JSES International 8 (2024) 185–190

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Clinical outcomes are unchanged after a mean of 12 years after reverse shoulder arthroplasty: a long-term re-evaluation

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A R T I C L E I N F O

Keywords:
Reverse shoulder arthroplasty
Glenohumeral osteoarthritis
Concentric osteoarthritis
Massive rotator cuff tear
Eccentric osteoarthritis
Constant-Murley Score
Scapular notching
Satisfaction

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

Background: The medium-term results of reverse shoulder arthroplasty (RSA) that has been performed by a single surgeon have been previously reported. The purpose of this study was to investigate the minimum 10-year clinical and radiographic outcomes of these patients.
Methods: In this prospective cohort study, 27 patients were evaluated after RSA for massive rotator cuff tear with or without eccentric osteoarthritis (OA) or concentric OA with the Constant-Murley Score (CMS), range of motion (ROM), and a radiologic assessment.
Results: At a mean 12-year follow-up, the CMS and ROM were significantly improved when compared with the baseline values (all $P < .001$). Once stratified by diagnosis, no difference in the ROM or total CMS was found between patients with massive rotator cuff tear with/without eccentric OA and those with concentric OA. Neither ROM nor CMS decreased when compared to the mid-term values of the previous study, for both the overall population and the diagnosis-stratified groups. Scapular notching was reported in 66.7% of cases that was similar to the data reported at mid-term follow-up. The calcification rate was 59.3% at the long-term evaluation, and there were no differences between the same case-series population (51.9%; $P = .785$) and the whole population at mid-term follow-up (47%; $P = .358$).
Conclusion: RSA led to excellent clinical and functional outcomes for patients up to 17 years postoperatively, and there was no decrease in the CMS over time. No loosening of implants was noted, and the rate of scapular notching was 66%, mostly grade 1 or 2.

Reverse shoulder arthroplasties (RSAs) have been increasingly performed in recent decades due to the expansion of indications and the evolution of implants.[7,8,21,22,24,25,27]

In this light, RSA has demonstrated promising short-term and mid-term outcomes, but despite its increased application, satisfactory relief of pain, and improved functional outcomes for multiple diseases, the long-term results of RSA have been rarely reported.[1,2,7,14,25]

By analyzing the long-term outcomes and assessing the rate of complications and survival of patients treated with RSA, researchers have provided reliable information for surgical and clinical decision-making,[25] even for the youngest patients for whom total shoulder arthroplasty may be preferred to RSA.[4] Long-term re-evaluation of patients[1] and seriated evaluations[2,13] have shown that function deteriorates over time.

The aim of this study is (1) to evaluate the long-term clinical and radiological outcomes in a prospective series of patients who underwent RSA and were followed up for at least 10 years and (2) to compare these results with the mid-term

Ethical approval for this study was obtained from Villa Maria Cecilia Hospital (ID: 0045/2002).

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https://doi.org/10.1016/j.jseint.2023.10.001

outcomes of the same case series[7] that was followed up for at least 3 years.

Methods

Study population

The study protocol was approved by the local ethical committee and performed in compliance with the Helsinki Declaration. Inclusion criteria were (1) patients who were aged more than 18 years at the time of the operation, (2) patients who underwent primary RSA, and (3) a minimum 10-year follow-up. Exclusion criteria were patients with proximal humeral fractures with fracture sequelae, rheumatoid arthritis, tumors, allergies to the materials of metal implants, a history of alcohol or other substance abuse, a predicted survival of less than 6 months, who were unwilling to participate in the continuation of the study, or legally incapacitated.

Operative technique and postoperative protocol

All the procedures were performed by one trained experienced shoulder surgeon (R.C.) by using a deltoid-pectoral approach. Patients were operated on under general anesthesia with an interscalene nerve block in the beach-chair position.[7] A Delta III implant (DePuy, Saint-Priest, France) was implanted in all the patients; all the implants were cemented with Palacos RþG (Heraeus GmbH, Wehrheim, Germany) using a vacuum mixing device (Palamix; Heraeus GmbH, Wehrheim, Germany). In all the patients, the glenoid baseplate was fixed into position with 4 3.5-mm unlocking screws and a 36-mm glenoid sphere was placed at a neutral offset. The subscapularis tendon was not repaired in any of the patients.

A surgical drain was used and removed one day after surgery. The patients used a 15-to-30 abduction shoulder brace for 3 weeks postoperatively; at discharge, passive-assisted and active-assisted range of motion (ROM) exercises were initiated, progressively allowing patients to return to daily living activities; exercises to strengthen the shoulder were permitted 2 months after surgery.

Clinical evaluation

A detailed clinical history was obtained from all the patients. Baseline social, anthropometric, educational, and occupational variables that might be associated with the outcomes were gathered through a study-specific questionnaire.[7] All the participants underwent a structured assessment using an expanded outcome set based on previously published measures and definitions.[7] Before surgery and at the last follow-up, the patients underwent a standardized examination to examine their shoulder ROM during active direct forward flexion, abduction, external, and internal rotation.[7] The preoperative and last follow-up Constant-Murley Scores (CMSs)[11] were recorded for all the patients, and as in the previous study, a digital dynamometer (Myometer 500 N; Atlantech Medical Devices, Nottingham, UK) was used for power measurements. The CMS was normalized for sex and age using the following formula: normalized CMS $=$ (raw CMS /normal CMS) $\times$ 100. Postoperative CMS values were compared with previously published sex-matched and age-matched norms.[17]

For both ROM and CMS, the recovery rate (RR) was computed using the following formula: $RR = (postoperative\ value - preoperative\ value)/postoperative\ value \times 100$, as previously described.[7] Intraoperative or postoperative problems and complications were also reported. Finally, patient satisfaction was noted, and patients were asked if they would undergo the same type of surgery again.

Table I
Baseline characteristics of included patients.

Patients	Mean ± SD (range) or no. (%)
Gender	
Male	4 (14.8)
Female	23 (85.2)
Civil Status	
Married	23 (85.2)
Widowed	4 (14.8)
Educational Level	
Illiteracy	6 (22.2)
Elementary School	12 (44.4)
Middle School	8 (29.6)
High School	1 (3.7)
Previous Shoulder Surgery	3 (11.1)
Preoperative Diagnosis	
MRCT	14 (51.9)
Eccentric OA	4 (14.8)
Concentric OA	9 (33.3)
Operated side	
Right	17 (63.0)
Left	10 (37.0)
Age at operation (yr)	71.4 ± 4.5 (63-73)
Age at all follow-up (yr)	84.2 ± 5.3 (75-91)
Follow-up (mo)	150.2 ± 13.9 (136-201)

SD, standard deviation; *MRCT*, massive rotator cuff tear; *OA*, osteoarthritis.

Radiological evaluation

A radiologic assessment was performed preoperatively and at the last follow-up. The radiographic evaluation was based on an axillary radiograph, true anteroposterior views of the glenohumeral joint, and a scapular lateral view of the shoulder. A trained author (A.M.) who was unaware of the patients' clinical features reviewed radiographic studies. The preoperative radiographs were graded as previously described by Hamada[16] et al. Medialization, tilting of the glenoid-sphere, and mobilizations of the stem were analyzed; evidence of humeral radiolucency was evaluated with the system described by Gruen et al and adapted to the shoulder[7,15,20]; humeral loosening was defined as a radiolucent line of 2 mm or greater in 3 or more contiguous zones[9]; radiolucency around the glenoid component was evaluated according to the criteria proposed in Melis[20] et al; and glenoid loosening was confirmed by lucent lines measuring 2 mm, a shift in position based on preoperative and postoperative radiographs or a displaced component.[20] Radiographs were also evaluated for scapular notching on the basis of the criteria proposed in Sirveaux[26] et al. Periprosthetic calcifications were evaluated in accordance with previous descriptions in Bufquin[5] et al.

Statistical analysis

The mean, standard deviation, and range were reported for continuous variables; counts were adopted for categorical variables. The distribution of the numeric samples was assessed using the Kolmogorov–Smirnov normality test. Based on this preliminary analysis, parametric tests were adopted. Paired and unpaired Student's *t*-tests were used to analyze the significance of the differences when appropriate.

IBM SPSS software (SPSS version 26; IBM Corp., Armonk, NY, USA) was used for database construction and statistical and power analyses. A *P* value less than .05 was considered significant.

Table II
Individual characteristics and clinical and functional data of included patients.

	Demographics							Preoperative ROM				Long-term follow-up ROM				Preoperative CMS					Long-term follow-up CMS				
	Year of operation	Diagnosis	Hamada classification	Age at operation	Gender	Side	Previous surgery	Flexion	Abduction	External rotation	Internal rotation	Flexion	Abduction	External rotation	Internal rotation	Total	Pain	ADLs	ROM	Power	Total	Pain	ADLs	ROM	Power
			Grade	Years				Degrees	Degrees	Degrees	Degrees	Degrees	Degrees	Degrees	Degrees										
1	2003	MRCT	2	77	M	R		110	90	30	50	180	140	60	80	25	0	6	14	5	81	15	20	34	12
2	2004	conc OA	4	70	F	L		80	60	5	40	150	150	70	80	16	0	6	10	0	76	15	20	34	7
3	2005	conc OA	4	69	F	R		80	65	10	40	180	180	50	80	19	5	6	8	0	75	15	20	36	4
4	2005	conc OA	4	74	F	R		80	60	0	30	170	160	20	60	20	5	6	8	1	77	15	20	32	10
5	2005	MRCT	2	67	M	R		70	60	5	20	170	150	40	70	15	5	4	6	0	59	10	16	26	7
6	2005	ecc OA	4	66	F	L		130	110	40	60	140	100	60	60	32	0	8	22	2	79	15	20	34	10
7	2006	ecc OA	4	71	F	R		80	70	15	50	160	150	70	80	20	0	8	12	0	76	15	20	34	7
8	2006	conc OA	5	69	F	R		80	55	0	30	180	150	40	70	18	0	12	6	0	73	15	20	30	8
9	2006	MRCT	2	63	F	R		80	50	0	20	180	130	60	80	16	5	6	4	1	66	15	18	28	5
10	2006	conc OA	4	76	F	R		100	90	20	50	150	100	60	80	25	0	8	16	1	69	15	18	26	10
11	2006	ecc OA	4	72	F	R		100	80	30	60	160	130	45	70	18	0	6	12	0	68	15	20	28	5
12	2006	MRCT	1	76	F	L	*	90	70	10	50	140	100	60	80	28	5	8	14	1	69	15	18	26	10
13	2007	conc OA	4	64	F	L	*	50	40	0	20	140	130	50	80	6	0	4	2	0	62	10	18	28	6
14	2007	MRCT	1	77	F	R		100	85	20	60	180	180	60	80	18	0	6	12	0	75	15	18	32	10
15	2007	ecc OA	4	73	F	R		110	90	30	60	180	170	50	80	29	5	6	16	2	69	15	18	32	4
16	2007	MRCT	1	77	F	R	*	120	80	20	30	100	90	30	60	31	5	8	16	2	50	15	10	20	5
17	2007	MRCT	4	73	F	R		110	90	15	55	170	100	30	60	20	0	6	14	0	65	15	18	28	4
18	2007	conc OA	4	75	F	R		100	75	15	50	180	180	60	80	20	0	6	12	2	73	15	18	32	8
19	2008	MRCT	2	67	M	L		110	90	30	65	130	120	60	80	33	5	10	16	2	71	15	18	32	6
20	2008	MRCT	2	69	F	L		140	100	40	60	140	100	60	60	32	0	8	22	2	64	15	16	28	5
21	2008	MRCT	2	68	F	R		110	100	30	70	180	180	50	80	33	5	10	16	2	73	15	20	32	6
22	2008	MRCT	4	75	F	L		100	85	20	50	180	180	20	60	24	5	6	12	1	76	15	20	36	5
23	2008	MRCT	4	78	F	L		90	80	10	50	150	100	60	80	28	5	10	12	1	69	15	18	26	10
24	2008	conc OA	5	72	F	L		90	80	20	50	130	100	20	40	24	5	6	12	1	51	10	14	26	1
25	2008	conc OA	4	63	M	L		120	100	30	60	180	180	60	80	24	5	6	12	1	77	15	18	36	8
26	2008	MRCT	2	73	F	R		120	100	40	70	180	180	30	70	32	0	10	20	2	71	15	20	34	2
27	2008	MRCT	4	75	F	R		100	80	25	60	180	180	20	70	20	0	8	12	0	67	15	20	28	4

ROM, range of motion; *CMS*, Constant-Murley Score; *MRCT*, massive rotator cuff tear; *ecc*, eccentric; *conc*, concentric; *OA*, osteoarthritis; *ADLs*, activities of daily living; *M*, male; *F*, female; *R*, right; *L*, left.
*History of previous surgery.

Table III
Preoperative and long-term follow-up clinical and functional outcomes.

	Preoperative mean ± SD (range)	Follow-up mean ± SD (range)	RR %	*P* value
ROM				
Flexion	98.2 ± 19.9 (50-140)	161.4 ± 22.5 (100-180)	64.4	**<.001**
Abduction	79.1 ± 17.4 (40-100)	140.9 ± 32.6 (90-180)	78.2	**<.001**
External Rotation	18.9 ± 12.8 (0-40)	48.0 ± 16.2 (20-70)	142.5	**<.001**
Internal Rotation	48.6 ± 15.0 (20-70)	72.3 ± 11.1 (40-80)	48.6	**<.001**
CMS				
Total	23.2 ± 6.9 (6-33)	69.7 ± 7.9 (50-81)	200.2	**<.001**
Pain	2.5 ± 2.6 (0-5)	14.5 ± 1.5 (10-15)	481.8	**<.001**
ADLs	7.3 ± 2.0 (4-12)	18.3 ± 2.4 (10-20)	151.3	**<.001**
ROM	12.4 ± 4.8 (2-22)	30.5 ± 4.1 (20-36)	241.5	**<.001**
Power	1.1 ± 1.2 (0-5)	6.4 ± 2.8 (1-12)	483.3	**<.001**

SD, standard deviation; *RR*, recovery rate; *ROM*, range of motion; *CMS*, Constant-Murley Score; *ADL*, activities of daily living.
Bold values indicate statistical significance ($P < .05$).

Results

Demographic and baseline characteristics

In a previous study,[7] 80 patients who underwent RSA from 2003 to 2008 were clinically evaluated at a mean 5-year follow-up; 62 of these 80 patients were also radiographically assessed. In the present study, we revaluated this population, and 27 patients (27 cases) were available for follow-up. In details, 9 (14.5%) of 62 refused to participate in the study due to disinterest or other reasons (ie, confinement, severe comorbidities, or inability to travel); 12 patients (19.4%) were lost to follow-up due to deactivation of the telephone line or changed address; 14 patients (22.6%) died from causes unrelated to the prosthetic implant. All the patients gave informed consent for participation in the continuation of the study, which was performed with prospective data collection. Table I shows the demographics of the included patients. The mean age at the time of surgery was 71.4 ± 4.5 years (range, 63-78), and 85.2% of the population was female.

According to the clinical and radiological preoperative investigations, 14 patients (51.9%) had massive rotator cuff tears (MRCTs), 4 (14.8%) had glenoid-humeral eccentric osteoarthritis (OA), and 9 (33.3%) had concentric OA. According to the Hamada[16] classification, 3 patients (11.1%) were stratified as grade 1, 7 patients (25.9%) as grade 2, 15 patients as grade 4 (55.6%), and 2 patients as grade 5 (7.4%) (Table II).

Clinical outcomes

At 12.5 ± 1.2 years (range, 11.3-16.8) follow-up, patients were aged 84.2 ± 5.3 years (range, 75-91). As shown in Table III, the ROM values and CMS showed statistically significant improvements ($P < .001$ for all parameters) in comparison to the preoperative assessment but no significant differences were noted in comparison to the values recorded at mid-term[7] (Table IV). At last follow-up, no patients showed a total CMS and a CMS pain less than 30 and 10, respectively, and postoperative CMS values were 85% of the sex-matched and age-matched normal values.

By stratifying cases by different diagnoses (ie, MRCT and/or eccentric OA group vs. concentric OA group), no differences in postoperative ROM and most of the CMS subscales were found (Table V) at last follow-up. Indeed, only the CMS pain subsection showed a statistically significant difference ($P = .008$) being higher in the MRCT/eccentric OA group.

As shown in Table VI, when the outcomes of the whole population at mid-term[7] were compared with those recorded after a mean of 12.5 years, the total CMS did not significantly differ.

In the present study, all the patients were satisfied and declared that they would have undergone the same operation again. No additional complications were noted in comparison to the mid-term follow-up[7] (ie, one hematoma, which was managed conservatively, and a dislocation, which was managed with polyethylene exchange).

Radiological results

After a mean of 12.5 years, none of the patients showed medialization, tilting of the glenosphere, or mobilization of the stem.

According to the Sirveaux classification, the degree of scapular notching, as reported in 66.7% of cases, was noted as grade 1 in 9 cases (33.3%), grade 2 in 7 cases (25.9%), grade 3 in 1 case (3.7%), and grade 4 in 1 case (3.7%). At mid-term follow-up,[5] the same cases showed 63.0% of evidence of scapular notching, stratified as follows: grade 1 in 10 cases (37.0%), grade 2 in 6 cases (22.2%), and grade 3 in 1 case (3.7%). Considering the whole population of the previous study,[5] 71% of patients showed evidence of scapular notching: 31 cases (50.0%) of grade 1, 10 cases (16.1%) of grade 2, 2 cases (3.2%) of grade 3, and 1 case (1.61%) of grade 4.

In the present study, 59.3% of patients showed periprosthetic calcifications in comparison to 51.9% of the same case series at mid-term follow-up[5] ($P = .785$); moreover, no difference was reported in comparison to the mid-term[5] calcification rate (47%) of the whole population ($P = .358$).

Discussion

In the present study, after a mean 12.5-year follow-up, the overall functional outcomes of the RSA were successful. No patients showed a total CMS less than 30 and the CMS values measured 85% of the sex-matched and age-matched normal values. None of the patients showed medialization or tilting of the glenosphere, nor loosening of the stem; a 67% of scapular notching, mostly grade 1 and 2 and a 59% calcification rate were reported. The most important finding of the present study was that the CMS, ROM, calcification rate, and scapular notching and a mean of 12.5 years after RSA did not significantly differ in comparison to the values recorded after a mean follow-up of 5 years.[5]

The lack of significant differences between outcomes measured 5 and 12 years after RSA is consistent with the observation that the length of follow-up is not a predictor of clinical outcomes.[7] With state-of-the-art technology and predictable outcomes, RSA is the primary focus of previous published reports suggesting that 7-10 years after surgery, patients who are aged less than 65 years did not show any functional deterioration after RSA[12] but rather functional scores and/or clinical features are expected to significantly decline thereafter. Favard et al[13] observed that functional decline after RSA, as measured with the CMS, should be expected starting from 9 years postoperatively. Bassens et al[2] found that CMSs at a mean follow-up

Table IV
Comparison between mid-term and long-term outcomes.

	Mid-term previous study (n: 27) mean ± SD (range)	Long-term current study (n: 27) mean ± SD (range)	P value
ROM			
Flexion	163.2 ± 20.1 (120-180)	161.4 ± 22.5 (100-180)	.104
Abduction	141.8 ± 31.4 (100-180)	140.9 ± 32.6 (90-180)	.162
External Rotation	48.9 ± 15.1 (20-70)	48.0 ± 16.2 (20-70)	.162
Internal Rotation	72.7 ± 10.8 (40-80)	72.3 ± 11.1 (40-80)	.329
CMS			
Total	70.7 ± 7.0 (50-81)	69.7 ± 7.9 (50-81)	.112
Pain	14.1 ± 2.0 (10-15)	14.5 ± 1.5 (10-15)	.162
ADLs	18.5 ± 1.9 (14-20)	18.3 ± 2.4 (10-20)	.189
ROM	31.0 ± 3.7 (26-36)	30.5 ± 4.1 (20-36)	.178
Power	6.5 ± 2.8 (1-12)	6.4 ± 2.8 (1-12)	.162

SD, standard deviation; *ROM*, range of motion; *CMS*, Constant-Murley Score; *ADL*, activities of daily living.

Table V
Comparison between diagnosis-based long-term follow-up values.

	MRCT + eccentric OA (No.: 18) mean ± SD (range)	Concentric OA (No.: 9) mean ± SD (range)	P value
ROM			
Flexion	161.7 ± 23.6 (100-180)	161.1 ± 19.0 (130-180)	.952
Abduction	139.4 ± 35.7 (90-180)	144.4 ± 29.6 (100-180)	.721
External Rotation	49.2 ± 15.9 (20-70)	45.6 ± 17.4 (20-70)	.595
Internal Rotation	72.8 ± 8.9 (60-80)	71.1 ± 13.6 (40-80)	.705
CMS			
Total	70.1 ± 6.9 (50-81)	68.8 ± 9.4 (51-77)	.678
Pain	15.0 ± 0.0 (15-15)	13.3 ± 2.5 (10-15)	**.008**
ADLs	18.3 ± 2.4 (10-20)	18.2 ± 2.1 (14-20)	.907
ROM	30.2 ± 4.0 (20-36)	30.4 ± 4.2 (26-36)	.895
Power	6.6 ± 2.8 (2-12)	6.8 ± 2.9 (1-10)	.848

SD, standard deviation; *MRCT*, massive rotator cuff tear; *OA*, osteoarthritis; *ROM*, range of motion; *CMS*, Constant-Murley Score; *ADL*, activities of daily living.
Bold values indicate statistical significance ($P < .05$).

of 9 years were significantly less than those at 5 years. Bacle et al[1] followed an RSA cohort for the long-term outcomes that were compared with results previously reported at a mean follow-up of 5 years.[28] At their final 12.5 years of follow-up, they reported a statistically significant decrease in CMS and all of its subsections with respect to the previous medium-term evaluation. The article by Gerber et al[14] is the only article with findings that are consistent with our data. The authors showed that the mean CMS did not significantly deteriorate over 15 years; however, the mean active abduction was significantly reduced over time, and they related this result to both muscle fiber recruitment decompensation and ongoing weakness caused by muscle aging. Similarly, Bacle et al[1] justified the deterioration of shoulder strength and ROM caused by impairment of the deltoid, in which contraction-stretching cycles might be altered due to the medialized center of rotation following RSA.

In our series, long-term postoperative flexion, abduction, external rotation, and internal rotation measured 161°, 141°, 48°, and 72°, respectively, and these values are higher than those of previous reports with a similar long-term follow-up.[1,12-14]

Stratification of patients according to the initial diagnosis revealed that those suffering from concentric OA exhibited higher postoperative pain than those suffering from eccentric OA/MRCT. In this context, our findings might be related to the natural history of concentric OA. Accordingly, Logli et al[18] demonstrated that while shoulders with an eccentric pattern stably remain eccentric,

Table VI
Comparison between the long-term CMS of 27 patients and those of the whole population at mid-term.

	Mid-term previous studies (n: 80) mean ± SD (range)	Long-term recent study (n: 27) mean ± SD (range)	P value
CMS			
Total	66 ± 11 (34-85)	69.7 ± 7.9 (50-81)	.110
Pain	14 ± 2 (5-15)	14.5 ± 1.5 (10-15)	.237
ADLs	17 ± 3 (10-20)	18.3 ± 2.4 (10-20)	**.044**
ROM	29 ± 6 (12-40)	30.5 ± 4.1 (20-36)	.231
Power	6 ± 3 (1-15)	6.4 ± 2.8 (1-12)	.544

SD, standard deviation; *CMS*, Constant-Murley Score; *ADL*, activities of daily living; *ROM*, range of motion.
Bold values indicate statistical significance ($P < .05$).

shoulders with a concentric pattern could deteriorate, developing eccentricity, as the natural history of concentric OA is characterized by a severe progression of humeral head subluxation and glenoid bone loss over time.

In our cohort, the rate of scapular notching was found to be 63% and 67% at a mean 5-year and 12-year follow-up, respectively, and a slight albeit clinically irrelevant worsening of grading was observed. These data confirm the regression analyses of our previous report assessing that the length of follow-up was a positive predictor of scapular notching, with an increase in severity over time.[7] Rates of scapular notching widely varied among different long-term studies on RSAs. Our rate is similar to the value reported by Bülhoff et al[6]; conversely, higher rates have been reported by Beck et al,[3] Bacle et al,[1] and Gerber et al,[14] while Ek et al[12] reported a lower rate. Different features have been previously demonstrated to account for the determinism of scapular notching, such as the surgical approach[23] and glenoid component positioning. Indeed, Mazaleyrat et al[19] reported that, in their cohorts, the rates of scapular notching were 44.6% and 50%, which are lower than all the aforementioned rates and may be related to the different cranial positions of the glenoid plate (ie, high, flush, low, and very low). Accordingly, Collotte et al[10] reported a very low 37% rate of scapular notching following overhang positioning of the glenoid component. Of note, the majority of cases of scapular notching in all the aforementioned studies, as in the current one, have been classified as low-grade (ie, grade 1 or 2) having an irrelevant clinical impact, while very few cases have been classified as high-grade (ie, grade 3 or 4) posing the risk for glenoid loosening.[27] Indeed, no component loosening was observed in our long-term cohort.

A certain limitation of the present study is the small cohort of patients who were enrolled for long-term re-evaluation, representing 56.3% of the living patients clinically and radiographically evaluated in our previous study.[7] This might alter the generalizability of our results. We believe that such a suboptimal recall rate may be related to the long-term follow-up. Indeed, even Bacle et al[1] reported a similar long-term recall rate of 59% with respect to their previous mid-term study.[28] Notably, the design of a long-term re-evaluation of a previous cohort rather than a simple long-term study led us to perform a mid-term vs. long-term comparison of results to evaluate whether postoperative benefits with surgery are maintained over time. While the evaluation of a single-surgeon cohort of procedures has certain benefits due both the standardized procedures and the homogeneity of patients' evaluation, intrinsic biases due to the lack of comparison among different techniques, learning curves, and setting have to be considered. The prospective nature of the data collection methods, the use of validated and standardized functional and radiological assessments, and either sample size or follow-up, comparable with the largest and longest series available, represent considerable strengths of the present study.

Conclusion

RSA achieves excellent clinical and functional results a mean of 12.5 years postoperatively. No medialization or tilting of the glenosphere or loosening of the stem was noted, and the rate of scapular notching was 66%, mostly grade 1 or 2. The ROM, CMS, scapular nothing, and calcification rate did not differ in comparison to the values recorded after a mean 5-year follow-up, thus implying that surgery has an overall stable benefit over time. Physicians should consider these results when discussing the outcomes of this surgery with patients.

Disclaimers:

Funding: Open access funding provided by Università degli Studi Magna Graecia di Catanzaro within the CRUI-CARE Agreement.

Conflicts of interest: The 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.

References

1. Bacle G, Nové-Josserand L, Garaud P, Walch G. Long-term outcomes of reverse total shoulder arthroplasty: a follow-up of a previous study. J Bone Joint Surg Am 2017;99:454-61. https://doi.org/10.2106/JBJS.16.00223.
2. Bassens D, Decock T, Van Tongel A, De Wilde L. Long-term results of the Delta Xtend reverse shoulder prosthesis. J Shoulder Elbow Surg 2019;28:1091-7. https://doi.org/10.1016/j.jse.2018.11.043.
3. Beck S, Patsalis T, Busch A, Dittrich F, Dudda M, Jäger M, et al. Long-term results of the reverse total evolutive shoulder system (TESS). Arch Orthop Trauma Surg 2019;139:1039-44. https://doi.org/10.1007/s00402-019-03135-5.
4. Brochin RL, Zastrow RK, Patel AV, Parsons BO, Galatz LM, Flatow EL, et al. Long-term clinical and radiographic outcomes of total shoulder arthroplasty in patients under age 60 years. J Shoulder Elbow Surg 2022;31:S63-70. https://doi.org/10.1016/j.jse.2022.02.002.
5. Bufquin T, Hersan A, Hubert L, Massin P. Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly: a prospective review of 43 cases with a short-term follow-up. J Bone Joint Surg Br 2007;89:516-20. https://doi.org/10.1302/0301-620X.89B4.18435.
6. Bülhoff M, Zeifang F, Welters C, Renkawitz T, Schiltenwolf M, Tross A-K. Medium- to long-term outcomes after reverse total shoulder arthroplasty with a standard long stem. J Clin Med 2022;11:2274. https://doi.org/10.3390/jcm11092274.
7. Castricini R, Gasparini G, Di Luggo F, De Benedetto M, De Gori M, Galasso O. Health-related quality of life and functionality after reverse shoulder arthroplasty. J Shoulder Elbow Surg 2013;22:1639-49. https://doi.org/10.1016/j.jse.2013.01.020.
8. Castricini R, Mercurio M, Galasso O, Sanzo V, De Gori M, De Benedetto M, et al. Femoral head allograft for glenoid bone loss in primary reverse shoulder arthroplasty: functional and radiological outcomes. J Shoulder Elbow Surg 2023. https://doi.org/10.1016/j.jse.2023.06.027.
9. Chuinard C, Trojani C, Brassart N, Boileau P. Humeral problems in reverse total shoulder arthroplasty. In: Reverse shoulder arthroplasty. Nice, France: Sauramps Medical; 2006. p. 275-88.
10. Collotte P, Bercik M, Vieira TD, Walch G. Long-term reverse total shoulder arthroplasty outcomes: the effect of the Inferior shifting of glenoid component fixation. Clin Orthop Surg 2021;13:505. https://doi.org/10.4055/cios20245.
11. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop 1987;214:160-4.
12. Ek ET, Neukom L, Catanzaro S, Gerber C. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: results after five to fifteen years. J Shoulder Elbow Surg 2013;22:1199-208. https://doi.org/10.1016/j.jse.2012.11.016.
13. Favard L, Levigne C, Nerot C, Gerber C, De Wilde L, Mole D. Reverse prostheses in arthropathies with cuff tear: are survivorship and function maintained over time? Clin Orthop 2011;469:2469-75. https://doi.org/10.1007/s11999-011-1833-y.
14. Gerber C, Canonica S, Catanzaro S, Ernstbrunner L. Longitudinal observational study of reverse total shoulder arthroplasty for irreparable rotator cuff dysfunction: results after 15 years. J Shoulder Elbow Surg 2018;27:831-8. https://doi.org/10.1016/j.jse.2017.10.037.
15. Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop 1979;141:17-27.
16. Hamada K, Fukuda H, Mikasa M, Kobayashi Y. Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop 1990;254:92-6.
17. Katolik LI, Romeo AA, Cole BJ, Verma NN, Hayden JK, Bach BR. Normalization of the constant score. J Shoulder Elbow Surg 2005;14:279-85. https://doi.org/10.1016/j.jse.2004.10.009.
18. Logli AL, Pareek A, Nguyen NTV, Sanchez-Sotelo J. Natural history of glenoid bone loss in primary glenohumeral osteoarthritis: how does bone loss progress over a decade? J Shoulder Elbow Surg 2021;30:324-30. https://doi.org/10.1016/j.jse.2020.05.021.
19. Mazaleyrat M, Favard L, Garaud P, Boileau P, Berhouet J. Press-fit vs. cemented humeral stem fixation for reverse shoulder arthroplasty: functional outcomes at a mean follow-up of 9.5 years. J Shoulder Elbow Surg 2021;30:72-9. https://doi.org/10.1016/j.jse.2020.04.052.
20. Melis B, DeFranco M, Lädermann A, Molé D, Favard L, Nérot C, et al. An evaluation of the radiological changes around the grammont reverse geometry shoulder arthroplasty after eight to 12 years. J Bone Joint Surg Br 2011;93:1240-6. https://doi.org/10.1302/0301-620X.93B9.25926.
21. Mercurio M, Castioni D, Iannò B, Gasparini G, Galasso O. Outcomes of revision surgery after periprosthetic shoulder infection: a systematic review. J Shoulder Elbow Surg 2019;28:1193-203. https://doi.org/10.1016/j.jse.2019.02.014.
22. Mercurio M, Cofano E, Familiari F, Corona K, Cerciello S, Gasparini G, et al. The 50 highest cited papers on shoulder arthroplasty. Healthcare (Basel) 2022;10:2000. https://doi.org/10.3390/healthcare10102000.
23. Nicholson GP, Strauss EJ, Sherman SL. Scapular notching: recognition and strategies to minimize clinical impact. Clin Orthop 2011;469:2521-30. https://doi.org/10.1007/s11999-010-1720-y.
24. Nielsen KP, Amundsen A, Olsen BS, Rasmussen JV. Good long-term patient-reported outcome after shoulder arthroplasty for cuff tear arthropathy. JSES Int 2022;6:40-3. https://doi.org/10.1016/j.jseint.2021.08.002.
25. Sheth MM, Heldt BL, Spell JH, Vidal EA, Laughlin MS, Morris BJ, et al. Patient satisfaction and clinical outcomes of reverse shoulder arthroplasty: a minimum of 10 years' follow-up. J Shoulder Elbow Surg 2022;31:875-83. https://doi.org/10.1016/j.jse.2021.09.012.
26. 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.
27. Spiry C, Berhouet J, Agout C, Bacle G, Favard L. Long-term impact of scapular notching after reverse shoulder arthroplasty. Int Orthop 2021;45:1559-66. https://doi.org/10.1007/s00264-021-04998-3.
28. Wall B, Nové-Josserand L, O'Connor DP, Edwards TB, Walch G. Reverse total shoulder arthroplasty: a review of results according to etiology. J Bone Joint Surg Am 2007;89:1476-85. https://doi.org/10.2106/JBJS.F.00666.