



ELSEVIER

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jseinternational.org

Is it worth the risk? Clinical and radiographic outcomes 24 months after reverse shoulder arthroplasty in an advanced geriatric population



David Endell, MD^a, Laurent Audigé, PhD^{a,b}, Jan-Philipp Imiolczyk, MD^c, Markus Scheibel, MD^{a,c,*}, Florian Freisleder, MD^a

^aShoulder and Elbow Surgery, Schulthess Klinik, Zurich, Switzerland

^bTeaching, Research and Development, Schulthess Klinik, Zurich, Switzerland

^cCenter for Musculoskeletal Surgery, Charité-Universitätsmedizin Berlin, Germany

ARTICLE INFO

Keywords:

Shoulder surgery
Reverse shoulder arthroplasty
Geriatric
Elderly
Joint replacement
Outcome
Complications

Level of evidence: Level IV; Case Series;
Treatment Study

Background: The application of reverse shoulder arthroplasty (RSA) has risen in the past decades especially due to its excellent long-term outcomes. With this positive trend, the indications for RSA have gradually extended to a broader age spectrum. The objective of this study was to identify the benefits of primary RSA in an advanced geriatric population with considerable comorbidity burden and higher perioperative risk.

Methods: For this observational study using data collected from our local RSA register, we identified 73 patients (77% female) with a minimum age of 85 years (range: 85-93 years) at the time of surgery and a complete 24-month postoperative follow-up. Clinical evaluations of pain, Subjective Shoulder Value, Constant score, Shoulder Pain and Disability Index, quality of life (European Quality-of-Life 5-Dimension 5-Level utility), and patient satisfaction were made. Radiographic evaluation followed an international consensus core set. Adverse events were documented according to a core event set.

Results: Preexisting medical conditions categorized following the American Society of Anesthesiologists physical status classification system indicated only 22% of patients with mild comorbidities (American Society of Anesthesiologists I-II), whereas severe (American Society of Anesthesiologists III-IV) comorbidities were common (78%). Indications for surgery were rotator cuff deficiency (72%), post-traumatic conditions (18%), and primary arthrosis (10%). There was significant improvement in all clinical evaluations up to 24 months post RSA: mean pain levels decreased from 6.2 to 1.6 points, where 0 indicates no pain ($P < .001$) and Subjective Shoulder Value, Constant score, Shoulder Pain and Disability Index, and European Quality of Life 5 Dimensions 5 Level increased from 36% to 76%, 26 to 61 points, 29 to 74 points, and 0.58 to 0.79, respectively ($P < .001$). Most patients (88%) opted in favor of undergoing the same surgery again based on their personal outcome. There were no signs of early loosening, migration or dislocation at 24 months postsurgery. However, 6 periprosthetic fractures were identified, 5 of which were treated conservatively. Adverse events were reported for 39% of patients, yet rarely led to the need for revision surgery (1.8%) or hospital readmission (3.6%).

Conclusion: Despite an advanced age over 85 years and numerous associated comorbidities, our geriatric population showed a distinct clinical improvement in their daily activities with high rates of patient satisfaction. Radiographic analysis at 24 months after surgery identified adequate implant stability. RSA is a safe procedure, even in these elderly patients, with an acceptable risk of unfavorable medical and surgical events.

© 2022 The Author(s). Published by Elsevier Inc. on behalf of American Shoulder and Elbow Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

This study was approved by the Cantonal Ethics Committee of Zurich, Obstgartenstrasse 21, Postfach, 8090 Zurich. Approval for the study (Nr. 2014-0483) was granted on 01-23-2015.

*Corresponding author: Markus Scheibel, MD, Schulthess Klinik, Department of Shoulder and Elbow Surgery, Lengghalde 2, Zurich CH-8008, Switzerland.

E-mail address: markus.scheibel@kws.ch (M. Scheibel).

<https://doi.org/10.1016/j.jseint.2022.05.005>

2666-6383/© 2022 The Author(s). Published by Elsevier Inc. on behalf of American Shoulder and Elbow Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Reverse shoulder arthroplasty (RSA) is a proven method that delivers adequate long-term results, and RSA implants have become the most frequently used worldwide within the last decade.^{10,18,32} Shoulder surgeons have consequently gained greater confidence in extending the indications for RSA to span a broader age spectrum. When identifying the target population, a mean age

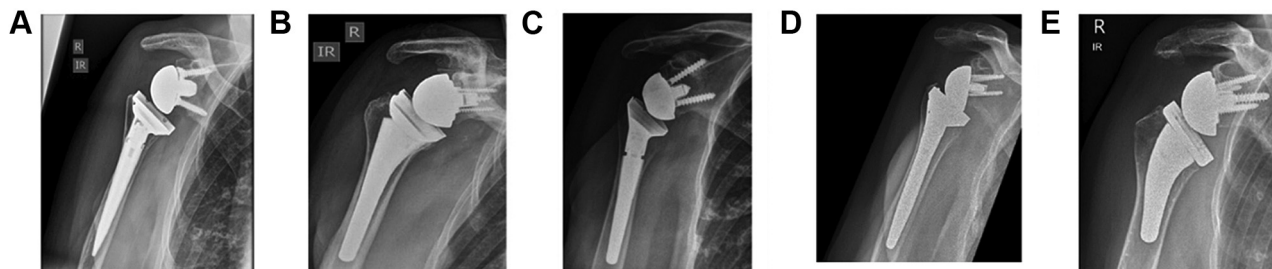


Figure 1 The utilized RSA implants included (A) the PROMOS Revers (Smith & Nephew Orthopaedics AG, Zug, Switzerland), (B) Univers Revers (Arthrex Swiss AG, Belp, Switzerland), (C) Lima SMR Reverse Modular Shoulder System (LimaCorporate S.p.A., Udine, Italy), (D) Aequalis Reversed, and (E) Ascend Flex (Stryker GmbH, Selzach, Switzerland). RSA, reverse shoulder arthroplasty.

at the time of surgery has been identified between 70 and 76 years according to several national registries, while a mean age of 79 years is recognized in trauma settings.^{24,25} Nonetheless, 2 recent studies have described the clinical performance of primary RSA in geriatric patient collectives aged 80 years and older, although this outcome was associated with an increased risk of surgery-related complications.^{19,26} This specific age group is mainly keen on reducing any pain and improving the functional status of their affected shoulder for carrying out basic daily living activities such as personal hygiene and to stay self-sufficient in their domestic environment.^{16,17} The proportion of persons aged 85 to 89 years who are in need of help for their daily basic hygiene needs in Germany is roughly twice as high as that for those aged 81 to 84 years (38% vs. 21%).⁵

Joint replacement could represent a reasonable option for maintaining autonomy and quality of life in this advanced age population. Yet, the true benefit of RSA and whether the prevalence of complications supersedes the functional outcome that can be achieved in patients older than 85 years is currently unknown. Therefore, our study objective was to investigate the short-term clinical outcome, patient satisfaction, and occurrence of complications 24 months after primary RSA in a geriatric patient group. We hypothesized that there is significant improvement in clinical outcome measures with high satisfaction rates at short term with acceptable rates of local postoperative adverse events (AEs).

Materials and methods

Patient selection

This is a retrospective treatment study of patients identified from the institutional shoulder arthroplasty register, who had undergone unilateral, primary RSA between March 2006 and April 2019 and were 85 years or older at the time of surgery. All corresponding patient records documented in the local register were included in our analysis.²³ Any patients who underwent prosthesis revision or declined consent for their clinical data to be used for research purposes were excluded. All patients were assessed preoperatively and documented according to the American Society of Anesthesiologists (ASA) physical status classification system.

Surgery and postoperative rehabilitation protocol

All surgical interventions were performed using a standardized deltopectoral approach by senior consultants specialized in shoulder surgery. After detachment of the subscapularis, for cases where the tendon showed continuity, each prosthesis was implanted according to the manufacturer's instructions in a standardized position with 10° to 20° of humeral retroversion. The utilized RSA implants included any 1 of the following: Promos Reverse (Smith & Nephew Orthopaedics AG, Zug, Switzerland), Univers Revers

(Arthrex Swiss AG, Belp, Switzerland) with either 155° or 135° humeral inclination, Lima SMR Reverse Modular Shoulder System (LimaCorporate S.p.A., Udine, Italy), Aequalis Reversed, and Ascend Flex (Stryker GmbH, Selzach, Switzerland) (Fig. 1). The subscapularis tendon was reattached whenever repair, depending on tendon and muscle quality, was possible.

All patients followed a standardized postoperative rehabilitation protocol beginning with sling immobilization in internal rotation during the first postoperative week, where early mobilization within the patient's field of vision was permitted. Passive movements involving limited internal and external rotation were performed followed by increasing range of motion from and beyond the third postoperative week. Active mobilization was recommended from the fifth postoperative week, but the length of the rehabilitation program differed based on each patient and their individual progress in shoulder function.

Clinical follow-up

Patients were examined at 6, 12, and 24 months after surgery. Clinical parameters included pain, shoulder active range of motion, that is, elevation, abduction, internal and external rotation at 90° abduction, external rotation at 0° abduction and capacity of internal rotation (using the Apley scratch test) at 0° abduction, shoulder strength in 90° abduction determined using a spring balance (Pesola AG, Schindellegi, Switzerland), and functional outcome based on the Subjective Shoulder Value,¹² Constant score (CS)^{7,8} and patient-reported Shoulder Pain and Disability Index.¹ Minimal clinically important differences were taken into consideration for evaluation.^{28,33} To assess quality of life (QOL), the European QOL 5-Dimension 5-Level questionnaire was used.¹⁵ The responses were converted into utilities (ranging from -0.66, indicating lowest QOL, to 1, highest QOL) using the European QOL 5-Dimension 5-Level value set for Germany.²⁰ Patient satisfaction was measured by willingness to opt for surgery again based on their personal experience. Overall satisfaction was graded by patients using a numerical scale, where 10 equals the best possible result.

AEs, defined as any deviation from the regular expected postoperative course including all local and nonlocal events,² were documented within 24 months post RSA. All treatment measures undertaken for an AE including revision surgery were recorded. Postoperative events were graded according to an adapted severity classification system.^{9,11}

Radiographic assessment

Standardized radiographic images taken in internal/external rotation and axillary views at 12 and 24 months postoperative follow-up examinations were evaluated for the appearance of radiolucent lines (RLLs) around the implant, signs of humeral or glenoid component loosening, bone resorption (including scapular

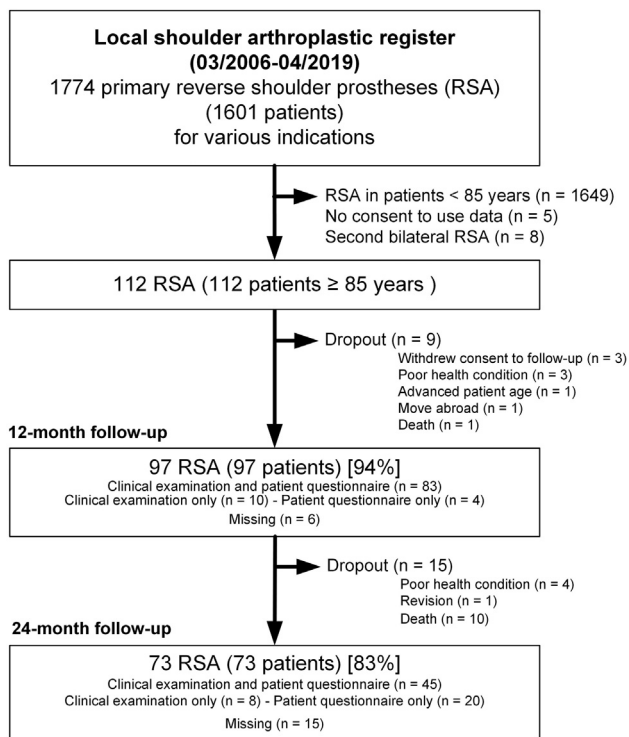


Figure 2 Flowchart visualization of the process of patient selection. RSA, reverse shoulder arthroplasty.

notching), bone formation, and signs of implant wear according to an international standard core set of radiographic parameters for shoulder arthroplasty monitoring.² The appearance of RLL was graded based on an adapted method originally described by the working groups of Sperling et al³⁰ and Schoch et al²⁷ and categorized as either incomplete (grade 1) or completely surrounding the implant (grade 2). Scapular notching was graded according to Sirveaux et al,²⁹ and heterotopic ossification around the implant was graded according to an adapted classification by Brooker et al⁴ for the shoulder.

Radiographic evaluation was performed independently by an orthopedic clinician who was neither involved during the surgical treatment, postoperative care, nor follow-up examinations.

Data management and statistical analysis

Register data were managed using the REDCap electronic data capture system¹⁴ and exported for statistical analysis into Intercooled Stata version (StataCorp LP, College Station, TX, USA).¹⁷

Baseline patient demographics and shoulder status as well as outcome parameters at the 12- and 24-month follow-ups were tabulated using standard descriptive statistics. Outcome parameters were presented from baseline to 24 months using line graphs for elective RSA, excluding fracture cases for lack of baseline data. Outcome parameter changes between 12 and 24 months were assessed using paired statistical testing and clinical judgement to assess if maximum improvement would be gained already around 12 months after surgery (Supplementary Appendix S1). Accordingly, we performed a last carried-forward approach to replace missing 24-month data by outcome values documented at 12 months. Baseline characteristics were compared between patients with and without documented outcome data to assess potential attrition bias. Outcome changes from baseline to 12 and 24 months were assessed using paired statistical testing.

Table 1 Baseline patient demographics, type of prosthesis, and additional procedures.

Baseline patient characteristics	n (%)
Age at surgery	87.2 (1.9)*
Sex	
Female	86 (77)
Male	26 (23)
ASA classification	
I	1 (1)
II	23 (20.5)
III	84 (75)
IV	4 (3.5)
Indication for RSA	
Rotator cuff tear with arthrosis	76 (68)
Rotator cuff tear without arthrosis	5 (4)
Primary arthrosis	11 (10)
Acute fracture	10 (9)
Posttraumatic deformity	9 (8)
Humeral head necrosis	1 (1)
Implant type	
PROMOS Revers [†]	41 (60)
Univers Revers [‡]	27 (40)
Aequalis Reversed [§]	12 (11)
Aequalis Ascend Flex reversed [§]	2 (2)
Lima SMR Reverse	8 (7)
Additional procedure	
Biceps tenotomy/tenodesis	49 (44)
Bone grafting	10 (9)
Tuberosity refixation	4 (3.5)
Plate/Osteosynthesis removal	3 (3)
Muscle transfer	2 (2)
Osteosynthesis	1 (1)

ASA, American Society of Anesthesiologists; RSA, reverse shoulder arthroplasty.

*Mean (standard deviation).

[†]Smith & Nephew Orthopaedics AG, Zug, Switzerland.

[‡]Arthrex Swiss AG, Belp, Switzerland.

[§]Stryker GmbH, Selzach, Switzerland.

^{||}LimaCorporate S.p.A., Udine, Italy.

AEs were tabulated separately as local and nonlocal events and according to severity grading, using absolute and relative frequencies. We also explored the effect of comorbidities (ie, ASA I-II vs. ASA III-IV) on 24-month outcome parameters using regression analyses adjusted for baseline values.

All analyses were considered explorative and statistical significance was set at 0.05.

Results

Patient selection process

Of 1774 RSA patients, 112 patients were eligible for this analysis once bilateral cases, revision cases, and patients without consent were excluded (Fig. 2). Follow-up rates were 94% and 83% for the expected 12- and 24-month time points, respectively. The identified reasons for patient dropout (n = 24; 21%) included death (n = 11; 9.8%) and poor health conditions not related with surgery (n = 7; 6.3%). Out of the additionally missing 21 patients, 14 patients deemed a routine follow-up not necessary in consideration of the associated journey to the clinic and their subjectively satisfying shoulder function, 2 patients cancelled due to COVID-19–related reasons, 1 patient underwent foot surgery elsewhere, and 4 patients were no-shows.

Of the 73 patients documented at the 24-month follow-up, 62% had completed both clinical and patient-reported assessments, while the remainder had either clinical or patient-reported data only. Seventy-two percent of our patients had a cuff tear arthropathy, and only 12% had undergone a previous shoulder surgery (Table 1).

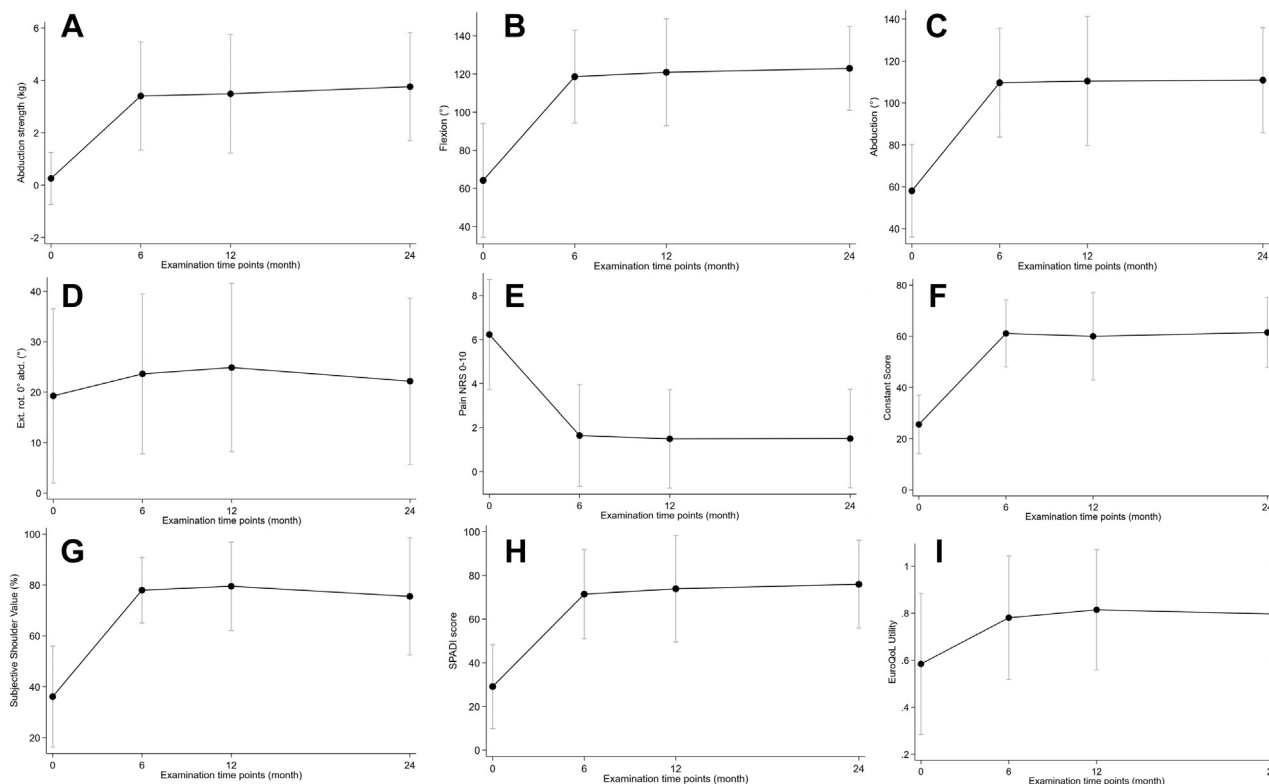


Figure 3 Development of clinical outcomes (A) abductions strength; (B) active flexion; (C) active abduction; (D) external rotation in 0° abduction; (E) pain; (F) CS; (G) SSV; (H) SPADI score; (I) European QOL 5-Dimension 5-Level utility from baseline to 6, 12 and 24 months after RSA implantations. CS, Constant score; SPADI, Shoulder Pain and Disability Index; SSV, Subjective Shoulder Value; RSA, reverse shoulder arthroplasty.

Clinical examination and patient-reported outcomes

Significant and clinically relevant improvements were observed in pain, flexion, and abduction and abduction strength ($P < .001$) by the final 2-year follow-up (Fig. 3; Supplementary Appendix S2). There were also improvements in external and internal rotation, although these trends were not statistically relevant ($P = .264$). All clinical scores (Subjective Shoulder Value, CS, and Shoulder Pain and Disability Index) showed similar relevant improvement ($P < .001$), with the CS clearly exceeding the established minimal clinically important differences. There was a significant increase in QOL by 0.24 at the 2-year follow-up (95% confidence interval: 0.15; 0.33) ($P < .001$). Patient-rated satisfaction was high with 80% of patients reporting great improvement and 13%, slight improvement; only 2% did not notice a difference and 5% reported a worsening of their overall postoperative outcome at 2 years. Overall, 88% stated that they would opt for surgery again, and the average rating of patients toward their expected outcome was 8.4 points (standard deviation 2.8).

No relevant differences between the level of patient comorbidity and the outcomes (pain, range of motion, muscle strength, Subjective Shoulder Value, CS, and Shoulder Pain and Disability Index) were observed at 24 months post RSA ($P \geq .209$). There was a trend of improved internal rotation for ASA I-II patients ($P = .029$), but a comparison of overall internal rotation was not statistically significant ($P = .338$).

Radiographic outcomes

The appearance of RLL around the implant was documented in a third (33%) of our cohort at the 24-month follow-up, although there were no severe cases with grade 2b RLL. Also, no signs suggesting

humeral or glenoid component loosening were identified. Overall, there were no signs of implant migration, dislocation, disassembly, or implant wear. Scapular notching was reported in 41% of the cases, where most (33%) was limited to the scapular pillar (grade 1) and 8% reached the inferior screw of the base plate (grade 2). Heterotopic ossifications were identified in 27% of the cases.

Local AEs and revisions

One patient sustained an intraoperative periprosthetic fracture of the proximal humeral diaphysis during RSA, which was undertaken 1 year after initial osteosynthesis of a proximal humerus fracture (Table II).

The proportion of patients with at least 1 postoperative local AE by 24 months was 12.5% (95% confidence interval: 7%; 20%) (Table II). Within the 24-month follow-up period, 6 patients had sustained postoperative fractures around the implant; of which, 2 involved the diaphysis of the humerus and 4, the acromion. The humerus fractures occurred at 13 and 23 months post RSA, respectively; both the patients required hospital readmission, and only 1 fracture was surgically stabilized via plate osteosynthesis. Due to a further fall-related trauma, this patient sustained a refracture of the previous osteosynthesis that was finally treated using nonoperative measures. All acromion fractures occurred within the first 3 months post RSA and included 1 Levy type I fracture, 2 type II, and 1 type III fracture; all were implant-related stress fractures and treated nonoperatively.

One patient required superficial wound revision surgery 1 month after RSA due to local wound dehiscence. The overall revision rate was 1.8%, yet the readmission rate was 3.6% as more patients required hospitalization for pain management. One patient experienced an atraumatic event of deep soft-tissue irritation due

Table II
Overview of intraoperative and postoperative local and nonlocal adverse events.

	n	%	95% CI
Adverse events	44	39.3	(30.2-49)
Intraoperative local event	1	0.9	(0.02-4.9)
Intraoperative nonlocal event	0	0	(0-3.2)
Postoperative local event	14	12.5	(7-20.1)
Postoperative nonlocal event	34	30.4	(22-39.8)
Postoperative local event			
Fracture around the implant	6	5.4	
Peripheral neurologic events	6	5.4	
Delayed wound healing	1	0.9	
Irritation of deep soft tissue	1	0.9	
Postoperative nonlocal event			
Cardiovascular event	18	16.1	
15 events with anemia requiring transfusion			
3 events with myocardial ischemia and anemia requiring transfusion			
Musculoskeletal system	5	4.5	
3 Fractures at other body region			
2 events of irritation of deep soft tissue at other body region			
Urinary tract events	3	2.7	
3 events with urinary tract infection			
Neuro-psychiatric event	3	2.7	
2 events of postoperative delirs			
1 events of cerebral ischemia			
Gastrointestinal event	2	1.8	
2 events inflammatory bowel disease			
Pulmonary event	1	0.9	
1 event bronchitis and lung embolism			
Other nonlocal event	6	5.4	
2 events of trauma related soft tissue injuries at other body region			
2 events of impaired renal function			
2 events of infections at other body region			

CI, confidence interval.

to the conjoining tendon with acute onset of pain at 20 months post RSA; no intervention was undertaken as the pain was self-limiting.

Peripheral neurologic disorders affecting the local arm after RSA were observed in 6 patients who all received nonoperative treatment. Three cases were considered as severe peripheral neurologic complications and recognized immediately after RSA: 1 patient experienced sensorimotor axillary neuropathy with persistent damage; 1 case of subtotal radialis paresis occurred at the immediate post-RSA period with full recovery achieved within 1 year; and the last patient had a lesion of the lower plexus brachialis with partial recovery and remaining sensorimotor ulnar neuropathy. All other peripheral neurologic disorders were transient with full recovery.

Postoperative nonlocal AEs

Postoperative nonlocal events were the most commonly occurring (77.2%) of all AEs and recorded in 34 patients (30%; 95% confidence interval: 22%; 40%) (Table II). Of the nonlocal AEs, most patients (16%) sustained postoperative anemia that required a blood transfusion. Of the 5 patients reported with a nonlocal musculoskeletal event, 1 required hospital readmission for treatment of a contralateral periprosthetic elbow fracture sustained upon falling

Discussion

The main finding of this study is that our patients aged 85 years and higher achieved good clinical results and are satisfied at 12 to 24 months after RSA.

All postoperative clinical scores significantly improved and patients showed high overall satisfaction, which is in line with the excellent functional outcome of RSA patients older than 80 years presented in a number of previous studies.^{6,19,22}

There are data highlighting a correlation between the presence of comorbidities and poorer final outcome after total joint replacement in aged persons, but this information mainly derives from hip and knee replacement patients. Only 1 study noted the same correlation between comorbidities in patients older than 80 years and poor final outcome after primary RSA.²² Our investigation, however, did not identify a poorer clinical outcome in patients with higher comorbidities (ASA III-IV) compared to healthier patients (ASA I-II). Furthermore, QOL increased for our patient cohort by the 2-year follow-up, which is consistent with a cost-utility analysis of shoulder arthroplasty.¹³

In a large series monitored over a 10-year period, 6 of 363 RSA patients (1.7%) required a reoperation within the first 90 days.³¹ We did not identify a higher rate of reoperations in our advanced elderly patients in the first 3 months. Within this period, we only had to revise 1 case from 112 patients (0.9%) 3 months after primary surgery because of delayed wound healing. A major factor in the development of local complications can be the increased tendency of advanced elderly patients to fall in combination with poor bone quality. Four of our patients (5%) fell within the first 3 months after RSA. Kriechling et al¹⁹ detected 9 cases (5%) of glenoid loosening, of which, 2 were definitively related to a fall. Furthermore, 38% of the reported fractures of the humeral stem, acromion, and scapular spine were related to a fall. We documented 3 patients who had fallen within the first 30 days after surgery.

Seven periprosthetic fractures (6.3%) were identified in our cohort. There were no signs of early loosening, migration, or dislocation after 24 months. Mangano et al²² reported on a group of 52 patients 80 years and older and showed a slightly lower number but similar fracture pattern (ie, 1 intraoperative and 1 postoperative humerus fracture as well as 1 postoperative acromial fracture). In another cohort of 179 patients older than 80 years (where 81 patients had complete 24-month follow-up data), Clark et al⁶ only observed 4% of patients with acromial fractures and no fractures of the humerus. None of these fractures needed revision, although 3 patients underwent surgery for implant-related AEs of dislocation (n = 2) and glenoid loosening (n = 1). Auxiliary subgroup analysis focusing only on those patients aged over 90 years established that none of them needed revision surgery, there were 2 local wound healing AEs, and no further cases of local AEs.⁶ Kriechling et al¹⁹ investigated the outcomes of 159 slightly younger patients (mean age: 84 years); they reported 14 (9%) postoperative fractures, with 5 of them requiring revision surgery. Moreover, there were also 9 cases of glenoid loosening, where 4 were completely displaced due to a fall and required revision surgery. With a total of 30 local complications (18%), 13 (8%) of these events had to be revised.¹⁹ These numbers are comparable to our reported percentage of local complications (13.4%) as well as AE data from further studies.^{6,34} The overall 24-month revision rate of our cohort was 1.8%; only 1 patient needed additional surgery due to local wound healing problems and another needed revision surgery due to a trauma-induced periprosthetic humerus fracture.

The overall mortality rate in our study was 9.8%, and none of our patients died within the first 3 months postoperatively. Mangano et al²² published a 0% 90-day mortality rate for primary RSA patients older than 80 years of age. Conversely, Clark et al⁶ reported an overall mortality rate of 19% for their cohort of 179 primary RSA patients with at least 24 months of follow-up, with only 1 patient (0.4%) from their original collective of 242 patients died within the first 3 months after surgery.

The 4 severe medical AEs (3.5%) reported in our cohort occurred during RSA hospitalization.

This rate is in line with previous data: Kriechling et al¹⁹ did not report any severe medical AEs in 159 patients and Clark et al⁶ reported 3% severe medical AEs (including deep vein thrombosis, stroke, and pneumonia) post RSA in 242 patients aged over 80 years. Our incidence (5.2% of all patients) of clinically evident local neurologic complications is also comparable with current literature. Subclinical neurologic injuries with postoperative electromyography changes are common after RSA, while the incidence of neurologic injury is less frequent (ie, ranging from 0.5% to 2.9% in the literature).³

Postoperative anemia requiring transfusion was the most frequent AE (16%), our rate was twice as high as that reported for a similarly aged RSA cohort.⁶ Nonetheless, Triplet et al³⁴ reported even higher transfusion rates of 22% in 51 patients aged over 80 years undergoing RSA.

We found no significant differences in regard to the occurrence of AEs between healthier patients (30.4% in ASA I/II) and the one with more comorbidities (29.2% in ASA III/IV).

If hospital readmission occurs after RSA, this event will usually take place early. An overall readmission rate of 6.6% for RSA patients is known in the first 90 days for a large series.²¹ Infections and instability were noted as the most common causes for readmission as an inpatient, and half of these readmissions required surgery.²¹ In our cohort, a readmission rate of 3.6% was observed.

There are several limitations to this investigation. This was a retrospective study based on prospectively collected data, which lacks a control group. Several types of implants were used by surgeons of a high-volume specialized shoulder unit, and this makes the translation of our results to less experienced surgeons with smaller volumes of RSA difficult. All patients were included in the analysis of mortality and morbidity, but only 65% of these advanced geriatric patients had a follow-up of 24 months. Nevertheless, we consider our overall missing rates of 5% for the 12-month follow-up and 18% for the 24-month follow-up acceptable for such patients of advanced age. Our functional results cannot be applied generally to all patients of this age group and in need of RSA as our cohort received predominantly elective primary surgery. And, also because the preoperative selection process for eligible patients for surgery poses a selection bias itself. Seventy-two percent of our patients had a cuff tear arthropathy and only 12% of our patients had a previous shoulder surgery. Despite these limitations, we could show the excellent improvement of shoulder function and low complication rate in this first study on a large cohort of patients 85 years and older receiving primary RSA.

Conclusions

Good short-term clinical outcomes and high patient satisfaction can be expected after RSA in patients older than 85 years. RSA is a safe procedure even in these elderly patients with an acceptable rate of shoulder local and other nonlocal unfavorable events.

Acknowledgments

We would like to acknowledge A. Marzel for his contribution in the early stages of conceptualization of this study. The authors would like to thank M. Wilhelmi PhD, medical writer at Schulthess Klinik, for the language editing of this manuscript.

Disclaimers:

Funding: Support for this research was provided by Schulthess Klinik.

Conflicts of interest: Markus Scheibel is a paid consultant of and receives royalties from Arthrex Inc. The other authors, their immediate families, and any research foundation 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.

Supplementary Data

Supplementary data to this article can be found online at [10.1016/j.jseint.2022.05.005](https://doi.org/10.1016/j.jseint.2022.05.005).

References

- Angst F, Goldhahn J, Pap G, Mannion AF, Roach KE, Siebertz D, et al. Cross-cultural adaptation, reliability and validity of the German Shoulder Pain and Disability Index (SPADI). *Rheumatology (Oxford)* 2007;46:87-92. <https://doi.org/10.1093/rheumatology/ke040>.
- Audigé L, Schwyzer HK, Durchholz H. Core set of unfavorable events of shoulder arthroplasty: an international Delphi consensus process. *J Shoulder Elbow Surg* 2019;28:2061-71. <https://doi.org/10.1016/j.jse.2019.07.021>.
- Barco R, Savvidou OD, Sperling JW, Sanchez-Sotelo J, Cofield RH. Complications in reverse shoulder arthroplasty. *EFORT Open Rev* 2016;1:72-80. <https://doi.org/10.1302/2058-5241.1.160003>.
- Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. Ectopic ossification following total hip replacement. Incidence and a method of classification. *J Bone Joint Surg Am* 1973;55:1629-32.
- Bundesamt S. *Ältere Menschen in Deutschland und der EU*. Wiesbaden: Statistische Bundesamt; 2016.
- Clark NJ, Samuelsen BT, Alentorn-Geli E, Assenmacher AT, Cofield RH, Sperling JW, et al. Primary reverse shoulder arthroplasty in patients older than 80 years of age. *Bone Joint J* 2019;101-B:1520-5. <https://doi.org/10.1302/0301-620x.101b12.Bjj-2018-1571.R2>.
- Constant CR. Assessment of shoulder function. *Orthopäde* 1991;20:289-94.
- Constant CR, Gerber C, Emery RJ, Sojbjerg JO, Gohlke F, Boileau P. A review of the Constant score: modifications and guidelines for its use. *J Shoulder Elbow Surg* 2008;17:355-61. <https://doi.org/10.1016/j.jse.2007.06.022>.
- Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13. <https://doi.org/10.1097/01.sla.0000133083.54934.ae>.
- Familiari F, Rojas J, Nedim Doral M, Huri G, McFarland EG. Reverse total shoulder arthroplasty. *EFORT Open Rev* 2018;3:58-69. <https://doi.org/10.1302/2058-5241.3.170044>.
- Felsch Q, Mai V, Durchholz H, Flury M, Lenz M, Capellen C, et al. Complications within 6 months after arthroscopic rotator cuff repair: registry-based evaluation according to a core event set and severity grading. *Arthroscopy* 2021;37:50-8. <https://doi.org/10.1016/j.arthro.2020.08.010>.
- Gilbart MKGC. Comparison of the subjective shoulder value and the Constant score. *J Shoulder Elbow Surg* 2007;16:717-21. <https://doi.org/10.1016/j.jse.2007.02.123>.
- Grobet CE, Glanzmann MC, Eichler K, Rickenbacher D, Meier F, Brunner B, et al. Cost-utility analysis of total shoulder arthroplasty: a prospective health economic study using real-world data. *J Shoulder Elbow Surg* 2021;30:1998-2006. <https://doi.org/10.1016/j.jse.2021.03.136>.
- Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research Electronic Data Capture (REDCap) - a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377-81. <https://doi.org/10.1016/j.jbi.2008.08.010>.
- Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res* 2011;20:1727-36. <https://doi.org/10.1007/s11136-011-9903-x>.
- Hillerås PK, Jorm AF, Herlitz A, Winblad B. Activity patterns in very old people: a survey of cognitively intact subjects aged 90 years or older. *Age Ageing* 1999;28:147-52.
- Horgas AL, Wilms H-U, Baltes MM. Daily life in very old age: everyday activities as expression of successful living. *Gerontologist* 1998;38:556-68.
- Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. *J Bone Joint Surg Am* 2011;93:2249-54. <https://doi.org/10.2106/jbjs.j.01994>.
- Kriechling P, Loucas R, Loucas M, Künzler T, Gerber C, Wieser K. Primary reverse total shoulder arthroplasty in patients older than 80 years: clinical and radiologic outcome measures. *J Shoulder Elbow Surg* 2021;30:877-83. <https://doi.org/10.1016/j.jse.2020.07.032>.
- Ludwig K, Graf von der Schulenburg J, Greiner W. German value set for the EQ-5D-5L. *Pharmacoeconomics* 2018;36:663-74. <https://doi.org/10.1007/s40273-018-0615-8>.
- Mahoney A, Bosco JA, Zuckerman JD. Readmission after shoulder arthroplasty. *J Shoulder Elbow Surg* 2014;23:377-81. <https://doi.org/10.1016/j.jse.2013.08.007>.

22. Mangano T, Cerruti P, Repetto I, Felli L, Ivaldo N, Giovale M. Reverse shoulder arthroplasty in older patients: is it worth it? A subjective functional outcome and quality of life survey. *Aging Clin Exp Res* 2016;28:925-33. <https://doi.org/10.1007/s40520-015-0493-2>.
23. Marzel A, Schwyzer H-K, Kolling C, Moro F, Flury M, Glanzmann MC, et al. The Schulthess local shoulder arthroplasty Registry (SAR): cohort profile. *BMJ Open* 2020;10:e040591. <https://doi.org/10.1136/bmjopen-2020-040591>.
24. Maugendre E, Gadisieux B, Chantelot C, Clavert P, Ramdane N, Werthel J-D, et al. Epidemiology and mortality in older patients treated by reverse shoulder arthroplasty for displaced proximal humerus fractures. *Orthop Traumatol Surg Res* 2019;105:1509-13. <https://doi.org/10.1016/j.otsr.2019.07.026>.
25. Murena L, Hoxhaj B, Fattori R, Canton G. Epidemiology and demographics of reverse shoulder arthroplasty. In: Gumina S, Grassi FA, Paladini P, editors. *Reverse shoulder arthroplasty: Current Techniques and complications*. Cham: Springer International Publishing; 2019. p. 59-67. 9783319977430, 3319977431.
26. Newman JM, Stroud SG, Yang A, Sodhi N, Dixit A, Doran JP, et al. Total shoulder arthroplasty in octogenarians: is there a higher risk of adverse outcomes? *J Orthop* 2018;15:671-5. <https://doi.org/10.1016/j.jor.2018.05.035>.
27. Schoch BS, Barlow JD, Schleck C, Cofield RH, Sperling JW. Shoulder arthroplasty for post-traumatic osteonecrosis of the humeral head. *J Shoulder Elbow Surg* 2016;25:406-12. <https://doi.org/10.1016/j.jse.2015.08.041>.
28. Simovitch R, Flurin PH, Wright T, Zuckerman JD, Roche CP. Quantifying success after total shoulder arthroplasty: the minimal clinically important difference. *J Shoulder Elbow Surg* 2018;27:298-305. <https://doi.org/10.1016/j.jse.2017.09.013>.
29. Sirveaux F, Favard L, Oudet D, Huquet D, Walch G, Molé D. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff. Results of a multicentre study of 80 shoulders. *J Bone Joint Surg Br* 2004;86:388-95. <https://doi.org/10.1302/0301-620x.86b3.14024>.
30. Sperling JW, Cofield RH, O'Driscoll SW, Torchia ME, Rowland CM. Radiographic assessment of ingrowth total shoulder arthroplasty. *J Shoulder Elbow Surg* 2000;9:507-13.
31. Streubel PN, Simone JP, Sperling JW, Cofield R. Thirty and ninety-day reoperation rates after shoulder arthroplasty. *J Bone Joint Surg Am* 2014;96:e17. <https://doi.org/10.2106/jbjs.M.00127>.
32. NJR Steering Committee. The national joint Registry [NJR] for England W, Northern Ireland and the Isle of Man. National joint registry for England, Wales, Northern Ireland and the isle of man (2018) 15th annual report 2018.
33. Torrens C, Guirro P, Santana F. The minimal clinically important difference for function and strength in patients undergoing reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2016;25:262-8. <https://doi.org/10.1016/j.jse.2015.07.020>.
34. Triplett JJ, Everding NG, Levy JC, Formaini NT, O'Donnell KP, Moor MA, et al. Anatomic and reverse total shoulder arthroplasty in patients older than 80 Years. *Orthopedics* 2015;38:e904-10. <https://doi.org/10.3928/01477447-20151002-58>.