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

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**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 number of reverse shoulder arthroplasties (RSAs) performed annually is rising1,3 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, which can lead to revision. Factors associated with glenosphere baseplate failure include the length, diameter, and orientation of peripheral screws,3,9,10 baseplate inclination, and glensphere 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.5,25 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,1,5,14 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 outcomes of RSA using a new hybrid baseplate design, in comparison with the literature on other common RSA baseplates.
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 1). 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)\(^\text{20}\) 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).\(^\text{21}\)

**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 1). The surgical procedure was previously described\(^\text{17}\) 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\(^\text{4}\)) (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.

**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)\(^\text{23}\) 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.\(^\text{22}\)

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**Table 1**

**Demographics.**

| Age at index surgery (yr) | Mean ± SD | Range | Mean ± SD | Range |
|--------------------------|-----------|-------|-----------|-------|
| of which <65 yr           |           |       |           |       |
| Gender                    |           |       |           |       |
| Male                      | 73.5 ± 7.6| (54-90)| 73.6 ± 7.3| (54-90)|
| Female                    | 21 (15%)  |       | 17 (14%)  |       |
| Side                      |           |       |           |       |
| Right                     | 83 (58%)  |       | 71 (60%)  |       |
| Left                      | 48 (34%)  |       | 36 (30%)  |       |
| Etiology                  |           |       |           |       |
| OA                        | 28 (20%)  |       | 26 (22%)  |       |
| 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%)|       |
| 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 (23%)  |       | 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.
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 excellent (intraclass correlation coefficient, 0.95; confidence interval, 0.92-0.97; 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 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 ± 27.8 (range, 24.0° to 100°) (P = .170), the AFE was 28.2 ± 10.6° (range, 10° to 45°) (P = .140), and the IR was 5.5 ± 3.1 (P = .130), respectively.

Univariable and multivariable regression analyses indicated that postoperative CS significantly decreased with age (β = −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 and systematic review by

![Figure 2 RSA at 2-year follow-up with bony increased offset (BIO). RSA, reverse shoulder arthroplasty.](image1)

![Figure 3 RSA at 2-year follow-up. RSA, reverse shoulder arthroplasty.](image2)
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 lateraled to nonlateraled glenospheres in RSA and included 7 studies which used BIO-RSA and found postoperative CS of 61 to 69, with no difference between lateraled or nonlateraled 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

| 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     |
| CTA (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.

Figure 4 Flow chart.
loosening had been performed with BIO-RSA that had been implanted with superior orientation. It is worth noting that Boileau et al 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 designs, which may 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.

**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.

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**Table III**

Preoperative and postoperative range of motion and clinical scores.

| Final cohort (n = 119) | Mean ± SD  | Range | P values |
|-----------------------|------------|-------|---------|
| Follow-up (yr)        |            |       |         |
| Preoperative          | 2.4 ± 0.6  | 2.0 to 4.0 |         |
| Postoperative         | 28.4 ± 11.0 | 6 to 62  | <.001   |
| Net improvement       | 54.2 ± 23.4 | 14 to 74 |         |
| Pain (0-15)           | 32.6 ± 22.1 | 10 to 50 |         |
| 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 (°) | 84.7 ± 36.2 | 0 to 170 | <.001   |
| Preoperative          | 136.0 ± 27.0 | 20 to 170 |         |
| Postoperative         | 51.2 ± 38.1 | –50 to 140 |         |
| Internal rotation (°) | 136.0 ± 27.0 | 20 to 170 |         |
| Preoperative          | 16.4 ± 25.0 | –50 to 80 |         |
| Postoperative         | 126.0 ± 21.8 | –45 to 80 | <.001   |
| Net improvement       | 5.8 ± 2.2  | 0 to 10 | <.001   |
| 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.
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**Table IV**

Univariable and multivariable regression analysis of postoperative Constant score.

| Variable                              | n | Univariable | Multivariable (n = 117) |
|---------------------------------------|---|-------------|-------------------------|
| 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 5.3 | .181 |
| Peripheral screws                     | 2  | 30          | REF                     |      |      |            |     |
| Glenoid vertical position             | 3  | 52          | 0.5                     | -5.7 to 6.6 | .885 | -1.4 | -8.1 to 5.4 | .686 |
| 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.