Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly

A PROSPECTIVE REVIEW OF 43 CASES WITH A SHORT-TERM FOLLOW-UP

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We used an inverted shoulder arthroplasty in 43 consecutive patients with a mean age of 78 years (65 to 97) who had sustained a three- or four-part fracture of the upper humerus. All except two were reviewed with a mean follow-up of 22 months (6 to 58).

The clinical outcome was satisfactory with a mean active anterior elevation of 97° (35° to 160°) and a mean active external rotation in abduction of 30° (0° to 80°). The mean Constant and the mean modified Constant scores were respectively 44 (16 to 69) and 66% (25% to 97%). Complications included three patients with reflex sympathetic dystrophy, five with neurological complications, most of which resolved, and one with an anterior dislocation. Radiography showed peri-prosthetic calcification in 36 patients (90%), displacement of the tuberosities in 19 (53%) and a scapular notch in ten (25%). Compared with conventional hemiarthroplasty, satisfactory mobility was obtained despite frequent migration of the tuberosities. However, long-term results are required before reverse shoulder arthroplasty can be recommended as a routine procedure in complex fractures of the upper humerus in the elderly.

The treatment of complex fractures of the proximal humerus in elderly patients remains controversial. Avascular necrosis is a frequent occurrence in four-part fractures and may be otherwise provoked by extensive osteosynthesis.1,2 Hence, replacement of the head of the humerus appears to be justified in three- or four-part fractures, particularly if they are associated with a dislocation of the glenohumeral joint.3,4 However, the results are often compromised by displacement of the tuberosities.5,6 The reverse shoulder arthroplasty, which was initially described by Grammont and Baulot,6 converts the glenoid into a spherical head and the head of the humerus into a socket, thus providing a stable fulcrum for glenohumeral joints with deficiency of the rotator cuff.7,8 Encouraging mid-term results using this prosthesis have been described in degenerative or inflammatory shoulder disease with massive deficiencies of the rotator cuff.7,8 The use of similar implants in trauma has been described only in small series.9,10 However, the mid-term results appear to be acceptable, with only one case of loosening due to aseptic necrosis of the glenoid observed in 16 patients followed for more than five years in the only series dealing with acute trauma.10 We now describe our experience with this technique in the short term in elderly patients.

Patients and Methods
Between January 2000 and January 2005 we treated 43 consecutive patients with a recent fracture of the proximal humerus using a Delta reversed shoulder prosthesis (Depuy, Saint Priest, France). All were over 65 years of age. Five had sustained a displaced three-part fracture and 38, of whom 12 had a dislocation, a four-part fracture of the proximal humerus as described by Neer.11 Those with an active infection, axillary nerve palsy, a deficient deltoid muscle or a bone tumour were excluded.

There were 41 women and two men with a mean age of 78 years (65 to 97). The dominant arm was involved in 26 patients (60%). All the operations were carried out within 15 days of the injury. Five patients had other fractures; in one a two-part fracture of the contralateral humerus, in one an ipsilateral fracture of the olecranon, in one an ipsilateral Colles’ fracture and two had a fracture of the hip.

All the patients were provided with an illustrated information sheet describing all the possible complications including loosening of the glenoid and infection.

Operative technique. The operations were performed by four surgeons (AH, LH, and two who are not authors). The patients were placed in the beach-chair position and operated on under general anaesthesia with associated local...
anaesthesia. A superolateral approach was used in the first 20 patients and a deltopectoral approach in the remaining 23, because it offered similar exposure without dividing the deltoid muscle. This modification in technique was perceived as a possible advantage for the patient because the approach was less invasive. The greater and lesser tuberosities were retracted allowing removal of the head of the humerus and wide exposure of the glenoid. The supraspinatus tendon and the long head of the biceps, if present, were divided.

The glenoid baseplate was implanted flush to the inferior, anterior and posterior rims of the glenoid, with an inferior inclination of approximately 10° and was secured using four lag screws inserted through the glenoid. The version of the component was adjusted in order to reproduce the physiological orientation of the glenoid, using prostheses of 36 mm in diameter. Adjustment of the version and of the length of the humerus was carried out after a trial reduction to test the laxity and stability of the joint. In the first half of the series the humeral component was positioned in retroversion, but in the remainder it was placed in neutral version to increase internal rotation, because retroversion was not found to be necessary for the stability of the implant. The definitive humeral stem was implanted with gentamicin-impregnated bone cement in all the shoulders. In 15 shoulders, an epiphyseal augment was required on the stem in order to optimise deltoid tension. Finally, the head of the humeral component was implanted on its trunnion. It was coated with hydroxyapatite in 37 patients and cemented in the remaining six. Insertion of the polyethylene insert completed the arthroplasty. The tuberosities were then sutured to each other and around the neck of the prosthesis in their anatomical position. No vertical sutures were required because the supraspinatus had been removed or was absent. Fixation of the tuberosities appeared to be questionable in five patients, but required the use of a retentive insert in only two of these.

After operation, the shoulder was immobilised for two days before active but gentle physiotherapy was begun. Patients continued with physiotherapy in a rehabilitation centre and then at home for an overall mean duration of seven months (3 to 18).

The patients were reviewed every six months by an independent observer (TB) and assessed by the Constant and Murley,12 the American Shoulder and Elbow Surgeons (ASES)13 and Disabilities of the Arm, Shoulder and Hand (DASH) scores.14 The modified Constant score was calculated as a percentage of the normal value relative to gender and age. The pre-operative movement was estimated based on the mobility score of the contralateral shoulder.

Two patients were excluded because they died from unrelated causes, at six and 18 months after surgery respectively and had incomplete radiological files. Three other patients died after they had completed follow-up at 16, 21 and 33 months, respectively, and were therefore not excluded. Hence, the results were available for 41 patients with a mean follow-up of 22 months (6 to 58).

Two patients had an examination by their personal doctor because they did not return for the last follow-up visit; therefore, some data are missing.

Fluoroscopic-guided anteroposterior radiographs in neutral, internal and external rotation, and scapular lateral radiographs were obtained at each visit. Inferior scapular notching was recorded and classified according to Sirveaux et al.7 Radiographs of the contralateral shoulder served as a reference to assess the position of the centre of the shoulder and the glenoid inclination angle. In the intact shoulder from the centre of rotation of the humeral head (position M) a line was constructed as a perpendicular to the tangent drawn across the top of the acromion, intersecting at position A (Fig 1a). In the reconstructed shoulder the centre of rotation was defined at the mid-point of the baseplate of the glenoid component (position M'). From this position a line was drawn perpendicular to a tangent constructed over the acromion intersecting at position A (Fig 1b). When the distances A to M and A to M' differed by more than 10 mm it was considered that the centre of rotation had been significantly inferiorly depressed. Additionally the distance from position A to a perpendicular to the tangent which intersected with the outer margin of the acromion was used to define the medialisation of the shoulder. When the respective distances A to a of the reconstructed and normal shoulders differed by more than 10 mm, significant medialisation was considered to have occurred. The inclination angle of the glenoid of the intact shoulder was measured from a line constructed along the lower border of the scapula intersect-
The clinical results were evaluated as a function of age with 24 patients older than 75 years and 17 below this age. The healing of the tuberosities (of which 17 healed anatomically and 24 showed nonunion or malunion) and of the approach (with 22 deltopectoral and 19 lateral). The mobility scores for external rotation were studied in relation to the mobility of the reconstructed tuberosities. The mobility scores for internal rotation were assessed in relation to the version of the humeral component; 17 were in neutral version and 24 retroverted. The clinical results of 18 patients with a low shoulder centre were compared with the other 14.

Statistical analysis. Comparisons were carried out between the various groups which were comparable according to age and gender. The non-parametric Kruskal-Wallis test was used to compare the mean Constant scores and the mean DASH scores in the different categories of patient. The correlation between the inclination of the glenoid component and the state of notching was studied using the Spearman correlation coefficient. The level of significance was set at $p \leq 0.05$.

Results

The patients were followed up at a mean of 22 months (6 to 58). The findings are detailed in Table I. Complications occurred in 12 patients. Reaming produced a glenoid fracture in one patient which was treated immediately by a revision baseplate. Five patients had neurological complications, most of which recovered. In three this affected the median nerve, in one the axillary nerve, and in one the ulnar nerve. Only two patients complained of some residual paraesthesiae in the fingers at the last follow-up. Another sustained a fracture of the acromion 12 months post-operatively; it healed uneventfully. Three patients developed reflex sympathetic dystrophy which resolved spontaneously. One had a non-traumatic anterior dislocation at six weeks. The humeral component was articulating with the coracoid process, but the patient declined further surgery. The modified Constant score at 17 months for this patient was 53%.

One patient who had been operated on through a superolateral approach had a separation of the anterior muscular flap. This was revised at 17 months by suturing the deltopectoral flap to the acromial process with no further complications. Three patients had no radiographs. Therefore, radiological evaluation was only possible in 40 patients.

There was no evidence of loosening of either component. A radiolucent line of 1 mm in thickness was observed behind one of the glenoid components, and a radiolucency around the superior screw of the baseplate in two shoulders, but all remained stable.

In the 36 shoulders in which the tuberosities had been fixed, secondary displacement occurred in 19 (53%) (Fig. 2), leading to malunion in five (13.8%) and nonunion in 14 (38.8%).

Scapular notching was observed in ten shoulders (25%). It reached the inferior screw in only one (Sirveaux grade 3). Notching was generally noted before the end of the first year and did not widen in those patients followed up for more than two years. The angle of inclination of the glenoid component was a mean of 15° greater than that of the contralateral side. No correlation was found between the grade of notching and the angle of inclination (Spearman correlation coefficient $r = 0.23$, $p = 0.20$). Heterotopic ossification was noted in 36 shoulders (90%).

Pre-operatively, the mean Constant score and the mean modified Constant score of the contralateral shoulder were 69 (53 to 83) and 105% (80% to 130%) respectively. After operation (Table I) none of the ranges of movement matched those of the contralateral shoulder. The mean active anterior elevation was 97° (35° to 160°) and the mean active external rotation in abduction 30°. The mean Constant score, the mean modified Constant score and the ASES score were all less than in the opposite shoulder. The mean Constant score was 44 (16 to 69). The mean modified Constant score was 66% (25% to 97%). The mean pain score was 12.5 of 15, the mean activity score 10.9 of 20, the mean mobility score 17.6 of 40 and the mean strength score 3.6 of 2.5. The mean ASES score was 9 (0 to 19) of 24 and the mean DASH score was the same in both arms at 44 (0 to 92) out of 100.

### Table I. Details (mean, range) of the clinical outcome at the last follow-up in 41 patients

<table>
<thead>
<tr>
<th></th>
<th>Delta shoulder</th>
<th>Contralateral shoulder</th>
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<tbody>
<tr>
<td>Active anterior elevation (°)</td>
<td>97 (35 to 160)</td>
<td>140 (100 to 160)</td>
</tr>
<tr>
<td>Active abduction (°)</td>
<td>86 (35 to 150)</td>
<td>97 (90 to 160)</td>
</tr>
<tr>
<td>Active external rotation (°) (with the arm at the side)</td>
<td>8 (40 to 40)</td>
<td>30 (10 to 45)</td>
</tr>
<tr>
<td>Active external rotation (°) (in abduction)</td>
<td>30 (0 to 80)</td>
<td>71 (30 to 90)</td>
</tr>
<tr>
<td>Constant score for pain (points)</td>
<td>12.5 (5 to 15)</td>
<td>14.4 (9 to 15)</td>
</tr>
<tr>
<td>Constant score for activity</td>
<td>10.9 (4 to 20)</td>
<td>15.9 (10 to 20)</td>
</tr>
<tr>
<td>Constant score for mobility</td>
<td>17.6 (2 to 34)</td>
<td>38.8 (12 to 40)</td>
</tr>
<tr>
<td>Constant score for strength</td>
<td>3.6 (0 to 10)</td>
<td>7.5 (2 to 12)</td>
</tr>
<tr>
<td>Constant score (points)</td>
<td>44 (16 to 69)</td>
<td>69 (53 to 83)</td>
</tr>
<tr>
<td>Modified Constant score (%)</td>
<td>66 (25 to 97)</td>
<td>105 (80 to 130)</td>
</tr>
<tr>
<td>ASES² score (points)</td>
<td>9 (0 to 19)</td>
<td>21 (16 to 24)</td>
</tr>
<tr>
<td>DASH† score (points)</td>
<td>44 (0 to 92)</td>
<td>44 (0 to 92)</td>
</tr>
</tbody>
</table>

² ASES, American Shoulder and Elbow Surgeons
† DASH, Disabilities of the Arm, Shoulder and Hand
The clinical results were not influenced by the type of approach or the healing of the tuberosities. Patients older than 75 years had a lower Constant score (< 75 years of age, mean 72 (33 to 97); > 75 years of age, mean 63 (26 to 96)), but this was not significant (Kruskal-Wallis, p = 0.06). The mean active anterior elevation of 94˚ (35˚ to 130˚) was lower than in patients younger than 75 years in whom it was 104˚ (45˚ to 160˚). The mean external rotation was maintained to a satisfactory level whatever the age, being 33˚ (0˚ to 70˚) in patients younger than 75 years and 20˚ (0˚ to 80˚) in those over 75 years of age. The active external rotation was greater when the greater tuberosity had healed anatomically, but this was not significant (Kruskal-Wallis, p = 0.07). The active internal rotation was not influenced by the version of the humeral component, but other factors such as malposition of the tuberosity or nonunion may have affected this. The shoulder centre had a mean medialisation of 21 mm (0 to 35) compared with the contralateral side. It was a mean of 9 mm (0 to 17) below the centre of rotation of the healthy side. Patients with a low shoulder centre had better results, but this difference was not significant (Kruskal-Wallis, p = 0.09).

Discussion

The length of follow-up appeared to be sufficient to allow assessment of functional recovery. Indeed, the definitive functional results after shoulder arthroplasty were acquired at the end of the first year.15 The rate of loss of patients in our study was lower than that in other series dealing with fractures of the upper humerus.10,15-17

The main difficulty encountered with reverse arthroplasty was the fixation of the tuberosities in an anatomical position.5,6 This has been described as the main prognostic factor influencing the functional recovery after arthroplasty of the shoulder.18 In our study, anatomical reconstruction was achieved in only 17 patients (41.5%), available for radiological review but the effect on the Constant score appeared to be moderate. The external rotation score decreased slightly although this was not significant, but the other ranges of movement remained satisfactory.

The mean age of the patients was high compared with other series of post-traumatic shoulder replacement.4,15,17-19 This may have affected the clinical results because age has been shown significantly to decrease the mobility score.15,16

The mean anterior elevation of 104˚ in patients younger than 75 years was comparable with that reported in series of conventional arthroplasty in the same age category in acute trauma15,17,19 or its sequelae.20 In patients older than 75 years, the mean anterior elevation in our study decreased to 94˚, as was the case with conventional replacement of the humeral head in the series of Goldman et al,15 who reported a mean anterior elevation of 93˚ in patients older than 70 years. Wretenberg and Ekelund,16 in a series of patients aged more than 75 years, measured a mean active anterior elevation of 55˚, which was worse than that obtained in our study in the same age category.

Using the reverse arthroplasty in acute trauma, Cazeneuve and Cristofari10 obtained better anterior elevation, which in all cases was more than 120˚. Their 16 patients represented a heterogeneous population with a mean age of 75 years (55 to 90).

The other complications were similar to those of conventional arthroplasty. Neer and McIlveen21 noted transient neurological complications in 27% of a series of 44 four-part fractures treated by hemiarthroplasty. Boileau et al20 also found a low rate of post-operative dislocation. In our study, none of these complications caused major problems. We encountered no cases of infection.

Relief from pain was the most noted improvement, explaining the high rate of satisfaction in this group who often had a previous deficiency of the cuff and moderate functional needs. Massive deficiency of the cuff was observed in 28% of the patients, which was likely to be an underestimate according to epidemiological data.22

Notching of the scapula has also been reported in degenerative disease treated by the same implant7,9 and also after acute trauma.10 Further follow-up is required in order to draw definite conclusions, but it is likely to have less consequence than in younger and more active patients. Heterotopic calci-
fication was frequent, but the effect on the functional outcome appeared to be limited.\textsuperscript{15,19}

Observation of the cases with the longest follow-up suggests that reverse arthroplasty in elderly patients sustaining a complex fracture of the upper humerus is an interesting option, because, like conventional replacement of the head, it provides excellent relief from pain and may also offer better and easier functional recovery than conventional arthroplasty in patients over 75 years of age. In patients between 65 and 73 years of age, it may limit the consequences of a failed reconstruction of the tuberosities, probably because of the medialisation and inferior displacement of the centre of the shoulder, which improves the lever arm and the tension of the deltoïd muscle.

Supplementary Material

A table showing the clinical details of the patients at the last follow-up is available with the electronic version of this paper on our website at www.jbjs.org.uk

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References