying diseases and previous treatments.

	7 days		90 days		1 year	
	Minor	Major	Minor	Major	Major	Major
Rheumatic diseases	22.1 %	0 %	11.1 %	<b>22.2%*</b>	11.1 %	p = 0.037 <sup>†</sup>
Psychiatric diseases	20 %	0 %	0 %	0 %	5 %	
Neurological diseases	21.1 %	0 %	<b>15.8%**</b>	10.5 %	5.3 %	p = 0.073**
Diabetes mellitus 2	14.3 %	0 %	4.8 %	9.5 %	4.8 %	
Cardiovascular disease	20 %	10 %	0 %	10 %	10 %	
Previous neoplasia	6.7 %	0 %	6.7 %	0 %	6.7 %	
Anticoagulant treatment <sup>a</sup>	<b>42.9 %*</b>	0 %	14.3 %	14.3 %	0 %	p = 0.025 <sup>†</sup>
Antiplatelet (300 mg) treatment	<b>33.3 %*</b>	0 %	0 %	0 %	0 %	p = 0.009 <sup>†</sup>
Antiplatelet (100 mg) or Nothing	<b>3.7 %*</b>	1.2 %	6.1 %	3.7 %	4.9 %	p = 0.001 <sup>†</sup>

<sup>a</sup> (acenocumarol or warfarin).

\* Statistical significance.

\*\* Statistical trend.

8.5% and 5.2%. In the first two centers, transfusion occurs when hemoglobin levels drop to less than 85 g/L while the third center waits until levels drop to less than 80 g/L; leading to their low transfusion rate. Mean preoperative hemoglobin levels in patients requiring a blood transfusion were 106.91 g/L, while in those not requiring transfusion, the mean was 126.77 g/L. Fifty percent of the transfusions occurred in patients with an ASA score of 3 (6 patients), while 41.7% occurred in patients with ASA 2 (5 patients). However, we observe no correlation between higher ASA score and transfusion rate (p = 0.460).

Mean hospital stay was 5.04 days (ranging 2–36 days) without correlation with ASA score (0.79, p = 0.427). Minor complications within the first week increase mean hospital length to 5.72 days, but not significantly (p = 0.4).

## Discussion

Reverse total shoulder arthroplasty is more often the option of choice in complex proximal humeral fractures in elderly patients,

however, there is still concern about the complication rate. This study shows that the overall rate of major complications of RSA, when used in acute fractures, is low for this population, and that the major complications occur between 90 days and the one-year follow-up.

Several systematic reviews compare complication rate of RSA versus HA in the treatment of acute proximal humeral fractures. Namdari et al. [8] concluded that RSA was associated with a four-fold increase (95% CI, 1.9–8.5 times) of postoperative clinical complications when compared with HA. Conversely, several studies have failed to find differences between the two treatments [11,12]. Criticism of systematic reviews emphasize that patients do not represent a homogeneous population and may be a source of bias. In the present study, our inclusion criteria resulted in an analysis of a single homogeneous population.

We identify a 25% rate of overall complications, which is slightly higher than previous reports (e.g. Zumstein et al. 24.6% [7], Cuff et al. 9.5% [12], and Wall et al. 13% [5]). These differences can be explained by the inconsistent definitions of minor and major

complications among the studies. The majority of complications are found at early stages post operation and are “minor”; while complications after 90 days are “major” and often require additional surgery (Table 1).

Instability is the most common complication, and can be as high as 11% (reported by Cazeneuve et al. [13]). This complication is primarily found within the first 6 months and 50% of cases can be properly addressed with closed reduction [14]. In the present study, the two observed dislocations were at 3 and 4 months and were successfully treated.

Deep infections have increased in prevalence in recent years, from 0.7% to 1.2% [15]. The risk factors related to infections include previous trauma, dead space and hematoma formation, age, and repeated shoulder surgery. The observed infection rate in this study is higher than previously reported (4.8%) and is more frequent in patients with rheumatic disease. *Propionibacterium Acnes* is the most common bacterium associated with acute and chronic shoulder infections [16], but we detect *P. acnes* in only one of the patients presenting an infection.

Many previous studies report an association between ASA and complication rate in hip and knee replacements, but, only one study (Johnson et al. [17]) correlates ASA and complications after TSA (total shoulder arthroplasty) and RSA in cases with primary arthritis. In our study, a trend towards an increase in minor complications in patients with a higher ASA score was found within the first week ( $p=0.072$ ). This is in contrast to the Johnson et al. [17] results where patients with primary arthritis did not show an association between ASA and medical complications ( $p=0.644$ ). In congruence with Johnson et al., we find that patients with higher ASA scores were more likely to develop major complications at 90 days ( $p=0.024$ ); they found that patients with ASA scores higher than 2 had greater risk of developing surgical complications (OR 2.27, 95% CI, 1.36–3.70,  $p<0.001$ ) [10].

Patients with ASA scores of 3 are at higher risk of major complications and thus surgery should be carefully considered. For comorbidities, patients with rheumatoid diseases incur a higher incidence of major complications at 90 days ( $p<0.037$ ). This is in line with Young et al. [18] and Jauregui et al. [19], who report in a cohort of patients treated with RSA for rotator-cuff arthropathy. The importance of adequate preoperative risk stratification and counseling in patients who have ASA scores greater than three has been clear; with an emphasis on medical comorbidities and preoperative anemia, which play a key role in improving outcomes after complications. Our results reemphasize this finding and consider patient history an important issue for making decisions about possible treatments.

The major strength of this study is the large homogeneous sample size of 104 reverse shoulder arthroplasties implanted following agreed inclusion criteria with a similar implant system, and the same antibiotic and rehabilitation protocol. No patients were lost to 1 year follow up, which is enough time frame to appearance of early complications.

Also the complications classification (minor and major) is based on a practical way (if it affects or not to the final result) which may be useful to the shoulder surgeon to decide and inform the patient.

Nevertheless, the main limitation of this study is its retrospective design with the implied risk of bias. A possible source of bias is that the procedures were performed by 4 surgeons in 3 different services. Another source of bias can be the fact that two different prostheses were included, but both systems are similar in biomechanics. The transfusion criteria is also different in the different centers included making comparison difficult.

Future prospective research will be necessary to compare complications and survivor depending on ASA score and patient comorbidities with stronger conclusions. By doing this, indications of RSA in proximal humeral fractures will be more carefully defined

and patients will be better informed about major and minor complications related to this procedure.

## Conclusion

The overall rate of major complications for RSA in acute fractures is low in this elderly population. Major complications (e.g. dislocations, deep infections, or periprosthetic fractures) develop later, from 90 days to 1-year postoperative and commonly require revision surgery. Surgery should be carefully considered for patients with ASA scores of 3 or higher and in patients with rheumatic diseases due to the increase in major complication rate at 90 days.

## Conflict of interest

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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## Ethical approval

“All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.”

This study was approved by the Hospital de la Santa Creu i Sant Pau Ethical Committee (IIBSP-HUM-2017-51).

## Informed consent

For this type of study formal consent is not required.

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