JSES International 5 (2021) 1049–1054

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Clinical and radiographic outcomes of reverse shoulder arthroplasty using a hybrid baseplate fixation mechanism

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ARTICLE INFO

Keywords:
Reverse shoulder arthroplasty
Baseplate
Glenoid loosening
Clinical outcomes
Short term
Range of motion
Complications
Revisions

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

Background: Despite the success of reverse shoulder arthroplasty (RSA), complication rates remain high (13% to 25%), due to instability, infection, and glenoid component loosening, which can lead to revision. The aim of the present study was to report the early clinical outcomes of RSA using a new hybrid baseplate design, in comparison with the literature on other common RSA baseplates.

Methods: The authors retrospectively analyzed the records of 142 patients (142 shoulders) who underwent primary RSA using a hybrid baseplate design by the senior surgeons between May 2014 and December 2018. Preoperative and postoperative assessments included the Constant score (CS) and range of motion, including active forward elevation, external rotation, and internal rotation.

Results: Of the initial cohort of 142 patients, 13 were lost to follow-up (8.6%), 2 died (1.3%), and 8 required reoperations with implant removal (5.3%). The remaining 119 patients comprised 71 women (60%) and 48 men (40%), aged 73.6 ± 7.3 years at index surgery, 43 of whom required bony increased offset (36%). At a minimum follow-up of 2 years, the CS improved by 37.3 ± 16.1, active forward elevation increased by 51.2° ± 38.1°, external rotation increased by 16.4° ± 25.0°, and internal rotation increased by 1.5 ± 3.2.

Conclusion: At a minimum follow-up of 2 years after RSA using a new hybrid baseplate system, the CS and range of motion were satisfactory and comparable to those in recent systematic reviews. The findings of this study suggest that this hybrid baseplate system provides satisfactory outcomes in the short term, although longer follow-up studies are needed to validate its long-term efficacy.

The number of reverse shoulder arthroplasties (RSAs) performed annually is rising[1,3] because of the increasing incidence of glenohumeral osteoarthritis, rotator cuff arthropathies, and proximal humeral fractures. Despite the success of RSA, its complication rates remain high (13% to 25%),[1,3,6,21] mainly due to instability, infection, and glenoid component loosening,[1,3] which can lead to revision.

Factors associated with glenosphere baseplate failure include the use of nonlocking peripheral screws and bone grafting to address glenoid deficiencies.[2] Baseplate fixation is also influenced by the length, diameter, and orientation of peripheral screws,[9,10] baseplate inclination, and glenosphere lateral offset.[9,24,25] The primary means of baseplate fixation remains the large central peg or screw, although there is no consensus to date regarding the superiority of either mechanism.[5,15] An unthreaded central peg allows congruent contact to promote bony ongrowth, which is particularly desirable in glenoids that require bone grafting to adjust offset or address retroversion and/or inclination; however, this mechanism may not resist micromotions that occur before osteointegration.[14] A threaded central screw can decrease micromotions as it anchors deeper into the scapula,[13,14] but may not grant rapid bony ongrowth because of limited possibilities of surface coatings and congruency of screw threads.

Recently, a monobloc baseplate was developed featuring a hybrid central post, with a threaded uncoated medial portion and an unthreaded titanium plasma-sprayed lateral portion, to optimize both short-term fixation and long-term osteointegration (Fig. 1). The aim of the present study was to report the early clinical

The institutional review board (IRB) of Hôpital Privé Jean Mermoz and the Centre Orthopédique Santy approved this study in advance (IRB#0009085).

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https://doi.org/10.1016/j.jseint.2021.07.006

Figure 1 A monobloc baseplate with a hybrid central post, with a threaded uncoated medial portion and an unthreaded titanium plasma-sprayed lateral portion.

outcomes of RSA using this hybrid baseplate design, in comparison with the literature on other common RSA baseplates. The hypothesis was that the hybrid baseplate grants comparable functional and clinical scores to those reported for other baseplates.

Methods

The authors retrospectively analyzed the records of 142 patients (142 shoulders) who underwent primary RSA using a hybrid baseplate design by the senior surgeons (L.N. and P.C.) between May 2014 and December 2018. Patients that underwent revision, resurfacing, stemless, or interposition arthroplasty were not included. The indications for surgery were cuff tear arthropathy (n = 99), primary glenohumeral osteoarthritis with B2/B3 glenoids (n = 28), glenohumeral osteoarthritis secondary to trauma or instability (n = 9), acute trauma (n = 3), locked dislocation (n = 2), or osteonecrosis (n = 1) (Table I). All patients were evaluated clinically and radiographically at a minimum follow-up of 2 years. All patients provided informed consent for the use of their data for research, and the study was approved in advance by the ethical board of GCS Ramsay Santé pour l'Enseignement et la Recherche (COS-RGDS-2021-03-005-NEYTON-L).

Preoperative assessment

Preoperative clinical and demographic data were recorded, including the Constant score (CS)[20] and range of motion (ROM), measured using a goniometer. Active forward elevation (AFE) was measured in the scapular plane, while external rotation was measured with the elbow at the side (ER). Internal rotation (IR) was measured using a 10-point scale (greater trochanter, 0; buttock, 2; sacrum-L4, 4; L3-L1, 6; T12-T8, 8; T7-T1, 10).[23]

Surgical procedure

All patients received the same glenoid components of the Aequalis Reversed II system (Tornier, Bloomington, MN, USA), while the humeral components comprised Aequalis Reversed II stem, or Aequalis Ascend flex stem, depending on implant availability on the day of surgery and the Aequalis Reversed fracture stem in cases of preoperative or intraoperative fractures (Table I). The surgical procedure was previously described[17] and consisted of the following steps: The humeral head was cut in 0° to 20° of retroversion. The glenoid was clearly exposed and reamed asymmetrically aiming for 0° to 10° of glenoid retroversion. This can either be achieved by asymmetrical reaming of the anterior aspect of the glenoid without medialization or using bony increased offset (BIO) graft. The cancellous graft was contoured to fit the posterior glenoid defect and to correct retroversion and provide lateralization (asymmetric BIO-RSA[4]) (Fig. 2). In cases that required BIO-RSA, only the threaded part of the central post was inserted into the native scapula, while the lateral unthreaded part was predominantly hosted within the graft. In cases that did not require BIO-RSA, the entire hybrid central post of the baseplate was inserted into the native scapula (Fig. 3). In all cases, 2 to 4 peripheral screws were used to secure fixation, as required.

Table I
Demographics.

	Mean ± SD n (%)	Range	Mean ± SD n (%)	Range
Age at index surgery (yr)	73.5 ± 7.6	(54-90)	73.6 ± 7.3	(54-90)
of which <65 yr	21 (15%)		17 (14%)	
Gender				
Male	59 (42%)		48 (40%)	
Female	83 (58%)		71 (60%)	
Side				
Right	94 (66%)		83 (70%)	
Left	48 (34%)		36 (30%)	
Etiology				
I OA	28 (20%)		26 (22%)	
II OA/locked dislocation	12 (8%)		10 (8%)	
Cuff tear arthropathy/mRCT	99 (70%)		80 (67%)	
Others (acute trauma/ON)	3 (2%)		3 (3%)	
Glenoid implant component				
Aequalis reversed II glenoid	142 (100%)		119 (100%)	
Humeral implant component				
Aequalis ascend flex stem	107 (75%)		87 (73%)	
Aequalis reversed II stem	31 (22%)		28 (24%)	
Aequalis reversed fracture stem	4 (3%)		4 (3%)	
Peripheral screws				
2	30 (21%)		30 (25%)	
3	61 (43%)		52 (44%)	
4	51 (36%)		37 (31%)	
Glenoid vertical position				
High	1 (1%)		1 (1%)	
Flush	24 (17%)		18 (15%)	
Low	82 (58%)		72 (61%)	
Very low	35 (25%)		28 (24%)	
BIO-RSA				
Yes	52 (37%)		43 (36%)	
No	90 (63%)		76 (64%)	

SD, standard deviation; *OA*, osteoarthritis; *mRCT*, massive rotator cuff tears; *ON*, osteonecrosis; *BIO-RSA*, bony increased offset reverse shoulder arthroplasty.

Postoperative assessment

All complications, reoperations, and revisions after the index surgery were noted. At final follow-up, two independent observers (A.N. and S.Z.) collected the CS, measured ROM using a goniometer (AFE, ER, IR), and assessed anteroposterior and scapular Y-view radiographs. Radiographic assessment included vertical position of the glenoid component (high, flush, low, very low)[4] and scapular notching (no notch; grade 1, small notch not involving screws; grade 2, notch extending to the lower screw; grade 3, notch extending beyond the lower screw; grade 4, notch extending up to central post) was measured by 2 surgeons (L.N. and A.N.) to calculate the reliability.[22]

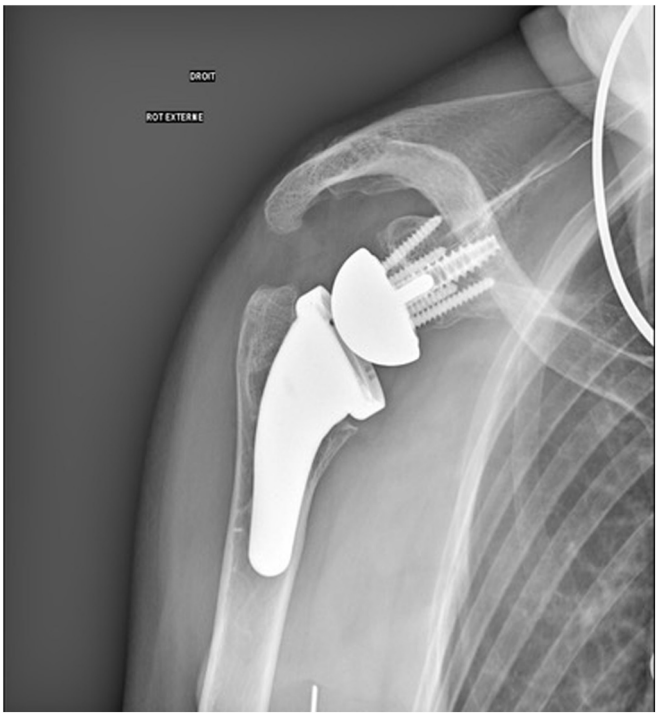

Figure 2 RSA at 2-year follow-up with bony increased offset (BIO). *RSA*, reverse shoulder arthroplasty.

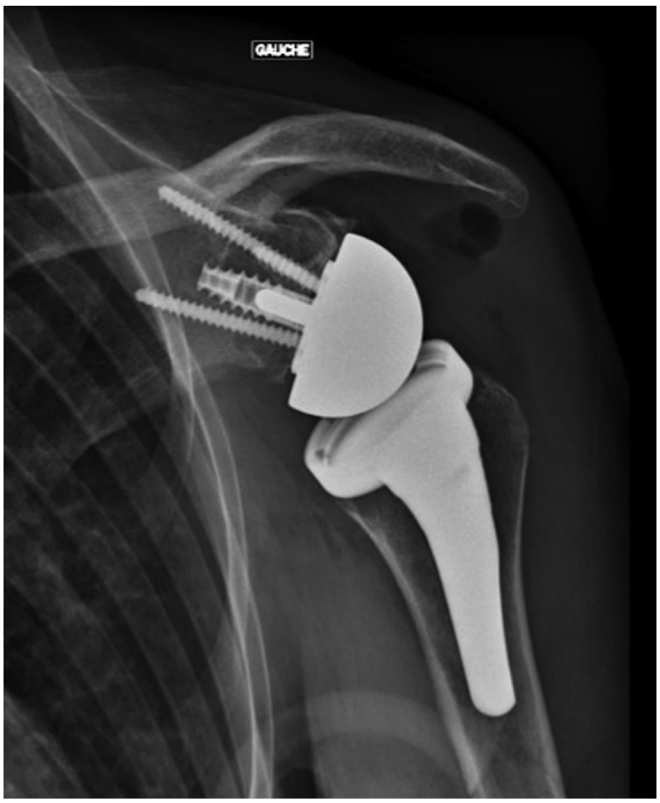

Figure 3 RSA at 2-year follow-up. *RSA*, reverse shoulder arthroplasty.

Statistical analysis

Descriptive statistics were used to summarize the data. The Shapiro-Wilk test was used to verify normality of distributions. Continuous variables were compared using paired t-tests or Wilcoxon signed-rank tests with Bonferroni correction for multiple testing. Categorical variables were compared using Chi-squared tests or Fisher's exact tests. Agreement between the 2 surgeons was calculated using intraclass correlation coefficients, which can be interpreted as poor for <0.40; fair, 0.41-0.59; good, 0.60-0.74; or excellent, 0.75-1.00.[7] The agreement between radiographic assessments of the 2 surgeons was excellent (intraclass correlation coefficient, 0.95; confidence interval, 0-93-0.97; $P < .001$). Univariable and multivariable regression analyses were performed to determine associations between the postoperative CS and 5 independent preoperative variables (age at surgery, sex, number of peripheral screws, glenoid vertical position, and use of BIO-RSA). *P* values < 0.05 were considered significant. Statistical analyses were performed using R, version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Of the initial cohort of 142 patients, 13 were lost to follow-up (8.6%), 2 died (1.3%), and 8 required reoperations with implant removal (5.3%) (Fig. 4). The reasons for implant removal included glenoid loosening (n = 4, 2.8%), deep infection (n = 3, 2.1%), and instability (n = 1, 0.7%) (Table II). All four cases of glenoid loosening had been performed with BIO-RSA that had been implanted with excessive superior orientation.

The remaining 119 patients comprised 71 women (60%) and 48 men (40%), aged 73.6 ± 7.3 years at index surgery, 43 of whom required BIO-RSA (36%) (Table I). One patient had an intraoperative humeral fracture (n = 1, 0.8%), and 4 patients had postoperative complications that did not require implant removal (3.3%), including transitory neuropraxia of the auxiliary nerve at 45 days postoperatively during the first follow-up (n = 2, 1.7%); a traumatic fracture of the scapular spine 14 months after index surgery (n = 1, 0.8%); and asymptomatic glenoid loosening 4.9 years after index surgery (n = 1, 0.8%).

At a mean follow-up of 2.4 ± 0.6 years (range, 2.0-4.0), the CS improved by 37.3 ± 16.1 (range, −12 to 72) ($P < .001$), and the pain component improved by 4.0 ± 3.0 (range, −10 to 7) ($P < .001$). The AFE increased by 51.2° ± 38.1° (range, −50° to 140°) ($P < .001$), ER increased by 16.4° ± 25.0° (range, −50° to 80°) ($P < .001$), and IR increased by 1.5 ± 3.2 (range, −6 to 8) ($P < .001$) (Table III). Scapular notching was observed in 33 patients (27.7%): grade 1 in 24 patients (20.2%), grade 2 in 7 patients (5.9%), and grade 4 in 2 patients (1.7%).

When stratifying the results by preoperative diagnosis of cuff tear arthropathy (n = 80, 67%) and primary osteoarthritis (n = 26, 22%), the preoperative CS, AFE, and IR were comparable, while the ER was significantly different ($P = .020$). Postoperatively, there were no significant differences, and the CS was 64.6 ± 13.6 and 68.8 ± 11.0 ($P = .110$), the AFE was 134.0° ± 27.8° and 143.8° ± 16.6° ($P = .170$), the ER was 28.2° ± 8.0° and 34.0° ± 17.8° ($P = .140$), and the IR was 5.5 ± 2.2 and 6.3 ± 1.9 ($P = .130$), respectively.

Univariable and multivariable regression analyses indicated that postoperative CS significantly decreased with age ($\beta = -0.39$, $P = .025$) but revealed no associations with any other variables (Table IV).

Discussion

The most important finding of this study was that, at a minimum follow-up of 2 years after RSA using the hybrid baseplate system, the postoperative CS was comparable to that reported in the recent meta-analysis by Nunes et al[18] and systematic review by

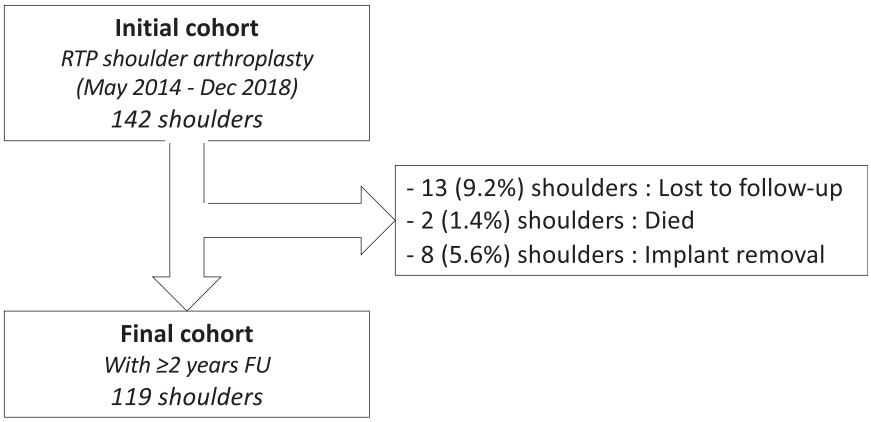

Figure 4 Flow chart.

Table II
Details of complications and revisions.

Diagnosis	Age at index RSA (yr)	Sex	BIO-RSA	Screws	Glenoid vertical position	Time from index RSA (mo)	Revision	Reason for revision
II OA (post fracture)	65	M	No	4	Low	0.1	Stem	Instability
CTA	81	M	No	4	Low	1.7	Entire implant	Deep infection
CTA	57	M	No	4	Very low	1.7	Glenoid + insert	Deep infection
II OA (post fracture)	84	M	Yes	3	Low	2.0	Entire implant	Deep infection
CTA	80	M	Yes	4	Flush	13.0	Entire implant	Extensive osteolysis
CTA	71	F	Yes	3	Flush	19.0	Glenoid	Glenoid loosening
CTA	68	F	Yes	4	Very low	24.8	Glenoid	Glenoid loosening
CTA	67	F	Yes	4	Very low	28.1	Glenoid	Glenoid loosening

RSA, reversed shoulder arthroplasty; *BIO-RSA*, bony increased offset reverse shoulder arthroplasty; *OA*, osteoarthritis; *M*, male; *CTA*, cuff tear arthropathy; *F*, female.

Kennedy et al.[11] The findings of this study suggest that this new hybrid baseplate provides comparable clinical outcomes in the short term although longer follow-up studies are needed to confirm its survival and safety.

Clinical scores

The postoperative CS in the present series was 65.8, but when stratifying by preoperative diagnosis, it was 64.6 for the 80 patients (67%) who had cuff tear arthropathy, which is slightly worse than the postoperative CS of 68.8 for the 26 patients (22%) who had primary osteoarthritis, although the difference was not statistically significant ($P = .110$). The recent systematic review by Kennedy et al[11] reported clinical outcomes and complications of RSA stratified by preoperative diagnosis, but without distinguishing between different RSA systems, and found postoperative CS of 60 to 74 for cuff tear arthropathy, compared to 65 to 88 for primary osteoarthritis. The recent meta-analysis by Nunes et al[18] compared lateralized to nonlateralized glenospheres in RSA and included 7 studies which used BIO-RSA and found postoperative CS of 61 to 69, with no difference between lateralized or nonlateralized glenospheres.

Complication rate

The present series found an overall complication rate of 4.2%, comprising 1 intraoperative humeral fracture (0.8%) and 4 postoperative complications (3.4%) that did not require implant removal, including 2 transient neurapraxia of the axillary nerve (1.7%), observed during first routine follow-up visit, 45 days after index surgery; 1 traumatic fracture of the scapular spine, 14 months after index surgery (0.8%); and 1 asymptomatic loosening of the glenoid component, 4.9 years after index surgery (0.8%). None of the reported complications were related to the baseplate, but larger studies are required to be able to confirm this. The systematic review by Kennedy et al[11] reported a pooled complication rate of 7.4% for patients diagnosed with cuff tear arthropathy, compared to only 1.4% for patients diagnosed with primary osteoarthritis. Furthermore, the most common complications in patients that had cuff tear arthropathy were acromial or scapular spine fractures (2%) and infection (1.6%), while in patients that had primary osteoarthritis, they were nerve palsy (2.3%) and infection (2%). The complication rate reported in the meta-analysis by Nunes et al[18] was stratified by the use of either metallic increased offset or BIO and found a complication rate of 0% to 56% for metallic increased offset and 0% to 14% for BIO. A recent systematic review by King et al[12] reported a 2.8% incidence of postoperative acromial and/or scapular spine fractures, while another systematic review by Patterson et al[19] reported a 4% complication rate. A recent study by Boileau et al[4] on the efficacy of BIO-RSA at 5-10 years follow-up reported a complication rate of 10%.

Revision rate

The present study found a revision rate of 5.3%, which comprised glenoid loosening (n = 4, 2.8%), deep infection (n = 3, 2.1%), and instability (n = 1, 0.7%). All four cases of glenoid

Table III
Preoperative and postoperative range of motion and clinical scores.

	Final cohort (n = 119)		
	Mean ± SD n (%)	Range	*P* values
Follow-up (yr)	2.4 ± 0.6	2.0 to 4.0	
Constant score (0-100)			
Preoperative	28.4 ± 11.0	6 to 62	<.001
Postoperative	65.8 ± 13.6	19 to 96	
Net improvement	37.3 ± 16.1	−12 to 72	
Pain (0-15)			
Preoperative	5.1 ± 2.1	0 to 10	<.001
Postoperative	1.1 ± 1.8	0 to 8	
Net improvement	4.0 ± 3.0	−10 to 7	
Active forward elevation (°)			
Preoperative	84.7 ± 36.2	0 to 170	<.001
Postoperative	136.0 ± 27.0	20 to 170	
Net improvement	51.2 ± 38.1	−50 to 140	
Active external rotation (°)			
Preoperative	12.6 ± 21.8	−45 to 80	<.001
Postoperative	28.7 ± 18.6	−10 to 70	
Net improvement	16.4 ± 25.0	−50 to 80	
Internal rotation (°)			
Preoperative	4.3 ± 2.6	0 to 10	<.001
Postoperative	5.8 ± 2.2	0 to 10	
Net improvement	1.5 ± 3.2	−6 to 8	
Scapular notching			
No notch	82 (68.9%)		
Grade 1	24 (20.2%)		
Grade 2	7 (5.9%)		
Grade 3	0 (0.0%)		
Grade 4	2 (1.7%)		
Missing	4 (3.4%)		

SD, standard deviation.

loosening had been performed with BIO-RSA that had been implanted with superior orientation. It is worth noting that Boileau et al[4] reported the same "technical mistake" with BIO-RSA graft failure using a different baseplate, with an overall revision rate of 4% (2% due to glenoid loosening). We, therefore, recommend that, for shoulders that require BIO-RSA, surgeons should avoid superior orientation, and manufacturers should consider developing a specific model of this hybrid baseplate, with a longer peg portion to increase the area of contact with the glenoid bone. In the meta-analysis by Nunes et al,[18] only 1 study was included in the forest plot on revision rates, reporting an incidence of 1.4%.[8] Mizuno et al[16] reported 4 patients with complications (15%); 1 patient had glenoid loosening (3.7%) which required revision, and 3 patients had nerve palsies (11%). As many of the complications encountered after RSA are related to suboptimal implant positioning, the use of assistive technologies such as patient-specific instrumentation or computer-assisted surgery should be considered to personalize glenoid orientation and humeral offset to the individual anatomy of each patient.

Range of motion

We found a postoperative AFE of 136°; but when stratifying by preoperative diagnosis, the AFE was 134° for the diagnosis of cuff tear arthropathy, while the AFE was 144° for the diagnosis of primary osteoarthritis. The systematic review by Kennedy et al[11] reported a mean AFE of 130° after cuff tear arthropathy and 134° after primary osteoarthritis. The meta-analysis by Nunes et al[18] reported a mean AFE of 136° to 158°. Similarly, we found an ER of 29°; but when stratifying by preoperative diagnosis, the ER was 28° for the diagnosis of cuff tear arthropathy, while the ER was 34° for the diagnosis of primary osteoarthritis. The systematic review by Kennedy et al[11] reported a mean ER of 26° after cuff tear arthropathy, and 27° after primary OA. The meta-analysis by Nunes et al[18] reported a mean ER of 17° to 40°.

We found a net change in AFE of 51°; but when stratifying by preoperative diagnosis, the AFE improved by 51° for the diagnosis of cuff tear arthropathy, while the AFE improved by 53° for the diagnosis of primary osteoarthritis. The systematic review by Kennedy et al[11] reported an improvement in AFE of 62° after cuff tear arthropathy, and 54° after primary OA. The meta-analysis by Nunes et al[18] reported an improvement in AFE of 53° to 96°. Similarly, we found an improvement in ER of 16°; but when stratifying by preoperative diagnosis, the ER improved by 12° for the diagnosis of cuff tear arthropathy, while the ER improved by 27° for the diagnosis of primary osteoarthritis. The systematic review by Kennedy et al[11] reported an improvement in ER of 17° after cuff tear arthropathy, and 21° after primary OA. The meta-analysis by Nunes et al[18] reported a mean ER of 2° to 39°.

Limitations

The present study has a number of limitations, typical of retrospective studies, including patients that were lost to follow-up or died, and not all patients were implanted with the same humeral component because of logistical constraints. Furthermore, the study does not comprise a control group using other baseplate designs, which would have rendered more valid comparisons than the ones made against the published literature. Finally, while comparing outcomes for patients that received BIO-RSA versus conventional RSA would have been possible for clinical scores and ROM, the outcome of interest was glenoid loosening, which was only observed in 4 shoulders, rendering the incidence of this event unsuitable for statistical analysis.

Conclusion

At a minimum follow-up of 2 years after RSA using this new hybrid baseplate system, the CS and ROM were comparable to those reported in recent systematic reviews. The findings of this study show that this new hybrid baseplate system provides satisfactory clinical outcomes in the short term; however, longer follow-up studies are needed to validate its long-term efficacy.

Acknowledgments

The authors are grateful to Luca Nover and Mo Saffarini for their assistance with data management and statistical analysis. The authors are also grateful to Wright Medical for supporting data collection for this study and thank GCS Ramsay Santé pour l'Enseignement et la Recherche for funding the statistical analyses and manuscript preparation.

Disclaimers:

Funding: Wright Medical supported data collection for this study, and GCS Ramsay Santé pour l'Enseignement et la Recherche funded the statistical analyses and manuscript preparation.
Conflicts of interest: Dr. Neyton receives consultant fees from Wright and Arthrex, royalties from Wright, and stock options from Sparta Biopharma. Dr. Collin receives consultant fees from Wright and Arthrex. 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.

Table IV
Univariable and multivariable regression analysis of postoperative Constant score.

Variable	n =	Univariable			Multivariable (n = 117)		
		β	95% CI	*P* value	β	95% CI	*P* value
Age at index operation (yr)	119	−0.4	−0.7 to −0.1	.025	−0.3	−0.7 to 0.0	.053
Male sex	48	3.9	−1.1 to 9.0	.123	3.8	−1.8 to 9.3	.181
Peripheral screws							
2	30	REF					
3	52	0.5	−5.7 to 6.6	.885	−1.4	−8.1 to 5.4	.686
4	37	3.4	−3.3 to 10.0	.322	−0.4	−8.0 to 7.3	.923
Glenoid vertical position							
High/flush	19	2.9	−4.1 to 9.8	.419	2.8	−4.2 to 9.7	.431
Low	72	REF					
Very low	28	1.7	−4.4 to 7.8	.575	2.7	−3.8 to 9.1	.414
BIO-RSA							
No	76	REF					
Yes	43	−1.7	−6.9 to 3.4	.512	−0.4	−6.1 to 5.3	.885

CI, confidence interval; *BIO-RSA*, bony increased offset reverse shoulder arthroplasty.

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