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Hemiarthroplasty versus reverse shoulder arthroplasty in 4-part displaced fractures of the proximal humerus: Multicenter retrospective study

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A B S T R A C T

Introduction: Complex 4-part fractures of the proximal humerus are one of the most difficult fractures to manage. For several years, reverse total arthroplasty (RSA) has been proposed as an alternative to hemiarthroplasty (HA) when internal fixation is insufficient. The goal of this study was to compare the short and intermediate term results of these 2 different types of arthroplasty.
Materials and methods: In a retrospective, multicenter study, 57 HA and 41 RSA were reviewed after a follow-up of at least 2 years. The clinical evaluation was based on the absolute and adjusted Constant scores, Simple shoulder value (SSV) and the quick-DASH scores. The radiological assessment included standard radiological tests.
Results: After a mean follow-up of 39 months, the RSA group had a significantly higher adjusted Constant score than the HA group (83% vs 73%, respectively $P = 0.02$). However, there was no significant difference in the absolute Constant score, the quick-DASH or the SSV scores. Active anterior elevation was better in the RSA group, while internal rotation was better in the HA group (130° vs 112°, $P = 0.01$; sacrum vs L3, $P = 0.03$). There was no significant difference in external rotation (28° vs 23°, $P = 0.31$). The rate of complications was higher in the HA group than in the RSA group (24% vs 10%, $P = 0.01$). The radiological rate of union of the greater tuberosity was similar in both groups (70%) and scapular notching was found in 23% of the RSA group.
Conclusion: The short and intermediate term clinical outcomes are better with RSA than with HA. The complication rate is higher with HA. Nevertheless, scapular notching occurred in more than 20% of patients with RSA, suggesting that care should be taken when using this prosthesis in young, active patients.

1. Introduction

Fractures of the proximal humerus represent 5 to 10% of fractures in adults and are now the third most frequent fracture in the elderly following fractures of the proximal femur and the distal radius [1,2]. Although simple fractures are elected to non-surgical treatment, the management of displaced, comminuted and complex factures is more controversial. The postoperative complication rate increases with age, whatever the type of internal fixation, because of unreliable fixation of the different fragments due to advanced osteoporosis and a high rate of necrosis of the humeral head [3–6]. In these cases, arthroplasty has been proposed as an alternative to internal fixation. The results of hemiarthroplasties (HA) are strongly dependent upon anatomic union of the tuberosities around the implant [6–9]. Because of the number of unsuccessful HA on one hand, and the promising outcome of reverse total arthroplasty (RSA) for cuff tear arthropathy of the

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shoulder on the other, this prosthesis has also been proposed as an option for the treatment of 3- or 4-part fractures of the proximal humerus in elderly subjects [10–13].

There are very few studies specifically comparing large series of HA and RSA for complex fractures of the proximal humerus [13–18]. The goal of this study was to evaluate the clinical and radiographic results of primary shoulder arthroplasties for 4-part fractures. The main hypothesis was that RSA would result in better short and intermediate term clinical outcomes than HA. The secondary hypothesis was that the rate of postoperative complications would be the same for both implants.

2. Patients and methods

This was a comparative multicenter retrospective study, in which 11 centers specialized in shoulder surgery participated following approval by the Ethics committee (*Comité de protection des personnes* EST–2013-A00050-36).

2.1. Inclusion and exclusion criteria

Inclusion criteria were:

- recent (< 3 weeks) displaced 4-part fractures of the proximal humerus;
- management between January 1, 2009 and December 31, 2011;
- treated by hemi-arthroplasty (HA group) or reverse total shoulder arthroplasty (RSA group).

Exclusion criteria were the following:

- patients without a minimum clinical and radiographic follow-up of 24 months;
- patients with a history of surgery in the involved shoulder.

One hundred and sixty-five patients were included (95 in the HA group and 70 in the RSA group); 6 patients died (HA group, $n = 5$; RSA group, $n = 1$) and 61 were excluded due to insufficient clinical ($n = 29$) or radiographic ($n = 32$) follow-up. Thus, a database of 98 patients (98 shoulders) was created including 57 HA and 41 RSA. All patients signed an informed consent form and gave their approval for the use of clinical and radiographic data for scientific purposes.

2.2. Study populations (Table 1)

There was no significant difference found between the HA and RSA populations for postoperative follow-up, ASA score (American society of anaesthesiologists), body mass index (BMI) or occupation. However, the patients in the RSA group were significantly older and there were more women in the HA group.

2.3. Surgical technique

All patients underwent surgery under general anaesthesia in the beach chair position. A deltopectoral approach was performed in 53 cases (HA group, $n = 44$; RSA group, $n = 9$) and an anterosuperior transdeltoid approach in 45 cases (HA group, $n = 13$; RSA group, $n = 32$). Specific implants for traumatic injuries were used in all cases.

The tuberosities were sutured around the stem of the prosthesis with non-absorbable thread by simple or double cerclage (HA group: 100% of the cases; RSA group: 90% of the cases) and in certain cases, an autograft from the humeral head was placed around the metaphysis of the implant (HA group: 71%; RSA group: 65%). Tenodesis or tenotomy of long head of the biceps was systematically performed.

The shoulder was usually immobilized in internal rotation and active postoperative rehabilitation was not begun until 6 weeks after surgery in 50% of the cases.

Table 1
Comparison of the study groups.

Criteria	HA group $n = 57$	RSA group $n = 41$	P
Follow-up (months)	39 ± 11.6 (20–63)	39 ± 10.1(25–63)	0.99
Age (years)	67 ± 10.1(38–87)	78 ± 5(60–88)	< 0.0001*
Gender (M/F)	18/39 (32%/68%)	4/36 (10%/90%)	0.01*
Occupation			
Inactive	14	11	0.76
Active retired	22	14	
Retired low activity	14	14	
Heavy manual laborer	1	0	
Light manual laborer	3	1	
Non manual laborer	3	1	
ASA score	1.61 ± 0.98 (1–3)	1.71 ± 0.98 (1–3)	0.66
BMI	28.1 ± 6.59 (19–44)	27.17 ± 6.21 (19–51)	0.50

ASA: American society of anesthesiologist; BMI: body mass index.
* Significant (0.05).

2.4. Evaluation criteria

The objective clinical Constant-Murley score (absolute and adjusted) and the quick-DASH (Disabilities of the arm, shoulder and hand) score were calculated [19–21] at the final follow-up. An adjusted Constant score of less than 70% was considered to be a poor result. The subjective assessment of overall function of the operated shoulder was based on the Simple shoulder value (SSV: scale from 0 to 100%) [19].

Active range of motion was measured for elevation, external rotation of the elbow at the side and internal rotation (level of vertebra reached by the thumb). A passive anterior elevation of less than 80°, associated or not with a passive external rotation of the elbow at the side of less than 10° at the final follow-up was considered to be stiffness.

The immediate postoperative radiographic assessment and at the final follow-up were based on an AP view in neutral rotation and a scapular view. The condition of the tuberosities was specifically evaluated in relation to union, osteolysis or non-union. The greater tuberosity was considered to be in an anatomical position when it was visible on the AP X-ray, lateral to the implant under the apex of the head of the prosthesis or of the stem in case of RSA (from 1 to 3 mm) (Fig. 1). In the RSA, a scapular notch was systematically looked for on the AP view at the final follow-up.

2.5. Statistical analysis

Statistical analyses were performed with SAS (Statistical analysis system) software, version 9.3. Quantitative variables were described by means, standard deviations, minimums and maximums. Normal distributions were tested by the Shapiro-Wilk test and confirmed graphically by histogram. Populations and percentages described qualitative variables. The qualitative parameters of the HA and RSA groups were compared with a Chi^2 test or Fisher exact test. The quantitative parameters of the two groups were compared using the Student t test or the Mann-Whitney test according to the distribution of the parameter. $P \leq 0.05$ was considered to be significant.

Fig. 1. AP X-ray in neutral rotation after HA. The position of the greater tuberosity can be considered anatomic: lateral to the implant, less than 3 mm under the head of the prosthesis.

3. Results

3.1. Clinical results

At a mean follow-up of 39 months (24–63; ±10.5), there was no significant difference between the HA and RSA groups for the mean absolute Constant score (54 points vs 57 points respectively; $P = 0.4$). Moreover, there was no significant difference in the Quick-DASH or SSV scores.

On the other hand, the mean adjusted Constant score was significantly better in the RSA group (HA group 73% vs RSA group 83%, $P = 0.02$) (Table 2 and Fig. 2). Moreover, a poor adjusted functional Constant score (<70%) was less frequent in the RSA group than in the HA group (21% vs 44% respectively, $P = 0.03$). If the greater tuberosity was not in an anatomic position, whether because of non-union or malunion, this resulted in a significantly poorer mean adjusted Constant score in the HA group (anatomic union: 80% vs 54% without anatomic union, $P < 0.0001$), but did not significantly influence the RSA group (anatomic union: 85% vs non union: 82%, $P = 0.36$).

Table 2
Objective and subjective clinical results at the final follow-up.

Constant score	HA group $n = 57$	RSA group $n = 41$	P
Pain (/15 points)	11.2 ± 3.6 (3–15)	12.1 ± 3.5 (3–15)	0.15
Activity (/20 points)	13.4 ± 4.4 (4–20)	15.6 ± 3.8 (6–20)	0.01*
Mobility (/40 points)	23.7 ± 8.9 (2–40)	24.6 ± 8 (6–40)	0.62
Strength (/25 points)	6.1 ± 4.2 (0–16)	5.22 ± 4.8 (0–25)	0.12
Absolute (points)	54 ± 17 (19–89)	57 ± 14 (23–90)	0.4
Weighted (/%)	73 ± 22 (25–111)	83 ± 21 (36–120)	0.02*
SSV (%)	66 ± 22 (20–100)	75 ± 15 (35–100)	0.08
Quick-DASH (points)	30 ± 19.6 (0–68)	28 ± 14 (0–59)	0.58
Active anterior elevation (°)	112 ± 42 (20–180)	130 ± 30 (50–180)	0.02*
Active external rotation position 1 (°)	28 ± 20 (0–80)	23 ± 20 (−20–70)	0.33
Active internal rotation (level vertebra-score)	L3 (4)	Sacrum (6)	0.03*

* Significant result (0.05).

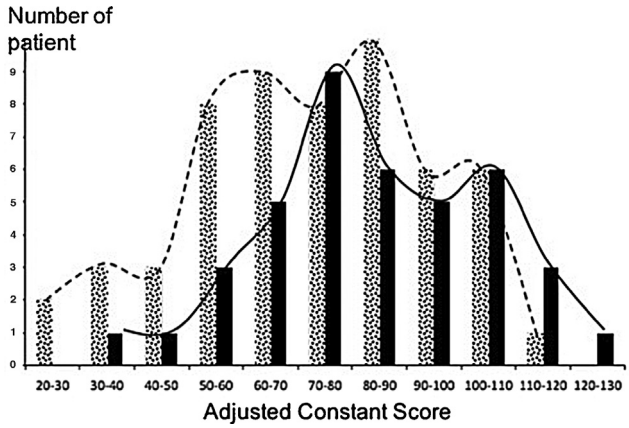

Fig. 2. Distribution of the adjusted Constant scores by population according to the type of implant (HA: spotted bar; RSA: black bar).

For active range of motion, mean anterior elevation was significantly better in the RSA group than in the HA Group (130° vs 112°, respectively, $P = 0.02$). There was no significant difference for external rotation of the elbow at the side, while internal rotation was significantly better in the HA group (Table 2).

3.2. Radiographic results

There was no significant difference between the two groups for the rate of anatomic union of the greater tuberosity, osteolysis or non-union. (Table 3).

Periprosthetic ossifications were found in 1 patient (2%) in the HA group and 2 patients (5%) in the RSA group.

A partial radiolucency was found around the humeral component in 5 and 6 cases in the HA and RSA groups respectively ($P = 0.9$). One complete radiolucent line was identified in the HA group and 2 in the RSA group ($P = 0.4$).

Scapular notching was found in 9 patients in the RSA group (23%). There were 5 radiolucencies around the peg of the base plate (12%).

3.3. Complications

The overall rate of postoperative complications was 24% and 10% in the HA and RSA groups, respectively ($P = 0.01$).

In the HA group, there were 11 cases of postoperative stiffness that were treated conservatively with long-term rehabilitation. A heterotopic ossification seems to have been the cause of one case of severe stiffness. One infection required early revision surgery with lavage, antibiotic treatment and preservation of the implant. Postoperative brachial plexus nerve injury was observed and was managed without revision surgery.

Table 3
Radiographic progression of the greater tuberosity (GT) at the final follow-up.

	HA group $n = 57$	RSA group $n = 41$	P
Anatomic union of GT	41 (72%)	30 (73%)	0.95
GT osteolysis	11 (19%)	7 (17%)	
Non union GT	5 (9%)	4 (10%)	

In the RSA group, one postoperative hematoma was considered to be non-compressive and did not require surgical revision. One case of postoperative brachial plexus injury was diagnosed. Two significant heterotopic ossifications were observed late in radiological follow-up.

There were no infections or implant instability.

4. Discussion

This study compared the short and intermediate term results of HA and RSA for the treatment of 4-part fractures of the proximal humerus. The main hypothesis was validated because the objective functional results of the adjusted Constant score were better with RSA after a mean follow-up of 39 months. Moreover, the secondary hypothesis was also validated because the rate of complications was significantly lower with RSA than with HA.

These results were similar to those in the literature. Cuff and Pupello [17] prospectively compared 26 HA and 27 RSA after a minimum follow-up of 24 months. The objective clinical results were better with RSA while more than 10% of HA were revised for non-union of the greater tuberosity. Boyle et al. [14] compared 55 RSA to 313 HA from the New Zealand register of prostheses. Although there was no significant difference for the 2 types of implants at 6 months, the results were better in the RSA group for the Oxford Shoulder Score at 5 years of follow-up. More recently, Sebastiá-Forcada et al. [16] performed a prospective randomized study in 31 HA and 31 RSA. After a mean follow-up of 28 months, the functional outcome was significantly better and the rate of revision was lower with RSA. The present study confirms that the short and intermediate term objective clinical results are better with RSA in a larger group of patients with longer follow-up.

Discrepant results have been reported with HA in complex fractures of the proximal humerus. The clinical results mainly depend on anatomical union of the tuberosities, which is obtained in 50 to 80% of cases depending on the series [6–9,21]. Other epidemiological (age, osteoporosis) and technical parameters (height of the implant, retroversion, quality of fixation of the tuberosities around the implant) also play an indirect role [8,22,23]. Because of a different biomechanical design, RSA is theoretically less dependent upon the tuberosities. Although this was not found in the functional scores used in the present study, preservation and fixation of the greater tuberosity improves the short and intermediate term results of RSA, in particular for recovery of active external rotation [10–13]. Moreover, with a rate of union of nearly 70% in both cohorts, we confirmed that the type of implant does not seem to influence the postoperative outcome of the greater tuberosity [16,17].

In a review of the literature, Ferrel et al. [24] reported a mean rate of complications of 9.6% following RSA and 4.1% after HA for fractures. The rate of complications in our study following HA was 6 times higher mainly because stiffness was considered to be a postoperative complication. Although this complication is rarely recorded in different studies, cases of severe pain with anterosuperior escape of the implant have been reported. In clinical practice, the latter is often associated with joint stiffness [8,14,16,22]. The rate of complications that we identified following HA was twice as high as that with RSA (24% vs 10%, respectively). However, the rate of scapular notching of more than 20%, which is specific to RSA, justifies taking care when indicating this option in young patients, because there is a long-term risk with clinical consequences and component loosening [10–12].

This study has certain limitations associated with its multicentre and retrospective design and a follow-up that was insufficient to assess the outcome of implants in general. Nevertheless, arthroplasty is a rare indication for fractures of the proximal humerus and this is one of the largest populations studied so far. Moreover, there was a significant difference in gender and age between the two study groups (younger in the HA group). Nevertheless, these parameters were adjusted by the use of the adjusted Constant score making it possible to evaluate the objective clinical results of the cohorts.

5. Conclusion

The short and intermediate term functional results of RSA are better than HA for 4-part fractures of the proximal humerus. Postoperative recovery of elevation is better and the complication rate is lower following RSA. Postoperative stiffness complicates the results of HA. The rate of union of the great tuberosity in an anatomic position is similar for both types of implant. On the other hand, scapular notching in more than 20% of the cases of RSA confirms that care should be taken when indicating this implant for young patients.

Disclosure of interest

Nicolas Bonnevialle is a consultant for Tornier and Depuy-Synthes.

Clément Tournier is a consultant for Depuy-Synthes.

Philippe Clavert is a consultant for Tornier, Mitek and Serf.

Xavier Ohl declares that he has no competing interest.

François Sirveaux is a consultant for Tornier and Profil Orthopédie.

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