Delta III reverse shoulder arthroplasty: Radiological outcome for acute complex fractures of the proximal humerus in elderly patients

J.-F. Cazeneuve*, D.J. Cristofari

Orthopaedics and Traumatology Department, Laon Central Hospital, 33, rue M.-Berthelot, 02001 Laon cedex, France

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KEYWORDS
Radiological outcome; Reverse shoulder prosthesis; Proximal humerus fracture

Summary
Purpose of the study: Acute complex proximal humerus fractures in the elderly population, treated by internal fixation or hemiarthroplasty, give well reported radiological results. We investigated the radiological outcome of the reverse arthroplasty concept in this indication.

Material and methods: From 1993 to 2007, 41 Delta III prostheses were implanted following 32 three-part and four-part displaced fractures, and in nine fracture/dislocations; three fractured patients were males and 38 females; mean age at fracture time was 75 years. The results were evaluated on AP and Lamy lateral shoulder views.

Results: Since nine of these patients were deceased and two had moved, 30 cases were available at review, with a mean follow-up of 6.5 years (range, 1–14). The radiographs showed two thick radiolucent lines on the glenoid component with one aseptic loosening of the base plate at 12 years. Based on the Nérot classification, 17 cases of inferior scapular notching were, in total, observed. The mean time to onset was 2 years for the seven grade 1 notches (41%), 4 years for the five grade 2 notches (30%), 5 years for the three grade 3 notches (17%) and 6 years for the two grade 4 notches (12%). Fourteen inferior spurs (stable after emergence) were reported with a mean time to onset of 2.5 years (range, 1–6 years). One joint ossification occurred at 6 months and was stable at the 6-year follow-up review. The humeral component results comprised four cases of medial (5, 6, 7 and 10 years) proximal bone loss and two cases of bone–cement interface deterioration (medial radiolucent lines at two-third of the stem height at the 5-year follow-up). In these six cases, a notch was present above this area. In addition, one case of humeral septic loosening is reported at 2-year follow-up.

Conclusion: For acute proximal humeral complex fractures in the elderly population, when refixation of the tuberosities on a classical orthopaedic devices appears compromised, the use of a Delta III reverse prosthesis is an attractive alternative; however, with a mean follow-up of 6.5 years, this prosthesis demonstrates unsatisfactory images in 70% of the cases. These flaws...
were noted on the glenoid component in 70% of the cases, appeared before 7 years in 86% and were progressive in 50% of the cases. However, only one revision was required for an aseptic loosening of the base plate at 12 years. New developments in designs and bearing surfaces and larger numbers analysis of long-term results will probably be needed to encourage extensive utilization of the reverse concept in this fracture indication.

**Level of Evidence**: Level IV. Therapeutic retrospective study.

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**Introduction**

In the physiologically old subject with osteoporosis who has undergone a proximal humerus fracture with complex displacement, the main obstacle is obtaining bone union of the tuberosities in the anatomical position. In cases of bone resorption, migration or non-union of these tuberosities, screwed plates, anterograde nailing, the Bilboquet implant and the cephalic implant showed a less desirable functional result with a risk of dependence [1,2]. The hemiarthroplasty has its place here because it functions only with the deltoid muscle. Reversal of the surfaces [3], stability when the center of rotation of the shoulder joint is medialized, as well as when the deltoid is put in pretension by lowering its insertion point [4,5] increase the lever arm of this muscle. The analysis of 627 cases of excentric scapulohumeral osteoarthritis, 210 of which were reviewed at more than 5 years, improved the knowledge on the clinical and radiographic progression of the reversed shoulder implant concept [6].

The objective of this retrospective study was to evaluate the radiographic results of the Delta III reversed shoulder arthroplasty in a context of geriatric injury with a follow-up of 1 to 14 years to prolong our earlier study [7] and to eventually reinforce Bufquin et al.’s [8] preliminary results.

**Material and methods**

From 1993 to 2007, 41 Delta III reverse arthroplasties (Depuy) were performed by a single operator for 32 acute complex three- or four-part fractures and nine complex fracture/dislocations classified according to Neer [9], in three men and 38 women, a mean age of 75 years (range, 58–92 years), with 19 on the right side.

The population study showed six patients with severe degenerative rotator cuff disease, three with type 1 or 2 diabetes, three with chronic complex Wernicke-Korsakoff syndrome, three cases of homelessness and three cases of morbid obesity. The fracture characteristics, the degree of osteoporosis, but above all the exact anatomy of the scapula neck in view of implanting the metaglene as optimally and with as little risk as possible, were assessed on plain x-rays and CT.

Surgery was performed in all cases under general anesthetic in the semi-seated position, via an anterolateral approach without osteotomy of the acromion, creating a trapeziodeltoid digastric flap. The long portion of the biceps was repaired using suture and then was resected at its insertion on the glenoid. A self-retaining retractor exposed the joint satisfactorily. The cap of the humeral head was extracted so that a size 36 or 42 sphere could be chosen and then was sent for pathological examination. Inferior anterior and posterior capsule excision allowed positioning the forked retractor under the glenoid overlapping the scapula, pushing down the humeral shaft and thus providing a perfect view of the glenoid. A cross was drawn on the glenoid using the electrocautery knife to position the pin guiding the drilling for the anchoring stud. Reaming was done manually, with no inclination, until bleeding subchondral bone was obtained. To facilitate this, we abraded the cartilage beforehand using the bone curette. The metaglene was presented and impacted with good primary stability each time. The four screws used for fixation were inserted in a convergent manner for the two middle screws, with good mechanical stability rarely obtained for the posterior screw.

We attempted to place the superior screw at the bottom of the coracoid process. The trajectory of the inferior screw was drilled at a slow rotation speed so that the bone contact could always be felt in the scapula with a slight inclination following the bisector of the angle formed by the two teeth of the forked retractor. After impaction and screwing, the implant had to be perfectly stable so that the remains of the tuberosities could be resected to prevent impingement, a factor contributing to prosthesis instability. The sphere chosen beforehand was screwed in place using the guide pin while always remaining strictly in its axis so that the prosthesis would be presented in perfect alignment with the metaglene. Unscrewing a quarter turn helped initiate the screwing procedure favorably. Six of the spheres were size 42. Humeral preparation was not problematic because the shaft was directly accessible in the operative field by moving the arm in adduction/flexion. The trial implants allowed us to adjust the tension and retroversion usually to 10°. Once reduction was obtained, ideal tension was achieved by sliding the pinky fingertip between the sphere and the trial polyethylene insert in a patient presenting optimal curarization. This required using the height of the cemented stem and/or an elevator. Once these parameters had been determined, implant stability as well as possible impingement with the lateral angle of the scapula and the acromion had to be verified. The final implant was cemented after placing a resorbable diaphyseal plug. All the stems were cemented except one. An elevator was used in four cases and a retenitive polyethylene was used in three cases.

The metaphyseal implant’s wing provided fixation of the long portion of the biceps. The trapeziodeltoid digastric flap was closed using points separated by resorbable suture crosses after placing a deep aspirating drain kept in place for 2 days.
Patients were fitted with a sling to immobilize the elbow next to the body for 21 days. Active postoperative rehabilitation, not always possible in patients who were homeless or morbidly obese, was initiated on the 3rd day after surgery. Rehabilitation caused little pain and was rapidly effective in all patients.

Postoperative evaluation was based on AP and Lamy lateral x-rays taken every month during the first 4 months, then every 3 months during the 1st year and finally every year.

Results

Because of nine deaths and two patients lost to follow-up, only 30 medical files were reviewed, with follow-up ranging from 1 to 14 years. Of these 30 patients, four complications were noted: two algodystrophic type I regional pain syndromes resolving in 6 and 9 months with medical treatment, one early postoperative *Acinetobacter* infection at 3 weeks requiring revision preserving the arthroplasty and one anterior dislocation at 1 month of follow-up because of a 10° anteverision of the humeral implant, which required the implant to be reoriented.

Two 2-mm-thick complete radiolucent lines on the glenoid appeared on the x-rays of two men who had size 42 spheres at 4 and 8 years of follow-up. The latter also developed a type II notch at 11 years, then loosening of the metaglene with breakage of the inferior screw 12 years after the surgery. The patient was reoperated and we found no foreign object granuloma and good bone stock, allowing impaction of a standard metaglene with good primary stability. The polyethylene extracted showed no macroscopic signs of wear. Three years after the second intervention, the radiological workup showed no particular anomalies.

According to the Valenti et al. [10] criteria, 17 cases of scapular notching were observed. The mean follow-up was 2 years for the seven cases of grade 1 notching, 4 years for the five cases of grade 2 notching, 5 years for the three cases of grade 3 notching and 6 years for the two cases of grade 4 notching. The longer the follow-up period was, the larger the notches were. Eleven cases of notching were isolated and six associated with medial humerus images, i.e., two bone—cement lines over two-third of the implant stem height appeared at 5 years of follow-up and four resorptions of the upper third of the humerus were observed at 5, 6, 7 and 10 years. Of the 11 cases of isolated notching, four were stable and seven progressed.

Fourteen non-progressive inferior pole osteophytes were observed at a mean 2.5 years (range, 1–6 years).

Two isolated proximal lateral humeral lyses were noted at 4 and 10 years. These were not post-traumatic bone defects, but late bone resorption.

One case of stem loosening was reported at 2 years of follow-up as well as a case of joint ossification appearing at 6 months and stable at 6 years, along with a grade 2 notch that had become grade 3 at the last follow-up.

In all, 18 patients out of 30 followed up had unsatisfactory images showing fixation screw breakage, progressive notching, radiolucent lines on the glenoid and humerus, proximal humeral lyases and loosening of the humeral stem (Table 1).

### Discussion

The classical techniques to treat recent complex proximal humerus fractures in the elderly subject have reached their limits, with disappointing functional results because it is extremely difficult if not impossible to obtain bone consolidation of the tuberosities in the anatomical position [1,2]. Reversed shoulder arthroplasty provides short functional recuperation while preserving autonomy and does not require active cooperation on the part of the patient [7]. This clinical result is obtained at the cost of unsatisfactory features on the follow-up x-rays.

The main problem consists in the notch forming in the neck of the scapula [11] and more rarely loosening of the metaglene [12]. The cause of this notching is debated. For Clavert et al. [13], it may result from micromovements of the lower screw caused by insufficient mechanical stability, whereas for Werner et al. [14], it may be impingement between the lateral border of the scapula and the medial border of the humeral cup, increased when the arm hangs alongside the body and during adduction movements. Its meaning has not been established. For Valenti et al. [10], grade 4 signifies loosening, a hypothesis that was not retained by Werner et al. [14]. For Sirveaux et al. [15], loosening can only be confirmed if there is a radiolucent border around the metaglene’s fixation screws. For Levigne et al. [16], although notching is frequent, it is not considered a complication. It seems to increase in size over time and is found with radiolucent lines on the glenoid and humerus. Preventing its onset did not involve implantation of the metaglene with slight inclination in the vertical plane, use of a humeral elevator, use of a large-diameter sphere, but rather lowering the implantation of the metaglene flush with the lower border of the glenoid without inclining it in the frontal plane [17,18] or a new prosthesis design [19]. This means fixation problems when there is insufficient bone stock and poor primary stability at impaction of the metaglene [20]. For Boileau et al. [21], the radiographic anomalies may be more frequent on the humeral side, with the possibility of deterioration over time [22]. The similarities between the anomalies

<table>
<thead>
<tr>
<th>Grade and association</th>
<th>Number of patients: 18 (series n = 30)</th>
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<tbody>
<tr>
<td>Isolated and progressive notch</td>
<td>7</td>
</tr>
<tr>
<td>Notch associated with 1-mm-thick radiolucent line on the humerus</td>
<td>2</td>
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<tr>
<td>Notch associated with medial humeral lysis</td>
<td>4</td>
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<tr>
<td>Notch associated with a lucent line on the glenoid and metaglene fixation screw breakage</td>
<td>1</td>
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<tr>
<td>Isolated 2-mm-thick lucent line on the glenoid</td>
<td>1</td>
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<tr>
<td>Isolated 2-mm-thick lucent line on the humerus (stem loosening)</td>
<td>1</td>
</tr>
<tr>
<td>Isolated lateral humeral lysis</td>
<td>2</td>
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</tbody>
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at the humerus and the glenoid could be explained by polyethylene debris responsible for resorption granuloma, as suggested by the analysis of the explanted prostheses [23,24,25].

In acute fractures, Bufquin et al. [8] studied a series of 43 cases with a short follow-up period and found 90% periprosthetic ossification, 25% notching and seemed satisfied with the reverse shoulder concept despite displacement of tuberosities in 53% of the cases. Our series of 30 surviving cases did not include tuberosity reinsertion. The presence of mechanically useable tuberosities is a contraindication to reverse shoulder arthroplasty. With follow-up ranging from 1 to 14 years, we report a 3.3% aseptic loosening rate of the metaglene, identical to the rate reported by Valenti et al. [12]. Two types of notches seem to exist: first the notches associated with humeral images showing medial proximal bone lysis and/or bone—cement lucent lines, which we believe to be biological in origin and related to polyethylene wear and then isolated notching brought on mechanically because of impingement between the humeral epiphysis and the lateral border of the scapula, resulting from the medialization of the center of rotation. The cases of notching that we describe herein were progressive in 82% of the cases. Is there a passage from one grade to another? This series demonstrates inferior polar osteophytes in 46% of the patients, probably related to incomplete release of the triceps tendon. They appear early and remain stable. Our results in acute fractures therefore contradict the results reported by Simovitch et al. [17] for the use of reverse arthroplasty for eccentric scapulo-humeral osteoarthritis. They found stable notches and progressive polar osteophytes, whereas we found the contrary.

Conclusion

For complex fractures of the proximal humerus in the physiologically aged subject with major osteoporosis, followed up for a mean 6.5 years, the use of reverse shoulder arthroplasty, in cases where refixation of the tuberosities is impossible, shows unsatisfactory radiographic images in 60% of the patients, including progressive notching of the scapula in 82% of the cases associated with proximal humeral bone resorption in 35% of the cases. Although we had only a single case requiring revision at 12 years for mechanical failure, we nevertheless believe that these observations need to be further investigated with an even longer follow-up period to validate the use of reverse shoulder arthroplasty for acute fractures.

References


