Year: 2019

Glenoid loosening and migration in reverse shoulder arthroplasty

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Abstract: AIMS The aim of this study was to report the outcomes of different treatment options for glenoid loosening following reverse shoulder arthroplasty (RSA) at a minimum follow-up of two years. PATIENTS AND METHODS We retrospectively studied the records of 79 patients (19 men, 60 women; 84 shoulders) aged 70.4 years (21 to 87) treated for aseptic loosening of the glenosphere following RSA. Clinical evaluation included pre- and post-treatment active anterior elevation (AAE), external rotation, and Constant score. RESULTS From the original cohort, 29 shoulders (35%) were treated conservatively, 27 shoulders (32%) were revised by revision of the glenosphere, and 28 shoulders (33%) were converted to hemiarthroplasty. At last follow-up, conservative treatment and glenoid revision significantly improved AAE, total Constant score, and pain, while hemiarthroplasty did not improve range of movement or clinical scores. Multivariable analysis confirmed that conservative treatment and glenoid revision achieved similar improvements in pain (glenoid revision vs conservative, beta 0.44; p = 0.834) but that outcomes were significantly worse following hemiarthroplasty (beta -5.00; p = 0.029). CONCLUSION When possible, glenoid loosening after RSA should first be treated conservatively, then by glenosphere revision if necessary, and last by salvage hemiarthroplasty Cite this article: Bone Joint J 2019;101-B:461-469.

DOI: https://doi.org/10.1302/0301-620X.101B4.BJJ-2018-1275.R1

Originally published at:
Lädermann, A; Schwitzguebel, A J; Edwards, T B; Godeneche, A; Favard, L; Walch, G; Sirveaux, F; Boileau, P; Gerber, C (2019). Glenoid loosening and migration in reverse shoulder arthroplasty. The Bone Joint Journal, 101-B(4):461-469.
DOI: https://doi.org/10.1302/0301-620X.101B4.BJJ-2018-1275.R1

■ SHOULDER & ELBOW

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doi:10.1302/0301-620X.101B4.BJJ-2018-1275.R1 $2.00

Bone Joint J 2019;101-B:461–469.

Aims

The aim of this study was to report the outcomes of different treatment options for glenoid loosening following reverse shoulder arthroplasty (RSA) at a minimum follow-up of two years.

Patients and Methods

We retrospectively studied the records of 79 patients (19 men, 60 women; 84 shoulders) aged 70.4 years (21 to 87) treated for aseptic loosening of the glenosphere following RSA. Clinical evaluation included pre- and post-treatment active anterior elevation (AAE), external rotation, and Constant score.

Results

From the original cohort, 29 shoulders (35%) were treated conservatively, 27 shoulders (32%) were revised by revision of the glenosphere, and 28 shoulders (33%) were converted to hemiarthroplasty. At last follow-up, conservative treatment and glenoid revision significantly improved AAE, total Constant score, and pain, while hemiarthroplasty did not improve range of movement or clinical scores. Multivariable analysis confirmed that conservative treatment and glenoid revision achieved similar improvements in pain (glenoid revision *vs* conservative, beta 0.44; p = 0.834) but that outcomes were significantly worse following hemiarthroplasty (beta -5.00; p = 0.029).

Conclusion

When possible, glenoid loosening after RSA should first be treated conservatively, then by glenosphere revision if necessary, and last by salvage hemiarthroplasty.

Cite this article: *Bone Joint J* 2019;101-B:461–469.

Over recent years, the use of reverse shoulder arthroplasty (RSA) has increased as the indications for its use have expanded to include proximal humeral fractures, cases with humeral and glenoid bone loss, post-traumatic sequelae, and massive rotator cuff tears.[1-5] As the use of RSA has increased and the indications have broadened, the frequency of observed complications has followed and the revision rate for both humeral and glenoid failure has increased. While the most common causes for revision of RSA are instability and infection, failure of the glenosphere has also been frequently reported,[6] usually due to glenoid loosening.[7]

As glenoid loosening is an important complication of anatomical total shoulder arthroplasty (TSA), several revision options have already been investigated, including revision of the glenoid component, conversion to RSA, or conversion to hemiarthroplasty.[8-11] Compared with TSA, failure of RSA due to aseptic glenoid loosening is rare, with a prevalence ranging from 1.7% to 3.5%,[6,12-16] often attributed to excessive height or superior inclination of the glenosphere.[6] There has been little investigation into the results of treatment options for glenoid loosening in RSA; current practice is to replace the glenosphere if there is sufficient bone stock, with salvage conversion to hemiarthroplasty being recommended when all other options are contraindicated.[6,13,17]

To the authors' knowledge, there are no published investigations of failure characteristics and treatment options for glenoid loosening in RSA. The purpose of this study was to describe and analyze a consecutive series of failures following RSA due to glenoid loosening, and to report the outcomes of different treatment options at a minimum follow-up of two years.

Patients and Methods

Study design. The authors retrospectively studied the records of all patients treated for aseptic loosening of the glenosphere following RSA between 1998 and 2013 at seven centres. The inclusion

Table I. Baseline demographics at index reverse shoulder arthroplasty (RSA) for the entire cohort (n = 84 shoulders); in all instances, 'n' refers to the number of shoulders

Characteristic	Value
Mean age, years (SD)	70.4 (12.0)
Mean body mass index, kg/m^2 (SD)	25.1 (4.1)
Male gender, n (%)	19 (23)
Dominant arm, n (%)	60 (*71*)
Indication for index RSA, n (%)	
Trauma sequelae	10 (*12*)
Cuff tear arthropathy (Hamada 3 to 5)	34 (*41*)
Rotator cuff tear (Hamada 1 to 2)	16 (*19*)
Failure of previous shoulder arthroplasty	23 (*27*)
Dislocation arthropathy	1 (*1*)
Comorbidities, n (%)	
None	50 (*60*)
Weight-bearing arm (wheelchair)	2 (*2*)
Osteoporosis	7 (*8*)
Inflammatory arthritis	14 (*17*)
Diabetes	2 (*2*)
Tobacco use	2 (*2*)
Unknown	7 (*8*)
Implant model, n (%)	
Aequalis (Tornier, Grenoble, France)	25 (*30*)
Delta (DePuy Synthes, Saint Priest, France)	18 (*21*)
Anatomical (Zimmer Biomet, Winterthur, Switzerland)	31 (*37*)
Other	10 (*12*)
Glenoid graft, n (%)	
None	51 (*61*)
Autograft	27 (*32*)
Allograft	2 (*2*)
Unknown	4 (*5*)
Postoperative immobilization, n (%)	
Abduction pillow	12 (*14*)
Sling	63 (*75*)
Unknown	9 (*11*)
Complications other than glenoid loosening, n (%)	
Intraoperative	13 (*16*)
Postoperative	11 (*13*)
Unknown	9 (*11*)

criteria were adult patients with a minimum follow-up of two years. Cases of loosening due to infection were excluded as were those treated with excision arthroplasty. A total of 86 patients (91 shoulders) were screened for eligibility, of which five were excluded due to infection and two were treated using excision arthroplasty. This left a cohort of 79 patients (84 shoulders), 19 of whom were men (19 shoulders, 23%) and 60 of whom were women (65 shoulders, 77%), with a mean age of 70.4 years (21 to 87) at the time of index RSA (Table I). The dominant side was affected in 60 patients (60 shoulders, 71%). The study protocol received institutional review board approval (IRB #2018-01).

Treatments. All shoulders had been treated either conservatively or surgically depending on the amount and quality of remaining glenoid bone. Conservative treatment comprised immobilization for six weeks, followed by progressive mobilization without physiotherapy or strengthening. Surgical treatment consisted of revision of the glenosphere or conversion to hemiarthroplasty. The treatment option was selected by each surgeon, based on their own experience and preferences, and informed by the mode of loosening of the glenoid and characteristics of the patient. Conservative treatment was preferred for patients with adequate secondary stabilization of their loosened glenoid components. Revision of the glenoid component was deemed necessary for patients with an unstable glenoid component, particularly those with broken screws but adequate glenoid bone stock. Conversion to hemiarthroplasty was performed as a salvage procedure for patients with an unstable glenoid component and severe glenoid bone loss, particularly in patients who had undergone two or more previous operations on the affected shoulder. The surgical approach was either deltopectoral or transdeltoid,[18,19] depending on surgeon preference and clinical picture. There were no transfers of the latissimus dorsi.[20] To compensate the glenoid bone loss, allografts were sometimes used in case of conversion to hemiarthroplasty and iliac crest autografts were systematically used to restore bone stock when the glenoid component was revised.[21] The postoperative management was based on previously described protocols.[22,23]

Radiological evaluation. Radiographs were available for 56 of the 84 failed RSAs, including true anteroposterior, lateral scapular, and axillary views. Glenoid loosening was confirmed following the criteria of Mélis et al,[24] the criteria being the presence of a radiolucent line > 2 mm thick. Radiographs were analyzed using Osirix (Pixmeo, Geneva, Switzerland) to describe loosening and/or migration of the glenosphere, screw breakage, or secondary stabilization. Secondary stabilization was defined by absence of additional movement of the implant over a six-month period, disappearance of radiolucent lines around the screws and the peg, and clinical improvement.

Clinical evaluation. Baseline clinical parameters were collected at the index RSA operation, including patient age, gender, body mass index (BMI), comorbidities, and indications for surgery. Complications were reported according to the classification of Zumstein et al.[16] Clinical evaluation included Constant score,[25] active range of anterior elevation, and external rotation. Clinical evaluation was performed when the diagnosis of glenoid loosening was made and at a minimum of two years after initiation of conservative or surgical treatment. Patient satisfaction with the treatment of glenoid loosening was assessed as either 'dissatisfied', 'satisfied', or 'very satisfied'.

Statistical analysis. Shapiro–Wilk tests were used to assess the normality of distributions. For non-Gaussian continuous data, differences between groups were evaluated using Mann–Whitney U test. For categorical data, differences between groups were evaluated using Fisher's exact test. Multivariable linear regression was performed to determine associations between the pain component of the Constant score (the only outcome significantly associated with treatment option) and five independent variables (gender, age at index RSA, follow-up, indication for index RSA operation, and treatment option). Statistical analyses were performed using R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria). A p-value < 0.05 was considered statistically significant.

Table II. Baseline demographics at index reverse shoulder arthroplasty (RSA) depending on glenoid loosening treatment; in all instances, 'n' refers to the number of shoulders

Characteristics	Conservative treatment (n = 29)	Glenosphere revision (n = 27)	Conversion to HA (n = 28)	p-value
Mean age, yrs (SD)	68.7 (16.7)	72.7 (7.9)	69.8 (9.3)	0.561*
Mean body mass index, kg/m² (SD)	23.8 (3.1)	26.6 (4.1)	24.1 (4.5)	0.036*
Male gender, n (%)	8 (*27.6*)	7 (*25.9*)	4 (*14.3*)	0.440†
Dominant arm, n (%)	21 (*72.4*)	18 (*66.7*)	21 (*75.0*)	0.792†
Indication for index RSA, n (%)				0.001†
Trauma sequelae	2 (*6.9*)	5 (*18.5*)	3 (*10.7*)	
Cuff tear arthropathy (Hamada 3 to 5)	15 (*51.7*)	12 (*44.4*)	7 (*25.0*)	
Rotator cuff tear (Hamada 1 to 2)	6 (*20.7*)	8 (*29.6*)	2 (*7.1*)	
Failure of previous shoulder arthroplasty	5 (*17.2*)	2 (*7.4*)	16 (*57.1*)	
Dislocation arthropathy	1 (*3.4*)	0 (*0*)	0 (*0*)	
Comorbidities, n (%)				0.334†
None	14 (*48.3*)	17 (*63.0*)	19 (*67.9*)	
Weight-bearing arm (wheelchair)	2 (*6.9*)	0 (*0*)	0 (*0*)	
Osteoporosis	3 (*10.3*)	1 (*3.7*)	3 (*10.7*)	
Inflammatory arthritis	7 (*24.1*)	2 (*7.4*)	5 (*17.9*)	
Diabetes	2 (*6.9*)	0 (*0*)	0 (*0*)	
Tobacco use	1 (*3.4*)	1 (*3.7*)	0 (*0*)	
Unknown	0 (*0*)	6 (*22.2*)	1 (*3.6*)	
Implant model, n (%)				< 0.001†
Aequalis (Tornier, Grenoble, France)	7 (*24.1*)	7 (*25.9*)	11 (*39.3*)	
Delta (DePuy Synthes, Saint Priest, France)	1 (*3.4*)	8 (*29.6*)	9 (*32.1*)	
Anatomical (Zimmer Biomet, Winterthur, Switzerland)	19 (*65.5*)	5 (*18.5*)	7 (*25.0*)	
Other	2 (*6.9*)	7 (*25.9*)	1 (*3.6*)	
Glenoid graft, n (%)				0.828†
None	18 (*62.1*)	16 (*59.3*)	17 (*60.7*)	
Autograft	10 (*34.5*)	7 (*25.9*)	10 (*35.7*)	
Allograft	1 (*3.4*)	0 (*0*)	1 (*3.6*)	
Unknown	0 (*0*)	4 (*14.8*)	0 (*0*)	
Postoperative immobilization, n (%)				0.113†
Abduction pillow	8 (*27.6*)	2 (*7.4*)	2 (*7.1*)	
Sling	21 (*72.4*)	18 (*66.7*)	24 (*85.7*)	
Unknown	0 (*0*)	7 (*25.9*)	2 (*7.1*)	
Complications other than glenoid loosening, n (%)				
Intraoperative	4 (*13.8*)	0 (*0*)	9 (*32.1*)	0.008†
Postoperative	4 (*13.8*)	1 (*3.7*)	6 (*21.4*)	0.205†
Unknown	0 (*0*)	6 (*22.2*)	3 (*10.7*)	

*Kruskal–Wallis test
†Fisher's exact test
HA, hemiarthroplasty

Results

From the original cohort of 79 patients (84 shoulders), 28 patients (29 shoulders, 35%) were treated conservatively, 25 patients (27 shoulders, 32%) underwent revision of the glenosphere, and 27 patients (28 shoulders, 33%) were converted to hemiarthroplasty. At the index RSA operation, the three groups differed significantly in terms of BMI, indication for surgery, and implant type; in particular, conversion to hemiarthroplasty was more common when the index operation was a revision and when intraoperative complications occurred during index surgery (Table II).

The three groups did not differ in the inclination (Fig. 1) or degree of migration (Fig. 2) of the glenosphere, nor in the location of loosening (screws or central peg) (Fig. 3). The conservative treatment group, however, included fewer broken screws (5%) than the glenosphere revision (40%) and hemiarthroplasty (25%) groups ($p = 0.023$). As might be expected, more cases of secondary stabilization were seen in the conservative group (47%) than in the glenosphere revision (7%) and hemiarthroplasty (5%) groups ($p = 0.001$) (Table III).

Post-treatment complications were noted in one shoulder that had been treated conservatively (periprosthetic fracture), in three shoulders that had revision of the glenosphere (one acromion fatigue fracture and two cases of scapular notching, of which one led to screw breakage), and in one shoulder that had undergone hemiarthroplasty (stress shielding of

Table III. Radiological findings at diagnosis of glenoid loosening; in all instances, 'n' refers to the number of shoulders

Variable	Conservative (n = 21)	Revision (n = 15)	Hemiarthroplasty (n = 20)	p-value
Mean time from index RSA, mths (SD)	4.1 (6.3)	29.0 (44.4)	22.4 (42.8)	0.456*
Glenosphere migration, n (%)	11 (*52*)	12 (*80*)	17 (*85*)	0.068†
Glenosphere superior inclination, n (%)	10 (*48*)	6 (*40*)	3 (*15*)	0.095†
Unknown	1 (*5*)	1 (*7*)	2 (*10*)	
Secondary stabilization, n (%)	10 (*48*)	1 (*7*)	1 (*5*)	0.001†
Unknown	1 (*5*)	0 (*0*)	0 (*0*)	
Loosening signs, n (%)				
Screws	14 (*67*)	10 (*67*)	8 (*40*)	0.275†
Central peg	14 (*67*)	10 (*67*)	9 (*45*)	0.340†
Unknown	1 (*5*)	1 (*7*)	3 (*15*)	
Broken screws, n (%)	1 (*5*)	6 (*40*)	5 (*25*)	0.023†
Unknown	0 (*0*)	0 (*0*)	1 (*5*)	

*Kruskal–Wallis test
†Fisher's exact test
RSA, reverse shoulder arthroplasty

Fig. 1a

Fig. 1b

a) Postoperative radiograph of a right bony-increased offset reverse shoulder arthroplasty (BIO-RSA) with inferior inclination of the base-plate. At two weeks, an acute migration was observed. b) One-year follow-up radiograph demonstrating a secondary stabilization of the prosthesis under the acromion.

Fig. 2a

Fig. 2b

a) Immediate postoperative anteroposterior radiograph of a left bony-increased offset reverse shoulder arthroplasty (BIO-RSA). b) Three months postoperative anteroposterior radiograph of the same patient showing that glenoid loosening appeared at the native scapula/autograft interface.

the proximal humerus). At last follow-up, external rotation did not improve in any of the three groups (Fig. 4). By contrast, conservative treatment and glenosphere revision significantly improved active anterior elevation (22.4° (SD 48.6°) and 38.6° (SD 53.0°)), the total Constant score (23.4 (SD 24.4) and 19.4 (SD 17.5)), and its pain component (5.7 (SD 6.7) and 4.3 (SD 4.3)). Hemiarthroplasty did not improve range of movement or clinical scores (Table IV, Fig. 5). Finally, revision of the glenosphere was associated with higher patient satisfaction (57%) than conservative treatment (20%) or hemiarthroplasty (6%) (p = 0.004).

Univariable analysis revealed that improvements in pain were significantly smaller in younger patients (p = 0.028) and following hemiarthroplasty (p = 0.016). Multivariable analysis confirmed that revision of the glenosphere led to similar improvements in pain relief compared to conservative treatment (beta, 0.44; CI -3.76 to 4.63; p = 0.834), but that there were significantly worse results following hemiarthroplasty (beta, -5.00; CI -9.56 to -0.53; p = 0.029) (Table V).

Discussion

The purpose of this study was to evaluate a consecutive series of RSA failures due to glenoid loosening and to report functional improvements following different treatments. Over one-third of these shoulders were treated conservatively, and another one-third were treated by revision of the glenosphere, both of which granted better clinical improvements than hemiarthroplasty.

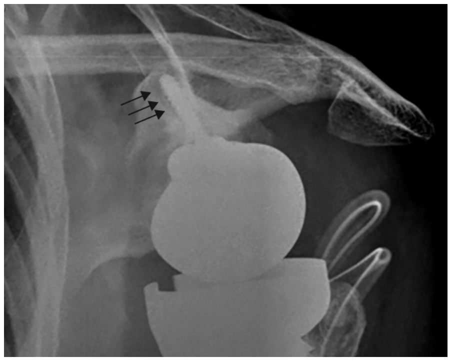

Fig. 3a

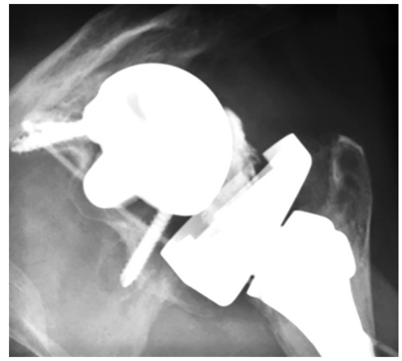

Fig. 3b

a) Immediate postoperative axial view of a left BIO-RSA. Radiolucent lines (arrows) illustrate non-integration of the glenosphere. b) Two-year follow-up radiograph of the same patient with clear signs of glenoid loosening without secondary migration.

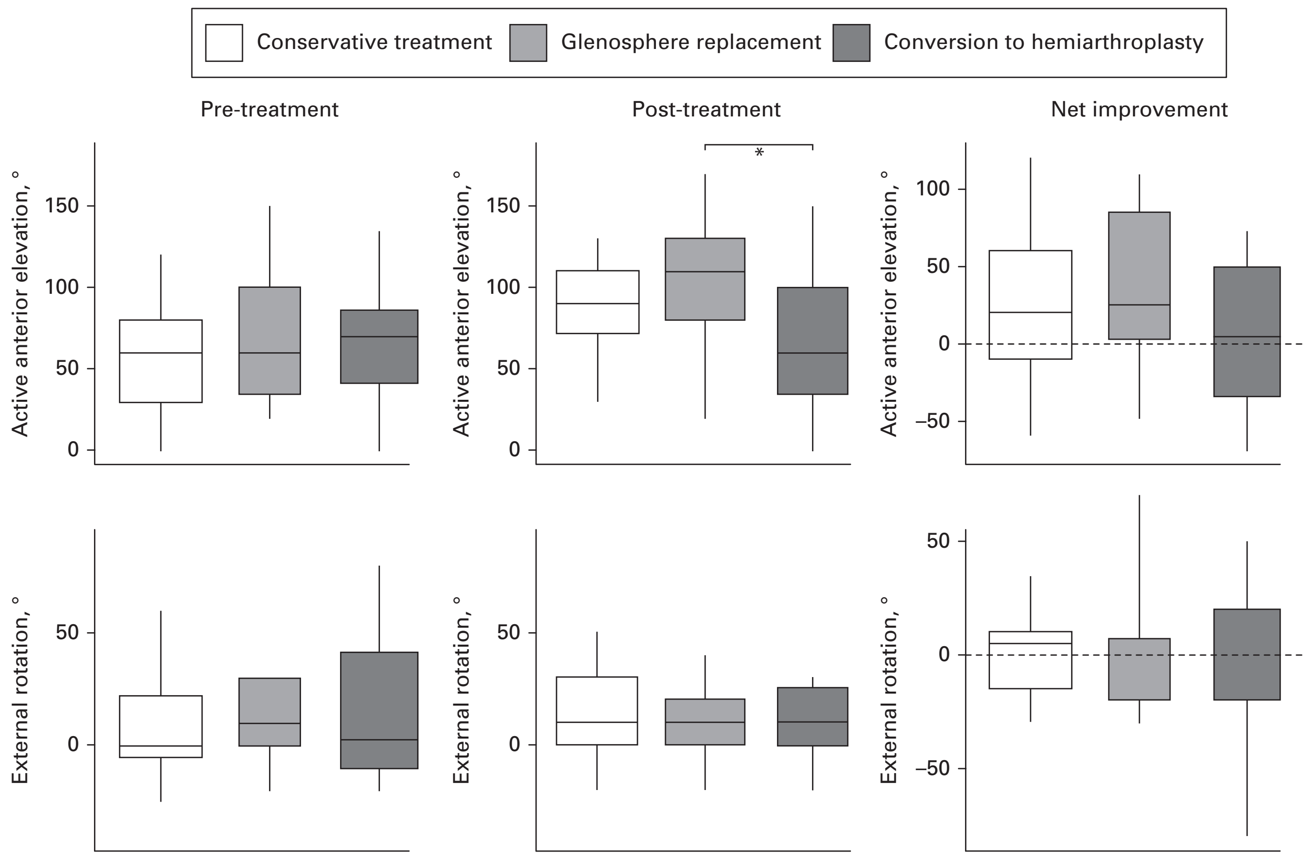

Fig. 4

Pre- and post-treatment active anterior elevation and external rotation depending on glenoid loosening treatment (conservative *vs* glenosphere replacement *vs* conversion to hemiarthroplasty). The plots illustrate median values (horizontal black lines), interquartile ranges (boxes), 95% confidence intervals (whiskers), and outliers (dots). Asterisks (*) indicate where significant differences were found between groups.

Glenoid loosening after RSA is a rare but burdensome complication (1.7% to 3.5%),[6,12-16] which may be related to infection,[24] poor bone stock,[13,26,27] design of the glenoid component,[28,29] technique of fixation,[13] or excessive shear forces (Table VI). In this series, we excluded cases of glenoid loosening due to infection, in order to focus on mechanical failures. Following RSA, the lever arm of the deltoid muscle is increased, thereby improving abduction range.[30,31] In abduction, the glenosphere provides the stable fulcrum, to allow shoulder elevation and prosthetic stability.[30] The increase

Table IV. Clinical data at diagnosis of glenoid loosening and at last follow-up; in all instances, 'n' refers to the number of shoulders

Measurement	Conservative (n = 29)	p-value, pre *vs* post	Revision (n = 27)	p-value, pre *vs* post	Hemiarthroplasty (n = 28)	p-value, pre *vs* post	p-value
Mean last follow-up, mths (SD)	46.2 (38.7); n = 29		35.5 (19.9); n = 27		30.0 (14.0); n = 28		0.078*
Mean active anterior elevation, ° (SD)		0.033†		0.030†		0.740*	
At diagnosis	61.3 (37.1); n = 27		72.0 (40.9); n = 15		61.7 (29.1); n = 24		0.759*
At last follow-up	85.2 (37.5); n = 26		107.8 (38.3); n = 25		68.7 (45.3); n = 19		0.014*
Net improvement	22.4 (48.6); n = 25		38.6 (53.0); n = 14		4.4 (47.5); n = 17		0.172*
Mean external rotation, ° (SD)		0.690†		0.600†		0.950*	
At diagnosis	14.1 (28.6); n = 27		11.3 (17.7); n = 15		14.4 (28.9); n = 24		0.949*
At last follow-up	14.0 (18.9); n = 25		10.4 (15.5); n = 24		9.2 (17.4); n = 19		0.736*
Net improvement	1.3 (21.3); n = 24		-2.9 (18.2); n = 14		-2.1 (33.8); n = 17		0.668*
Mean Constant score, total (SD)		0.001†		0.002†		0.078*	
At diagnosis	18.5 (15.1); n = 25		29.4 (11.5); n = 19		23.7 (10.9); n = 24		0.002*
At last follow-up	41.1 (19.8); n = 24		45.6 (17.0); n = 20		37.1 (19.3); n = 17		0.362*
Net improvement	23.4 (24.4); n = 22		19.4 (17.5); n = 15		13.8 (24.0); n = 16		0.384*
Mean Constant score, pain component (SD)		0.003†		0.007†		0.890*	
At diagnosis	4.6 (4.0); n = 22		7.1 (2.9); n = 17		7.8 (3.0); n = 18		0.012*
At last follow-up	9.3 (5.0); n = 26		11.9 (3.3); n = 22		8.6 (5.2); n = 18		0.052*
Net improvement	5.7 (6.7); n = 20		4.3 (4.3); n = 14		0.5 (5.8); n = 13		0.060*
Post-treatment satisfaction, n (%)							0.004‡
Very satisfied	5 (*17*)		13 (*48*)		1 (*4*)		
Satisfied	13 (*45*)		6 (*22*)		8 (*29*)		
Dissatisfied	7 (*24*)		4 (*15*)		9 (*32*)		
Unknown	4 (*14*)		4 (*15*)		10 (*36*)		

*Kruskal–Wallis test
†Paired Mann–Whitney U test
‡Fisher's exact test
pre, pre-treatment; post, post-treatment

Table V. Univariable and multivariable regression analysis of pain improvement. Data presented as regression coefficient (95% confidence interval (CI)); in all instances, 'n' refers to the number of shoulders

Variable	Univariable (n = 84)	p-value*	Multivariable (n = 47)	p-value†
Continuous				
Age, yrs (95% CI)	0.21 (0.02 to 0.40)	0.028	0.14 (-0.08 to 0.36)	0.207
Last follow-up, mths (95% CI)	0.08 (-0.03 to 0.20)	0.150	0.05 (-0.06 to 0.16)	0.384
Categorical Indication for index RSA (95% CI)				
Rotator cuff tears	Referent		Referent	
Cuff tear arthropathy	2.13 (-2.74 to 6.99)	0.384	0.98 (-3.73 to 5.69)	0.677
Trauma sequelae	-3.73 (-9.87 to 2.41)	0.227	-4.07 (-9.78 to 1.64)	0.158
Failure of previous shoulder arthroplasty	2.35 (-3.42 to 8.11)	0.416	3.74 (-2.16 to 9.64)	0.207
Male gender	-1.97 (-5.96 to 2.02)	0.326	-0.46 (-4.76 to 3.83)	0.828
Glenoid loosening treatment (95% CI)				
Conservative treatment	Referent		Referent	
Glenosphere revision	-1.36 (-5.44 to 2.71)	0.503	0.44 (-3.76 to 4.63)	0.834
Conversion to hemiarthroplasty	-5.19 (-9.35 to -1.02)	0.016	-5.00 (-9.46 to -0.53)	0.029

*Univariable linear regression with analysis of variance
†Multivariable linear regression with analysis of variance
RSA, reverse shoulder arthroplasty

in compressive forces has a stabilizing effect on the glenosphere,[32] while shear forces could contribute to destabilizing this semi-constrained component,[33] potentially leading to glenoid loosening.

Different locations and modes of failure have been observed. Loosening may appear at the interface between the baseplate and the native scapula, the interface between the scapula and any bone graft used, or in the body of the scapula, medial to the baseplate screws. This is important as it dictates the type of revision surgery possible.

In our series, one-third of RSA failures due to glenoid loosening were treated conservatively, with comparable clinical improvements to revision of the glenosphere. A study of 16 consecutive glenosphere revisions after failed RSA[34] reported pain relief and improved function but higher complication rates than primary RSA. We, therefore, suggest treating RSA failures

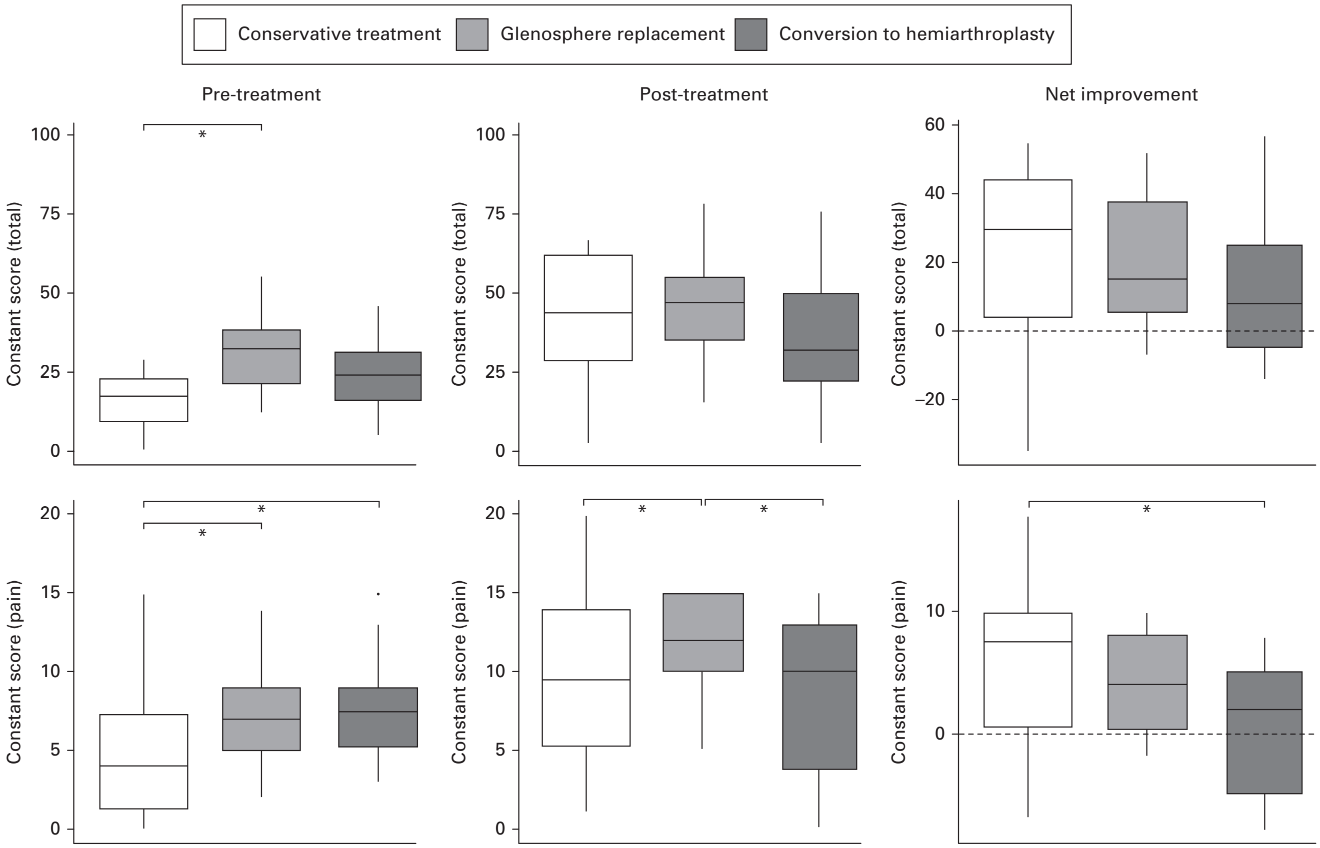

Fig. 5

Pre- and post-treatment Constant score (total and pain component) depending on glenoid loosening treatment (conservative *vs* glenosphere replacement *vs* conversion to hemiarthroplasty). The plots illustrate median values (horizontal black lines), interquartile ranges (boxes), 95% confidence intervals (whiskers), and outliers (dots). Asterisks (*) indicate where significant differences were found between groups.

Table VI. Different causes of loosening and migration of the glenoid component

Possible causes
Preoperative
Pathological insufficiency of bone (osteoporosis, tumour)
Poor bone stock
Intraoperative
Fracture of the scapular neck or glenoid
Baseplate specificities
Baseplate implanted too high on the glenoid
Superior tilt of the glenosphere
Bone graft with a central peg that was too short and did not reach the native bone
A central glenoid hole that was too large, excessively reamed glenoid, medial vault penetration, poor screw placement
Non-assemblage of the glenosphere on the baseplate
Postoperative
Excessive shear forces in case of superior tilt, large or lateralized glenosphere, excessive deltoid retensioning, associated latissimus dorsal transfer
Grade 4 scapular notching or osteolysis due to wear particles from the polyethylene acetabular component
Infection

due to glenoid loosening conservatively whenever possible. If conservative treatment fails, revision of the glenosphere could be considered as a subsequent option,[35] and conversion to hemiarthroplasty should remain a last salvage option.

Our practice has been informed by the results of this study. Given that secondary stabilization is possible, we do not recommend passive or active movements during the first six weeks postoperatively if immediate signs of loosening are observed. For the same reason, we recommend that shoulders with acute superior glenosphere migration and inferior inclination should first be treated conservatively rather than revised immediately, as they may go on to stabilize with a good functional outcome. Finally, in primary surgery where glenoid fixation is found to be suboptimal intraoperatively, we recommend conversion to a two-stage revision procedure.

Established risk factors for glenoid loosening include female gender, younger age (less than 70 years), superior tilt of the glenoid component, use of bone grafts and non-locking screws, and the superolateral approach.[7,14,36-38] Over three-quarters of our cases (77%) of glenoid loosening were in women, which would appear to corroborate the existence of female gender as a risk factor, but we do not know the gender distribution of the cohort as a whole once successful RSA is included. In our series, 17% of patients had inflammatory osteoarthritis, which is above the 11% prevalence in a recent nationwide database study, suggesting that this may represent a risk factor for loosening.[39]

This study has limitations typical of retrospective designs, including missing preoperative, radiological, and clinical data. As a result, only improvements in external rotation, anterior elevation and Constant scores could be analyzed. Moreover, the choice of treatment was not randomized but based on subjective assessment of remaining glenoid bone volume and quality, which rendered direct comparisons among the treatment groups difficult. The hemiarthroplasty group comprised patients who had worse clinical scores prior to revision and the poor results in this group are at least partly a result of this difference at baseline. Because of missing data, some confounding factors could not be controlled for in the multivariable analysis. The strengths of this study include the fact that it is large (given that this is a rare complication) and, by conducting the study over a number of centres, we can reflect the experience of a large group of experienced shoulder surgeons. Future prospective trials are needed to confirm our findings.

This study has demonstrated that better clinical improvements are achieved by conservative treatment and glenoid revision compared to salvage hemiarthroplasty in cases of glenoid loosening in RSA. We recommend that, when possible, glenoid loosening after RSA should ideally be treated conservatively, then by revision of the glenosphere, and last by salvage hemiarthroplasty. Further prospective studies with larger cohorts are needed to identify risks factors for each treatment to help surgeons choose the most suitable treatment based on patient characteristics.

Take home message

- Glenoid loosening may appear at the interface between the baseplate and the native scapula, the interface between the scapula and any bone graft used, or in the body of the scapula, medial to the baseplate screws.
- Over one-third of glenoid loosening are treated conservatively, and another one-third by revision of the glenosphere, both of which granted better clinical improvements than hemiarthroplasty.
- Given that secondary glenosphere stabilization is possible, passive or active movements during the first six weeks postoperatively, if immediate signs of loosening are observed, are not recommended.

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References

1. **Urch E, Dines JS, Dines DM.** Emerging indications for reverse shoulder arthroplasty. *Instr Course Lect* 2016;65:157–169.
2. **King JJ, Nystrom LM, Reimer NB, et al.** Allograft-prosthetic composite reverse total shoulder arthroplasty for reconstruction of proximal humerus tumor resections. *J Shoulder Elbow Surg* 2016;25:45–54.
3. **Postacchini R, Carbone S, Canero G, Ripani M, Postacchini F.** Reverse shoulder prosthesis in patients with rheumatoid arthritis: a systematic review. *Int Orthop* 2016;40:965–973.
4. **Anakwenze OA, Zoller S, Ahmad CS, Levine WN.** Reverse shoulder arthroplasty for acute proximal humerus fractures: a systematic review. *J Shoulder Elbow Surg* 2014;23:e73-e80.
5. **Boileau P, Watkinson D, Hatzidakis AM, Hovorka I.** Neer Award 2005: The Grammont reverse shoulder prosthesis: results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. *J Shoulder Elbow Surg* 2006;15:527–540.
6. **Boileau P.** Complications and revision of reverse total shoulder arthroplasty. *Orthop Traumatol Surg Res* 2016;102(Suppl):S33-S43.
7. **Farshad M, Gerber C.** Reverse total shoulder arthroplasty-from the most to the least common complication. *Int Orthop* 2010;34:1075–1082.
8. **Raphael BS, Dines JS, Warren RF, et al.** Symptomatic glenoid loosening complicating total shoulder arthroplasty. *HSS J* 2010;6:52–56.
9. **Jean K.** Classifications of glenoid dysplasia, glenoid bone loss and glenoid loosening: a review of the literature. *Eur J Orthop Surg Traumatol* 2013;23:301–310.
10. **Bonnevialle N, Melis B, Neyton L, et al.** Aseptic glenoid loosening or failure in total shoulder arthroplasty: revision with glenoid reimplantation. *J Shoulder Elbow Surg* 2013;22:745–751.
11. **Neyton L, Sirveaux F, Roche O, et al.** Results of revision surgery for glenoid loosening: a multicentric series of 37 shoulder prosthesis. *Rev Chir Orthop Repar Appar Mot* 2004;90:111–121. (Article in French)
12. **Lawrence C, Williams GR, Namdari S.** Influence of Glenosphere Design on Outcomes and Complications of Reverse Arthroplasty: A Systematic Review. *Clin Orthop Surg* 2016;8:288–297.
13. **Boileau P, Melis B, Duperron D, et al.** Revision surgery of reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2013;22:1359–1370.
14. **Bitzer A, Rojas J, Patten IS, Joseph J, McFarland EG.** Incidence and risk factors for aseptic baseplate loosening of reverse total shoulder arthroplasty. *J Shoulder Elbow Surg* 2018;27:2145–2152.
15. **Alentorn-Geli E, Samitier G, Torrens C, Wright TW.** Reverse shoulder arthroplasty. Part 2: systematic review of reoperations, revisions, problems, and complications. *Int J Shoulder Surg* 2015;9:60–67.
16. **Zumstein MA, Pinedo M, Old J, Boileau P.** Problems, complications, reoperations, and revisions in reverse total shoulder arthroplasty: a systematic review. *J Shoulder Elbow Surg* 2011;20:146–157.
17. **Glanzmann MC, Kolling C, Schwyzer HK, Audigé L.** Conversion to hemiarthroplasty as a salvage procedure for failed reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2016;25:1795–1802.
18. **Boileau P, Walch G.** The Surgical Anatomy and Osteotomy Technique for the Humeral Head. In: Walch G, Boileau P, eds. *Shoulder Arthroplasty.* Berlin: Springer-Verlag, 1999:105–123.
19. **Walch G, Wall B.** Indication and techniques of revision arthroplasty with a reverse prosthesis. In: Walch G, Boileau P, Mole D, Favard L, Lévigne C, Sirveaux F, eds. *Reverse Shoulder Arthroplasty.* Montpellier, France: Sauramps Medical, 2006:243–246.
20. **Gerber C, Maquieira G, Espinosa N.** Latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. *J Bone Joint Surg [Am]* 2006;88-A:113–120.
21. **Malhas AM, Granville-Chapman J, Robinson PM, et al.** Reconstruction of the glenoid using autologous bone-graft and the SMR Axioma TT metal-backed prosthesis. *Bone Joint J* 2018;100-B:1609–1617.
22. **Gerber C, Pennington SD, Nyffeler RW.** Reverse total shoulder arthroplasty. *J Am Acad Orthop Surg* 2009;17:284–295.
23. **Liotard J.** Painful shoulder rehabilitation: How to do it simple. *Revue du rhumatisme monographies* 2010;77:239–245.
24. **Mélis B, DeFranco M, Lädermann A, 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-B:1240–1246.
25. **Constant CR, Murley AH.** A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res* 1987;214:160–164.
26. **Sirveaux F, Favard L, Oudet D, et al.** 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-B:388–395.
27. **Cazeneuve JF, Cristofari DJ.** Grammont reversed prosthesis for acute complex fracture of the proximal humerus in an elderly population with 5 to 12 years follow-up. *Rev Chir Orthop Reparatrice Appar Mot* 2006;92:543–548. (Article in French)

28. **Harman M, Frankle M, Vasey M, Banks S.** Initial glenoid component fixation in "reverse" total shoulder arthroplasty: a biomechanical evaluation. *J Shoulder Elbow Surg* 2005;14(1 Suppl S):162S-167S.
29. **Werner CM, Steinmann PA, Gilbart M, Gerber C.** Treatment of painful pseudoparesis due to irreparable rotator cuff dysfunction with the Delta III reverse-ball-and-socket total shoulder prosthesis. *J Bone Joint Surg [Am]* 2005;87-A:1476–1486.
30. **Boileau P, Watkinson DJ, Hatzidakis AM, Balg F.** Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg* 2005;14(1 Suppl S):147S-161S.
31. **Werner BS, Chaoui J, Walch G.** Glenosphere design affects range of movement and risk of friction-type scapular impingement in reverse shoulder arthroplasty. *Bone Joint J* 2018;100-B:1182–1186.
32. **Gagey O, Hue E.** Mechanics of the deltoid muscle. A new approach. *Clin Orthop Relat Res* 2000;375:250–257.
33. **Yang CC, Lu CL, Wu CH, et al.** Stress analysis of glenoid component in design of reverse shoulder prosthesis using finite element method. *J Shoulder Elbow Surg* 2013;22:932–939.
34. **Black EM, Roberts SM, Siegel E, et al.** Failure after reverse total shoulder arthroplasty: what is the success of component revision? *J Shoulder Elbow Surg* 2015;24:1908–1914.
35. **Wagner ER, Hevesi M, Houdek MT, et al.** Can a reverse shoulder arthroplasty be used to revise a failed primary reverse shoulder arthroplasty? *Bone Joint J* 2018;100-B:1493–1498.
36. **Molé D, Favard L.** Excentered scapulohumeral osteoarthritis. *Rev Chir Orthop Reparatrice Appar Mot* 2007;93(6 Suppl):37–94. (Article in French)
37. **Laver L, Garrigues GE.** Avoiding superior tilt in reverse shoulder arthroplasty: a review of the literature and technical recommendations. *J Shoulder Elbow Surg* 2014;23:1582–1590.
38. **Gutiérrez S, Greiwe RM, Frankle MA, Siegal S, Lee WE III.** Biomechanical comparison of component position and hardware failure in the reverse shoulder prosthesis. *J Shoulder Elbow Surg* 2007;16(3 Suppl):S9-S12.
39. **Jauregui JJ, Paul Hovis J, Ashfaq Hasan S.** Characteristics of rheumatoid arthritis patients undergoing reverse shoulder arthroplasty. *Clin Rheumatol* 2018;37:339–343.

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T. B. Edwards: Wrote the manuscript.
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L. Favard: Collected the data.
G. Walch: Designed the study, Edited the manuscript.
F. Sirveaux: Collected the data.
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Funding Statement:
The author or one or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article.

ICMJE COI statement:
A. Godeneche reports consulting fees from Wright, Arthrex, and Conmed related to this study. G. Walch reports consulting fees from Wright related to this study. C. Gerber reports consulting fees from Zimmer Biomet related to this study, as the designer of the anatomical shoulder arthroplasty system.

Acknowledgements:
The authors are grateful to Hugo Bothorel and Mo Saffarini for their assistance with data management, statistical analysis, and manuscript redaction.

Ethical review statement:
This study received institutional review board approval (IRB #2018-01).

This article was primary edited by A. D. Liddle and first proof edited by G. Scott.