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

N. Bonnevialle, C. Tournier, P. Clavert, X. Ohl, F. Sirveaux, D. Saragaglia

Département de chirurgie orthopédique, hôpital Riquet, CHU de Toulouse, place Baylac, 31059 Toulouse cedex, France
Service d’orthopédie traumatologique, hôpital Pellegrin, place Amélie-Raba-Leon, 33076 Bordeaux cedex, France
Service de chirurgie du membre supérieur, hôpitaux universitaires-CCOM, 10, avenue Baumann, 67400 Illkirch, France
Service d’orthopédie traumatologique, hôpital Maisonneuve-Bonheur, 31100 Toulouse, France
Service d’orthopédie-traumatologie, centre chirurgical E-Galle, 49, rue Hermite, 54000 Nancy, France
Service d’orthopédie-traumatologie, CHRU de Grenoble, 38000 Grenoble, France

ARTICLE INFO

Article history:
Received 28 June 2015
Accepted 24 February 2016

Keywords:
Fracture
Hemiarthroplasty
Reverse shoulder arthroplasty
Cephalotuberosity fracture
4-part fracture

ABSTRACT

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 score. 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.

© 2016 Elsevier Masson SAS. All rights reserved.

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 fractures 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...
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.

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 Chi² 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 ≤ 0.05 was considered to be significant.

### Table 1
Comparison of the study groups.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>HA group</th>
<th>RSA group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up (months)</td>
<td>39 ± 11.6 (20–63)</td>
<td>39 ± 10.1 (25–63)</td>
<td>0.99</td>
</tr>
<tr>
<td>Age (years)</td>
<td>67 ± 10.1 (38–87)</td>
<td>78 ± 5.6 (60–88)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Gender (MF)</td>
<td>18/39(32%/68%)</td>
<td>4/36 (10%/90%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inactive</td>
<td>14</td>
<td>11</td>
<td>0.76</td>
</tr>
<tr>
<td>Active retired</td>
<td>22</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Retired low activity</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Heavy manual laborer</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Light manual laborer</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Non manual laborer</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ASA score</td>
<td>1.61 ± 0.98 (1–3)</td>
<td>1.71 ± 0.98 (1–3)</td>
<td>0.66</td>
</tr>
<tr>
<td>BMI</td>
<td>28.1 ± 6.59 (19–44)</td>
<td>27.17 ± 6.21 (19–51)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

ASA: American society of anesthesiologist; BMI: body mass index.

* Significant (0.05).
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%, \( P = 0.36 \)).

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 4 and 6 cases in the HA and RSA groups respectively (\( P = 0.9 \)). One complete radiolucency 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>
<thead>
<tr>
<th>Table 3</th>
<th>Radiographic progression of the greater tuberosity (GT) at the final follow-up.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HA group ( n = 57 )</td>
</tr>
<tr>
<td>Anatomic union of GT</td>
<td>41 (72%)</td>
</tr>
<tr>
<td>GT osteolysis</td>
<td>11 (19%)</td>
</tr>
<tr>
<td>Non union GT</td>
<td>5 (9%)</td>
</tr>
</tbody>
</table>
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 radio-
logical 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 mini-
 mum 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 func-
tional 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.

Discrepancy data have been reported with HA in complex frac-
tures 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 epidemi-
ological (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 dif-
ferent biomechanical design, RSA is theoretically less dependent
upon the tuberosities. Although this was not found in the func-
tional 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 pos-
teroperative complication. Although this complication is rarely
recorded in different studies, cases of severe pain with anterosupe-
rrior 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 multicen-
tre and retrospective design and a follow-up that was insufficient
to assess the outcome of implants in general. Nevertheless, arthro-
plasty 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. Post-
operative 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 greater tuberosity in an anatomic posi-
tion 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 Bonneville 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.

Dominique Saragaglia is a consultant for BBraun.

Acknowledgements

We would like to thank:

• the investigators: P. Boileau, P. Clavert, C. Cuny, L. Doursounian,
L. Favard, L. Obert, P. Mansat, H. Thomazeau, T. Fabre, X. Ohl,
D. Saragaglia, F. Sirveaux;

• the participants in the symposium: D. Block, R. Bouchet, F. Gadea,
T. D’Ollonne, C. Tournier, N. Bonneville;

• the following for their scientific contributions: A. Berni, M.O. Gauci,
J. Mayer, P. Mangin, C. Nérot, R. Saadnia, X. Clement,
G. Dillmann, B.J. Chedal Bornu, G. Boudard, J. Lombard, Y. Knaffo,
C. Goetz, L. Decroocq, Y. Boujo, J. Berhouet, G. Bacle, A. Erbland,
B. Dunet, H. Demezon, J. Rigal, A. Adam, E. Jardin, T. Zapatera,
N. Gasse, S. Rochet, D. Ancelin, T. Trang, J. Lebon, B. Aisene,
H. Coudane, D. Mainard;

• Frégéac of AERCOT and N. Ramadane at the statistics department
at the CHU of Lille.

References

with hip fractures in those aged over 60 years: a study of patterns of injury and
[3] Petrigliano FA, Bezkulov N, Gambrt DC, Sookoof NF. Factors predicting complica-
tion and reoperation rates following surgical fixation of proximal humeral frac-
[4] Bonneville N, Boudard A, Mansat P, Bonneville P. Kapandji pinning and
uberosities fixation of three- and four-part fractures of the proximal humerus.
choice affects inpatient adverse events and mortality in older aged inpatients
with an isolated fracture of the proximal humerus. J Shoulder Elbow Surg
2014;23:800–6.
[7] Sirveaux F, Roche O, Moré D. Shoulder arthroplasty for acute proximal humerus


