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Original article

Clinical and radiological outcomes of 17 reverse shoulder arthroplasty cases performed after failed humeral head resurfacing

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ABSTRACT

Introduction: Despite the good outcomes with shoulder resurfacing procedures reported by some authors, our team has documented several failures caused by glenoid erosion and rotator cuff rupture, likely due to implant overstuffing. The aim of this study was to evaluate the clinical and radiological outcomes of reverse shoulder arthroplasty (RSA) performed after failed humeral head resurfacing (HHR).

Material and methods: This was a retrospective, single-center study of 17 patients who underwent RSA after failed HHR between January 2011 and February 2016. The mean patient age was 69.4 years and the mean time between HHR and surgical revision was 41 months (14.7–73.5 ± 18.8). Preoperative ultrasonography and CT were used to evaluate the condition of the rotator cuff, extent of glenoid erosion and to look for signs of humeral cup loosening. The clinical outcomes were evaluated pre- and postoperatively using the simple shoulder test (SST), DASH (Disabilities of the Arm, Shoulder and Hand) and the Constant-Murley score. Pain was estimated using a visual analog scale (VAS). The range of motion (ROM) was determined pre- and postoperatively. All patients had standard AP and lateral X-ray views of the shoulder taken as part of their postoperative follow-up protocol to look for implant loosening.

Results: The mean follow-up was 35.9 months (24–59 ± 10.7). There were no intraoperative or postoperative complications. All the functional scores were improved after RSA. The median weighted Constant score preoperatively was 46% (36; 62) while it was 92% postoperatively (78; 100) ($p < 0.0001$). The active ROM improved by 65° in forward flexion ($p = 0.0003$) and by 30° in external rotation ($p = 0.002$). On X-rays, we identified one patient with Sirveaux stage 4 glenoid notching and one patient with a humeral periprosthetic radiolucent line less than 2 mm thick in zone 6, with no clinical consequences.

Conclusion: The excellent outcomes after RSA for failed HHR in our study are similar to the ones reported when RSA is performed for cuff tear arthropathy.

1. Introduction

Humeral head resurfacing (HHR) for glenohumeral osteoarthritis was popularized by Copeland in the 1980s [1]. The main arguments in favor of these resurfacing implants are the preservation of the humeral head anatomy and of the bone stock, which would facilitate a future surgical revision (if needed) [2].

The first mid-term results in young, active patients with glenohumeral OA were encouraging [2–5]. For example, Thomas et al. [6] reported 98.2% survival of 55 Copeland Mark III implants at a mean follow-up of 5 years. Unfortunately, recent studies have reported an HHR failure rate of 23% to 37% [7,8]. Glenoid erosion is the primary cause of failure. The next step is surgical revision using anatomical or reverse shoulder arthroplasty implants, depending on the condition of the rotator cuff. The relationship between implant overstuffing and glenoid wear was suggested by Soudy et al. [9], who reported a 17% failure rate.

The aims of our study were to evaluate the clinical and radiological outcomes of failed HHR cases revised by reverse shoulder arthroplasty (RSA). We hypothesized that RSA would lead to similar functional outcomes in this context as those achieved with primary RSA.

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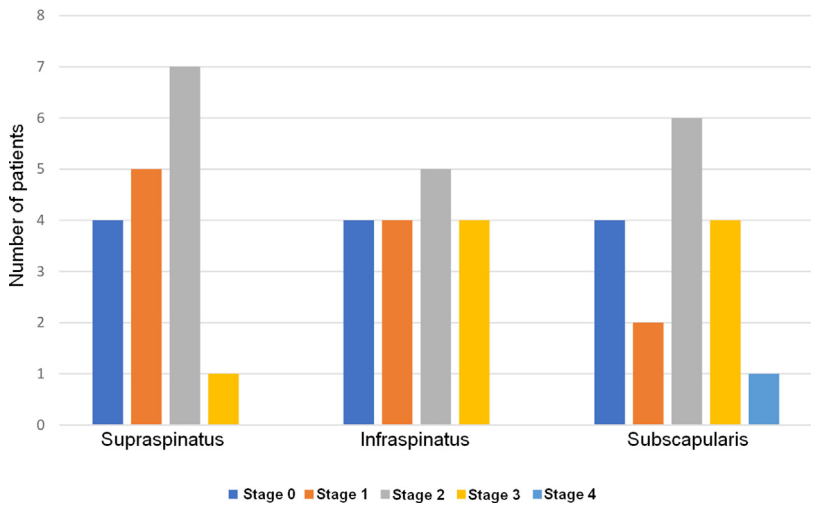

Fig. 1. Preoperative fatty infiltration of the rotator cuff using the Goutallier classification. SupS: supraspinatus, InfraS: infraspinatus, SubScap: subscapularis.

2. Materials and methods

2.1. Patients

This was a retrospective, observational, single-center, multi-surgeon study. We included all the patients with failed HHR who subsequently underwent RSA between January 2011 and February 2016. Surgical revisions in which the HHR implant was not removed and patients with less than 2 years' follow-up were excluded.

Our cohort consisted of 17 patients (2 men, 15 women) with a mean age of 69.4 years (54–83 ± 8.2) at the time of revision. The right shoulder was operated in eight cases and the left in nine; the dominant side was affected in 35% of cases.

The indication for the initial HHR procedure was primary glenohumeral OA in 16 cases and glenohumeral OA secondary to osteonecrosis of the humeral head in the other case. In two cases, the removed HHR implant was the Copeland Mark III™ (Biomet Merck, UK) and in 15 cases it was the Aequalis Resurfacing Head™ (Tornier, Edina, MN, United States).

The decision to perform surgical revision by RSA was based on a range of clinical and radiological findings.

All patients had mechanical or nighttime pain in their shoulder or both. If the source of the pain was unclear, an ultrasound-guided corticosteroid injection was done in the joint. If an infection was suspected, laboratory markers for inflammation were measured (ESR, CRP) along with leukocyte scintigraphy. Joint aspiration with microbiology analysis was also carried out if the previous examinations were not conclusive. Thus, scintigraphy was performed in 11 shoulders and showed glenoid uptake with no evidence of infection, thus suggestive of glenoiditis. Joint aspiration was performed in two shoulders and came back negative. Arthroscopic acromioplasty was performed in one shoulder but did not relieve pain. Lastly, one shoulder underwent a cortisone injection and the patient reported temporary pain relief.

A radiographic, ultrasonography and CT work-up was carried out in all patients preoperatively.

The preoperative ultrasonography identified a complete rotator cuff tear in 47% of cases (8 patients) and a partial intra-articular tear in 2 patients. Intraoperatively, all patients were found to have rotator cuff damage, with 5 having a partial tear and 12 having a complete tear.

A CT scan was performed to evaluate fatty infiltration of the rotator cuff muscles as described by Goutallier et al. [10]. The fatty degeneration was graded 2 or higher for the supraspinatus and infraspinatus muscles in 8 patients and 2 or higher for the subscapularis in 11 patients (Fig. 1). No instances of HHR loosening were identified on CT scan.

Glenoid erosion and glenohumeral subluxation were analyzed on CT scan images as described by Rispoli et al. [11]. Erosion was considered null when the subchondral bone was clearly visible; mild when partial or full wear was seen up to 5 mm deep; moderate when the erosion affected the lateral portion of the coracoid process (5–10 mm depth); severe when the erosion extended beyond the base of the coracoid process (> 10 mm deep). All the patients in our cohort had some amount of glenoid erosion: mild in 2 cases, moderate in 8 patients and severe in 7 patients.

Glenohumeral subluxation was described as a function of its direction and extent. It was considered null when no subluxation was present; mild when the prosthetic humeral head was translated less than 25% relative to the center of the glenoid; moderate when the head was translated 25% to 50%; severe when translated more than 50%.

The subacromial space (SAS) was estimated on a strict AP view with the patient supine and the shoulder in neutral rotation, as described by Railhac et al. [12]. The main features of the study population are summarized in Table 1.

2.2. Surgical technique

The patient was placed in a semiseated position under general anesthesia. The deltopectoral approach from the previous surgical procedure was reused in all cases. A vertical tenotomy of the subscapularis tendon was done at its attachment on the lesser tuberosity and the tendon was left on two traction sutures. The long head of biceps muscle was no longer present, as it had been tenotomized during the HHR procedure. Extensive joint release was then performed and the condition of the posterosuperior rotator cuff was evaluated. Once the humeral head had been exposed, the HHR implant was removed and multiple samples were collected for microbiology testing. The humeral head was cut using a dedicated cutting guide that allows humeral retroversion to be set. The subscapularis tendon was reattached depending on its quality and retraction. In the 17 revision cases, the Aequalis Reverse™ (Tornier, Edina, MN, United States) was used 15 times and the Unic inversée™ (Evolutis, France) was used 2 times (Fig. 2). The features of these two RSA implants are listed in Table 2.

Table 1
Characteristics of study population.

Case	Profession	Glenoid erosion (Rispoli)	Superior subluxation	Posterior subluxation	Anterior subluxation	Preop SAS
1	Retired	Moderate	Moderate	Mild	None	5
2	Retired	Moderate	Mild	None	None	8
3	Retired	Severe	Mild	None	None	12
4	Retired	Mild	Mild	None	None	7
5	Retired	Severe	Moderate	None	None	5.5
6	Retired	Severe	None	None	Mild	16
7	Retired	Moderate	Mild	None	None	7.3
8	Physical job	Mild	Moderate	None	None	5
9	Retired	Severe	Severe	None	None	2
10	Retired	Moderate	Mild	None	None	10
11	Retired	Severe	None	None	None	12
12	Retired	Moderate	Mild	None	None	10
13	Retired	Moderate	Mild	None	None	8
14	Retired	Moderate	Moderate	None	None	6.5
15	Retired	Severe	Mild	None	None	8
16	Sedentary job	Moderate	Mild	None	None	7
17	Retired	Severe	Moderate	Mild	Mild	5

Glenohumeral subluxation evaluated as described by Rispoli et al., SAS: Subacromial space expressed in millimeters.

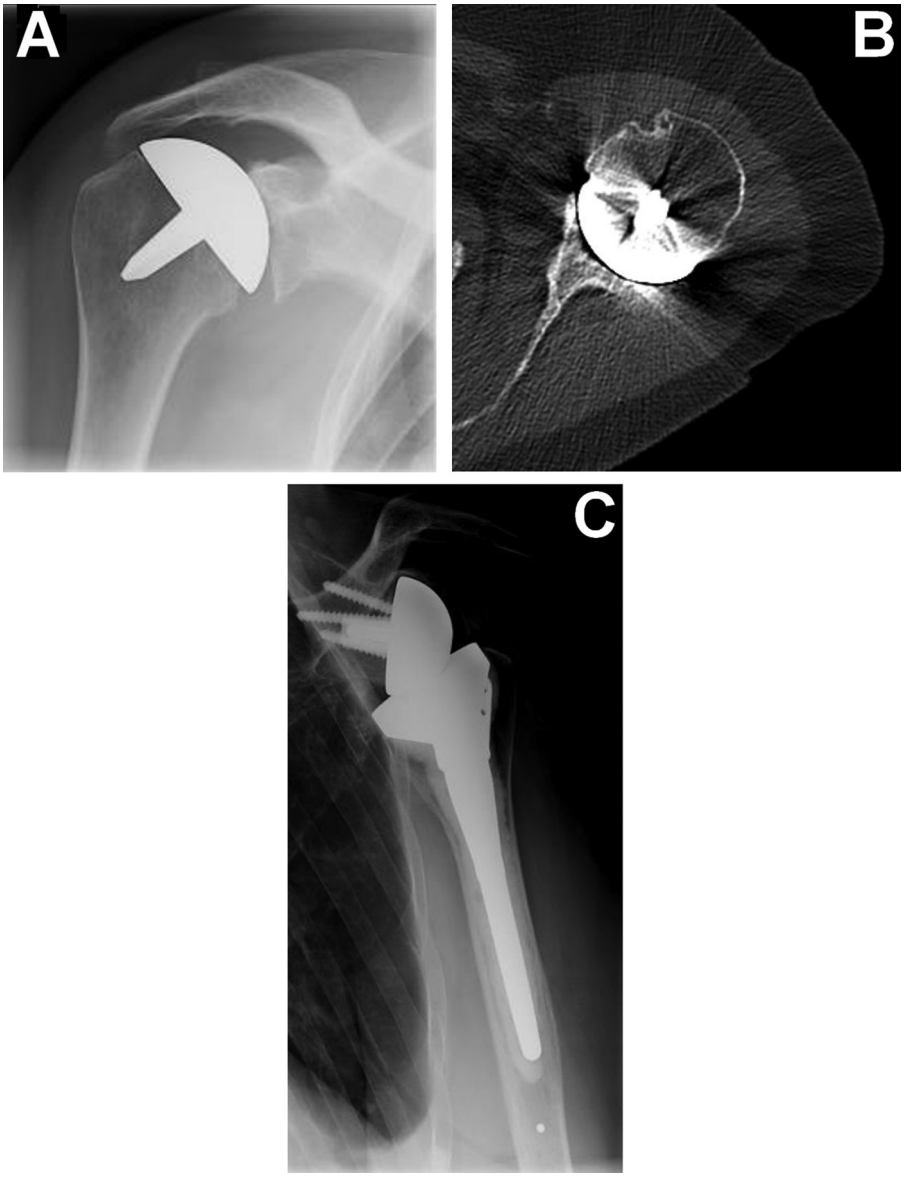

Fig. 2. A: AP view of the left shoulder showing elevation of the humeral head due to a massive rotator cuff tear after surface replacement arthroplasty. B: CT of left shoulder (axial slice) showing centered glenoid erosion. C: follow-up X-ray after revision of the resurfacing implant with Aequalis Reverse™ (Tornier, Edina, MN, United States).

Table 2
Characteristics of the RSA implants used.

Patient number	Glenosphere size	PE thickness (mm)	Retroversion humeral stem
1	36 mm	+6	10°
2	36 mm	+6	10°
3	36 mm	+6	20°
4	36 mm	+6	10°
5	36 mm	+9	20°
6	36 mm	+9	20°
7	36 mm	+9	20°
8	36 mm	+6	30°
9	36 mm	+9	10°
10	36 mm	+6	20°
11	36 mm	+9	20°
12	42 mm	+6	30°
13	36 mm	+9	0
14	36 mm	+6	10°
15	36 mm	+6	20°
16	36 mm	+9	10°
17	36 mm	+6	20°

PE: polyethylene.

Fig. 3. Intraoperative view of the bony in-growth at the bottom of the cup after removing the implant.

2.3. Surgical difficulties

The joint exposure was difficult in 11 cases because of fibrosis and capsule contracture. The HHR implant was removed without technical difficulties. We found good osteointegration of the humeral cup (Fig. 3). In one case, we used a cancellous bone autograft harvested from the humeral head to carry out the Bio-RSA™ technique [13]. In 12 cases, the subscapularis could not be reattached because the tendon was retracted, and the tissue was of low quality.

2.4. Clinical and radiological outcome assessments

All the patients were reviewed by an independent surgeon after a minimum follow-up of 2 years.

The Simple Shoulder Test (SST), DASH (Disabilities of the Arm, Shoulder and Hand) [14] and Constant-Murley score (raw and adjusted for age and gender) [15] were determined pre- and postoperatively. Pain was estimated using a visual analog scale (VAS). The range of motion (ROM) was determined pre- and postoperatively.

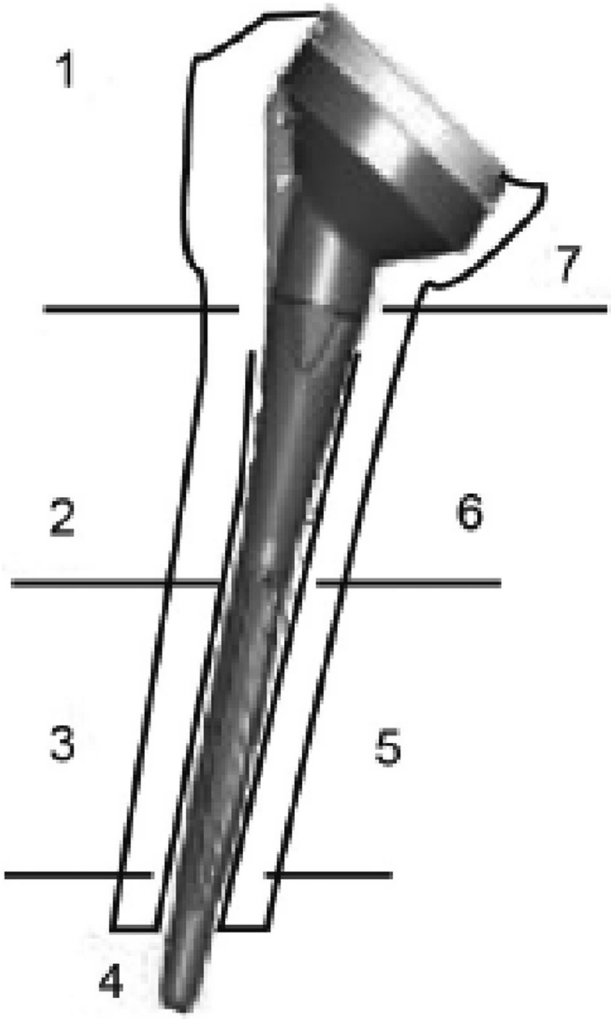

Fig. 4. Drawing showing the seven humerus zones used to analyze the periprosthetic radiolucent lines. This drawing was taken from the article by Mélis et al.

The patients were asked to rate their satisfaction was “very satisfied”, “satisfied”, “somewhat satisfied” and “not satisfied”.

At the review, the radiography assessment consisted of an AP view of the shoulder in neutral rotation and a Lamy lateral view. Notching at the lateral border of the scapula was analyzed as described by Sirveaux et al. [16]. Humeral periprosthetic radiolucent lines were evaluated as described by Melis et al. [17] with seven zones on the humerus, consistent with the Gruen classification [18] modified for the shoulder (Fig. 4) and classified by its thickness (< 2 mm or ≥ 2 mm).

2.5. Statistical analysis

Statistical analysis was carried out using the R Studio software (version 1.0.153–© 2009–2017 R Studio, Inc.). The data were summarized using the “describe” function of the “Pretty R” package. The pre- and postoperative mean and median values were compared using the Mann-Whitney, since the sample size was not large enough to generate normally distributed data. The median values are shown in the results with their first and third quartile values. The mean values are shown in the results as: mean (minimum – maximum ± standard deviation). The Wilcoxon

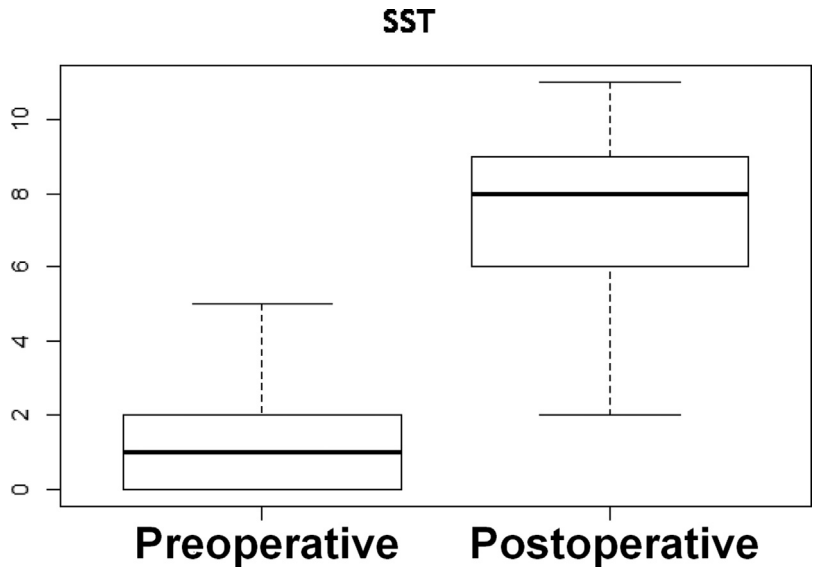

Fig. 5. Comparison of median preoperative and postoperative SST scores.

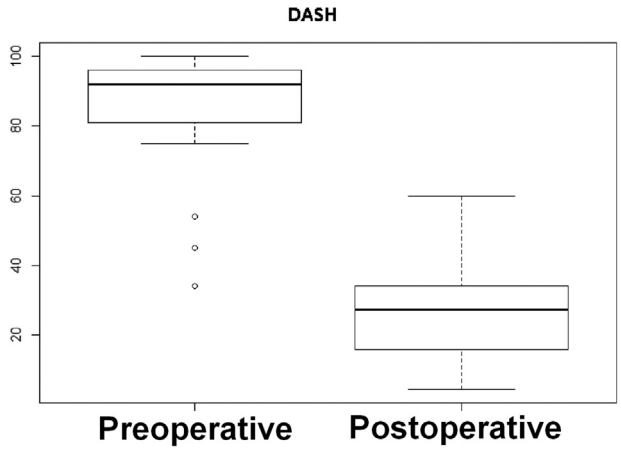

Fig. 6. Comparison of median preoperative and postoperative DASH scores.

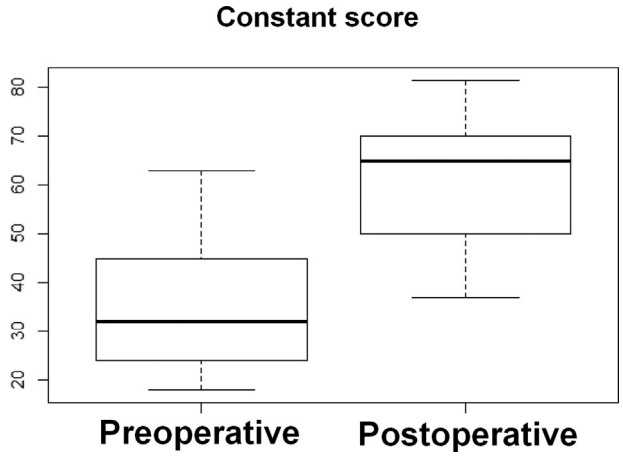

Fig. 7. Comparison of median preoperative and postoperative Constant score.

ranked-sum test for paired samples was used to compare the preoperative and postoperative ROM. The null hypothesis was rejected when $p < 0.05$.

3. Results

3.1. Complications

There were no neurological, infection-related or blood-related complications and none of the patients required another surgery.

3.2. Functional outcomes

At a mean follow-up of 35.9 months (24–59 ± 10.7), all the functional scores were significantly improved. Preoperatively, the median SST was 1/12 (0; 2) and it was 8/12 (6; 9) ($p < 0.0001$) after the revision surgery (Fig. 5). The median change in the DASH between the preoperative and postoperative period was 22 ($p = 0.0002$) (Fig. 6). The median preoperative Constant score was 32 points (24; 45); it improved to 65 points (50; 70) ($p < 0.0001$) at the final follow-up. The age- and gender-adjusted Constant score was 46% (36; 62) preoperatively and 92% (78; 100) postoperatively ($p < 0.0001$) (Fig. 7).

Table 3
Detailed Constant score and range of motion.

Constant sub-score	Preop median	Postop median	*p*
Pain (/15)	5 (0; 5)	13.5 (10; 15)	0.0001*
Daily activity level (/10)	2 (2; 4)	6 (6; 8)	0.0001*
Use of hand (/10)	4 (2; 8)	8 (6; 10)	0.03*
Strength (/25)	5 (5; 5)	10 (5; 10)	0.01*
Forward flexion	80° (70; 100)	145° (115; 160)	0.0003*
Abduction	80° (70; 80)	110° (100; 30)	0.00047*
External rotation (ER1)	40° (20; 60)	70° (60; 75)	0.002*
Internal rotation	2 (2; 6)	4 (2; 4)	0.4

* : Statistical significiance value.

All of the ROM measurements were significantly improved, except for internal rotation. The median active forward flexion went from 80° (70; 100) preoperatively to 145° (115; 160) postoperatively ($p = 0.0003$) (Table 3).

The median preoperative pain level was 7 (7; 10) versus 1 (0; 7) at the last follow-up. Twelve of the 17 patients (70%) were very satisfied, 4 (24%) were satisfied and one was somewhat satisfied (6%) with the procedure because of persistent diffuse shoulder pain graded as 7/10 with no evidence of implant loosening.

3.3. Radiographic evaluation

At the final review, we found only one case of stage 4 glenoid notching, which was well tolerated by the patient and did not require surgical revision. One patient had a humeral periprosthetic radiolucent line < 2 mm thick in zone 6 discovered at the 6-year follow-up visit, with no functional consequences for the shoulder. There was no evidence of tuberosity resorption at the final follow-up.

4. Discussion

The aim of this study was to analyze the functional outcomes of HHR revision with RSA. The working hypothesis was that the theoretical advantage of HHR (preservation of humeral anatomy and bone stock) makes surgical revisions simpler and ensures clinical outcomes identical to those of primary RSA. Our findings support this hypothesis since the outcomes of RSA were satisfactory in the context of HHR revision, with the weighted Constant score improving from 46% to 92% without any intraoperative or postoperative complications.

Despite the good mid- and long-term results achieved with HHR [3,6,19], our group [9] found a high failure rate (17%) in a series of 105 HHR cases reviewed at a mean follow-up of 56 months. Other studies have also reported a high surgical revision rate; for example, Werner et al. [7] had a 37% revision rate at a mean of 77 months after surgery in a series of 38 HHR cases.

Predictors of poor HHR outcomes identified by Soudy et al. [9] were the presence of glenoid erosion ($p < 0.0001$) or preoperative rotator cuff lesions ($p < 0.001$). Implant overstuffing increases the lateral glenohumeral offset and triggers glenoid erosion and failure of the rotator cuff [9,20]. Early glenoid erosion and rotator cuff lesions are also considered as the main causes of HHR failure by various authors [8,9,21–24].

We found that the time between HHR and revision was fairly short (mean 41 months) like in the Jaiswal et al. study [24] where the mean time was 43.2 months. The decision to perform revision surgery was taken fairly quickly, which makes the procedure easier since glenoid wear is mild or moderate (10 cases) and glenoid autograft was only needed in one case. The preservation of bone stock in the humeral head provides good quality graft material when using the classic Bio-RSA technique [13].

There are very few published studies reporting the functional outcomes after HHR revision [21,23,24]. In the Streubel et al. study [23] of 11 failed HHR cases, total shoulder arthroplasty (TSA) was performed in 9 cases and RSA in 2 cases, with a mean follow-up of 3 years. The results of revision by TSA were poor since 7 patients were dissatisfied, with 4 experiencing glenohumeral subluxation. Jaiswal et al. [24] had reported good outcomes for revision by TSA in 14 cases for glenoid erosion without rotator cuff lesion at 5 years' follow-up. The median postoperative weighted Constant score was 85% (40–100). However, they reported one case of aseptic glenoid loosening and two cases of rotator cuff tears.

In a study using the Danish shoulder registry, Rasmussen [21] found that the functional outcomes of failed HHR revised by RSA were not statistically different than those of primary RSA. The median postoperative Western Ontario Osteoarthritis of the Shoulder index was 77 (50;93) in the primary RSA group and 68 (46; 93) in the HHR revision by RSA group ($p = 0.66$) while the outcomes of revision by TSA were not equal to those of primary TSA. Our findings confirm those of Rasmussen et al., since the mean Constant score after RSA (65 points) was comparable to the functional outcomes after primary RSA reported in the literature [16,25–28].

In our study, the decision to revise a patient by TSA or RSA was dictated by the condition of the rotator cuff at the time of revision, as shown by Boileau and Levy [29,30], who had reported a significant increase in function after RSA was used to revise failed hemiarthroplasty cases. We chose to perform RSA only since all our patients had rotator cuff lesions discovered during the preoperative ultrasonography scan (10 cases) or observed intraoperatively (17 cases). In addition, our population was somewhat older (69.8 years) and minimally active (15 patients were retired), which can justify revision with RSA.

One option that was ruled out was conversion to TSA with a glenoid polyethylene implant and preservation of the humeral cup, due to the risk of increasing the lateral offset. Camus et al. [31] analyzed the short-term consequences of increasing lateral offset after performing TSA for failed HHR on AP views of the shoulder in neutral rotation. They observed a mean increase in the lateral offset of 14 ± 6 mm with the Constant score improving from 68 ± 7 to 91 ± 9 points postoperatively with a mean 20 months' follow-up. According to these authors, this lateralization increases the tension on the rotator cuff and the risk of secondary rupture. Harryman et al. [32] also identified this problem in a cadaver study.

Lastly, the ease of revising HHR implants allowed us to avoid intraoperative mechanical complications related to removing the humeral stem. This is not the case for revision of stem-based hemiarthroplasty [33–36].

Our study has weaknesses related to its retrospective design, low statistical power due to the small sample size and the relatively short follow-up (35.9 months). Moreover, we did not have a control group; this would have allowed us to confirm the theoretical advantages of revising HHR implants over humeral stem implants. Similarly, we did not perform any comparisons with primary RSA cases.

5. Conclusion

The success of HHR reported in the 2000s seems to have been progressively negated by numerous failures, mainly related to glenoid erosion and rotator cuff tears. In our experience, surgical revision of HHR by RSA leads to satisfactory results similar to the outcomes of primary RSA, with no intra- or postoperative complications or significant technical difficulties.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Authors' contribution

Pierre Gaeremynck: study design, data collection and entry, manuscript preparation.
Thomas Amouyel: study design, manuscript preparation.
Charlotte Germon: data collection.
Benjamin Gadisseux: data collection.
Marc Saab: study design.
Kevin Soudy: data collection.
Christophe Szymanski: manuscript preparation.
Carlos Maynou: study design and manuscript preparation.

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