Orthopaedics & Traumatology: Surgery & Research (2009) **95**, 48—55

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ORIGINAL ARTICLE

Three or four parts complex proximal humerus fractures: Hemiarthroplasty versus reverse prosthesis: A comparative study of 40 cases

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Accepted: 30 September 2008

KEYWORDS
Shoulder;
Fracture;
Reverse prosthesis;
Hemiarthroplasty

Summary
Introduction. — As population ages, the number of fractures of the proximal humerus in still-active patients is increasing. For three- or four-parts displaced fractures in which replacement is indicated, hemiarthroplasty with tuberosity reattachment remains the reference treatment; this technique, however, can lead to catastrophic functional results due to nonunion or tuberosity migration. The present study compared short-term functional results for reverse prosthesis and hemiarthroplasty in complex fractures of the proximal humerus.
Hypothesis. — In selected complex proximal humerus fractures, the reverse shoulder arthroplasties is a superior treatment option.
Patients and methods. — Forty patients were treated by shoulder replacement for three- or four-part displaced fractures of the proximal humerus between 1996 and 2004. Twenty-one had a hemiarthroplasty and 19 were treated by reverse prosthesis. All patients of both groups were reviewed retrospectively by an independent observer. Joint amplitude and Constant score were measured; quality of life was assessed by DASH score. Standard X-ray assessment comprised frontal imaging in three rotation positions and Lamy's incidence.
Results. — In the hemiarthroplasty group, 17 patients, mean age 74 years (range: 49—95), were followed up for a mean 16.5 months (6—55). In the reverse prosthesis group, 16 patients, mean age 74 years (range: 58—84), were followed up for a mean 12.4 months (6—18). The reverse prosthesis group showed better results in terms of abduction (mean = 91° versus 60°), anterior elevation (mean = 97.5° versus 53.5°) and Constant score (mean = 53 versus 39). Rotation was better in the hemiarthroplasty group (external rotation, 13.5° versus 9°; internal rotation, 54.6° versus 31°). DASH scores were identical in both groups. X-ray showed three abnormal tuberosity fixations in the hemiarthroplasty group and 15 glenoid notches in the reverse arthroplasty group.

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1877-0568/$ - see front matter
doi:10.1016/j.otsr.2008.09.002

Discussion. — In three- or four-part displaced proximal humerus fracture, arthroplasty does not ensure recovery of pretrauma shoulder function. Management is therefore to be decided in terms of outcome predictability and rapid recovery of daily comfort for elderly patients. Hemiarthroplasty can provide good functional results, but depends on tuberosity union quality and this often necessitates a prolonged immobilization. Reverse prostheses provide reliable, rapid and predictable results in terms of abduction, anterior elevation and pain relief, but impaired rotation; this impacts quality of life and long-term implant durability (glenoid notching). Reverse prostheses should thus prove advantageous in the treatment of complex fractures of the proximal humerus if these two drawbacks can be resolved and at present seem indicated on condition that the patient is no younger than 70 years of age.
Level of evidence: level IV; therapeutic study.

Introduction

As the population ages, an increase in the incidence of fractures of the proximal humerus can be observed [1] in still-active patients.

When there is little or no displacement, orthopedic management gives good functional results in most of these fractures. In complex (3 or 4 part) displacement fractures, however, indications for surgery are controversial. Presently, two options are open.

The first, supported by many authors [2—4], is osteosynthesis. The disadvantage, however, is that bone quality is often poor in elderly patients and there is a non-negligible risk of osteonecrosis of the humeral head [5,6].

The second, introduced by Neer in the 1950s, is glenohumeral joint replacement [7], for which the reference technique is anatomic hemiarthroplasty. This, however, inevitably involves tuberosity reinsertion, which frequently entails complications with a catastrophic impact on the evolution of shoulder function [8].

Certain teams [9—12] have implanted reverse (Grammont type) shoulder prostheses, avoiding the tuberosities and, thus, the rotator cuff.

For eight years, we treated such complex fractures initially by hemiarthroplasty using the Aequalis® (TORNIER) modular humeral prosthesis and more recently using the Delta III® (DEPUY) reverse prosthesis.

The present study retrospectively compared short-term clinical and X-ray results of emergency treatment of three- or four-part displacement fractures of the proximal humerus (Fig. 1) by standard Aequalis® anatomic prosthesis and Delta III® reverse prosthesis.

Patients and methods

Whole series

From 1996 to 2004, 40 patients underwent shoulder replacement for three- or four-part displacement fracture of the proximal humerus. Two types of prosthesis were implanted: between 1996 and 2001, anatomic prostheses, and between 2002 and 2004, reverse prostheses.

Assessment

Patients of both groups were reviewed retrospectively by an independent assessor.

All patients underwent clinical examination, comprising measurement of active joint amplitude in the operated shoulder and Constant scoring [13].

Subjective assessment was made using the DASH functional score [14].

Qualitative and quantitative variables were compared by nonparametric Mann-Whitney test.

All patients underwent standard X-ray examination, comprising a frontal shoulder view under the three rotations (neutral, external and internal) and a Lamy's profile view. For the reverse prostheses, glenoid notching was assessed by Nérot's classification [15].

Characteristics of the two groups

Hemiarthroplasty group

Twenty-one patients were operated on by a deltopectoral approach, with the patient semi-seated on the shoulder table. Standard cemented-stem Aequalis® (TORNIER) prostheses were implanted (Fig. 2). Tuberosities were reinserted using Boileau's technique [16].

Initial X-ray examination found 13 four-part and eight three-part fractures on the Neer classification [17], eight

Figure 1 Four-part (Neer) fracture [17].

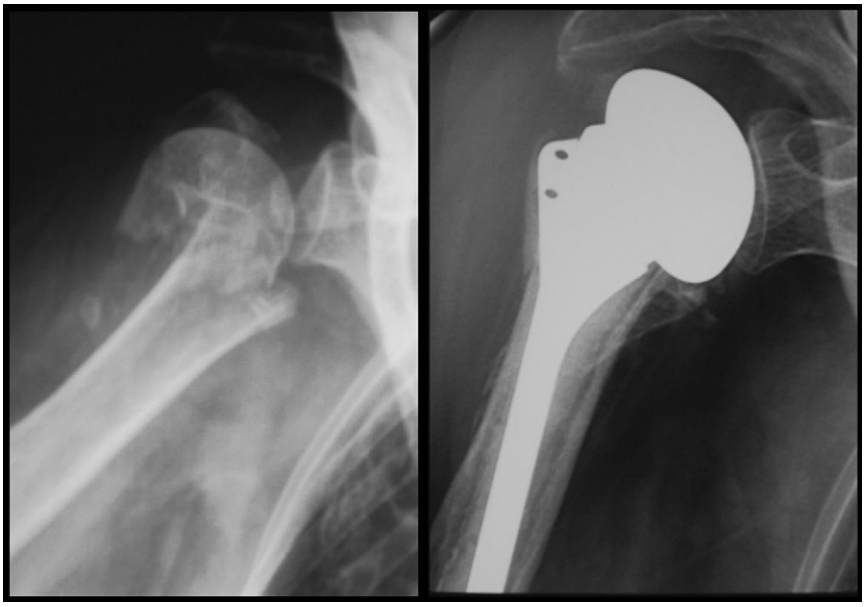

Figure 2 Standard Aequalis® anatomic hemiarthroplasty in four-part (Neer) fracture [17].

type-2, 11 type-3 and two type-4 cephalotuberosity fractures on the Duparc classification [18] and 21 C-fractures on the AO classification [19].

Ten cases involved the dominant side.

There were two associated regressive axillary palsies.

The shoulder was immobilized in an internal shoulder rotation cast for 45 days.

Postoperative rehabilitation followed Neer's program as described by Boileau et al. [20], with immediate passive rehabilitation and active rehabilitation initiated around day 45.

Reverse prosthesis group

Nineteen patients were operated on by a superolateral approach, with the patient semi-seated on the shoulder table. Cemented-stem Delta III® (DEPUY) reverse prostheses were implanted (Fig. 3). The anterior deltoid was detached subperiosteally from the anterior edge of the acromion and reinserted by bone suture at the end of surgery. One patient underwent tuberosity reinsertion around the fin of the prosthesis; otherwise, tuberosities and cuff were removed.

Initial X-ray examination found 15 four-part and four three-part fractures on the Neer classification [17], three type-2, 13 type-3 and three type-4 cephalotuberosity fractures on the Duparc classification [18] and 19 C-fractures on the AO classification [19].

Seven cases involved the dominant side.

There was one associated contralateral shoulder posterior dislocation fracture and one case of ipsilateral axillary palsy not detected on preoperative examination.

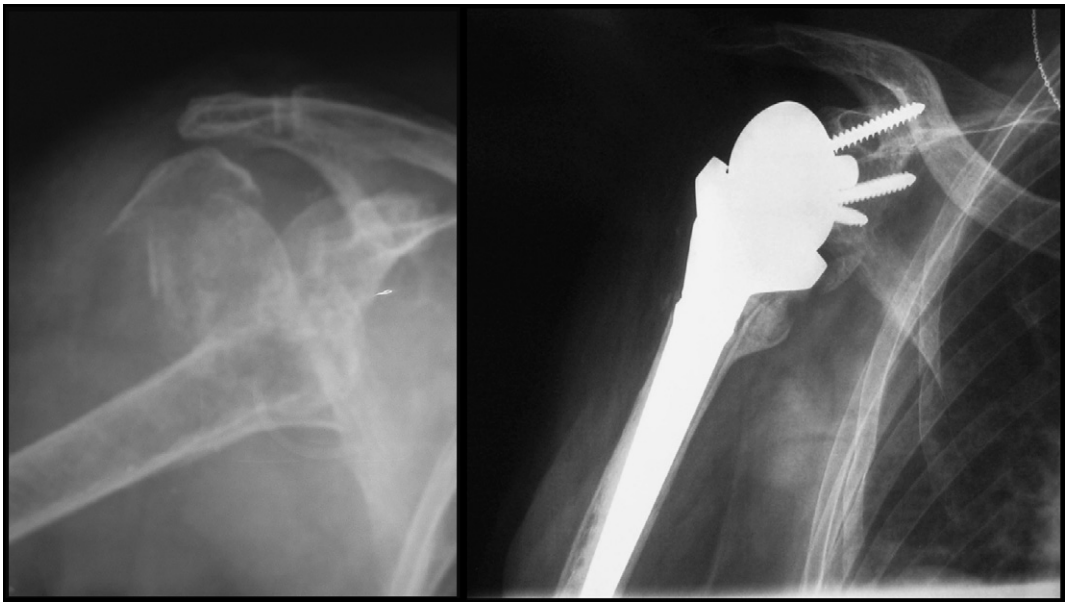

Figure 3 Delta III® reversed prosthesis in four-part (Neer) fracture [17].

Table 1 General epidemiological characteristics of the two groups.

	Reverse prosthesis	Anatomic prosthesis
Number of cases	16	17
Age (years)	74 (58—84)	74 (49—95)
Sex-ratio	Female: 0.81	Female: 0.88
Dominant side involvement	7	10
Initiation of active rehabilitation	D 10 (2—60)	D 45
FU	12.4 months (4—18)	16.5 months (6—55)

Table 2 Mean active joint amplitude in the two groups.

	Reverse prosthesis	Anatomic prosthesis
Abduction	91° (10—150)	60° (30—90)
Anterior elevation	97.5° (20—150)	53.5° (30—100)
External rotation with the elbow at the side	9° (0—80)	13.5° (0—30)
Internal rotation in abduction	31° (0—60)	54.6° (0—60)

Passive and active rehabilitation were initiated as of postoperative week 1.

Results

Epidemiological data

In the hemiarthroplasty group

In the hemiarthroplasty group, four patients were lost to follow-up. The group thus finally comprised 17 patients: 15 female, two male; mean age, 74 years (49—95); mean follow-up, 16.5 months (6—55). The 49-year-old outlier had a history of chronic alcoholism with evolved cirrhosis of the liver.

Complications comprised:

- one case of transitory axillary palsy;
- two cases of reflex sympathetic dystrophy, which responded to medical treatment;
- one superficial infection, treated by antibiotics.

One patient suffered a humeral shaft fracture under the prosthesis stem, following a fall on postoperative day 15; the fracture consolidated under 45 days' orthopedic treatment.

Fifteen patients underwent rehabilitation in a specialized center and two at home.

In the reverse prosthesis group

In the reverse prosthesis group, three patients were lost to follow-up. The group thus finally comprised 16 patients: 13 female, three male; mean age, 74 years (58—84); mean follow-up, 12.4 months (6—18).

Complications comprised:

- one deep infection, leading to prosthesis removal 17 months postsurgery;
- one superficial infection, treated by antibiotics;
- and one case of reflex sympathetic dystrophy, which responded to medical treatment.

Passive rehabilitation was initiated on average at postoperative day 6 (2—30) and active rehabilitation at day 10 (2—60). Immobilization used an internal shoulder rotation cast in seven cases and a simple sling in nine, for a mean 20 days (5—60).

Six patients underwent rehabilitation in a specialized center and the others with a physiotherapist or at home.

The anatomic group thus comprised 17 patients and the reverse prosthesis group 16; Table 1 presents their general epidemiological characteristics.

Clinical results

Mean joint amplitudes

Mean joint amplitudes are shown in Table 2.

Abduction was significantly better in the reverse prosthesis group ($p < 0.001$), as was anterior elevation ($p < 0.001$).

External rotation with elbow at the side (ER-1) was significantly better in the hemiarthroplasty group ($p = 0.001$).

Internal rotation at 90° abduction (IR-2) showed a non-significant tendency to be better in the hemiarthroplasty group ($p = 0.055$).

Mean Constant and DASH scores

Mean Constant and DASH scores are shown in Table 3.

The Constant score was significantly better in the reverse prosthesis group ($p = 0.005$).

Table 3 Mean Constant and DASH scores in the two groups.

	Reverse prosthesis	Anatomic prosthesis
Constant total	53 (34—76)	39 (19—61)
Constant breakdown		
Pain	13.1/15 (5—15)	9.2/15 (0—15)
Mobility	21/40 (10—30)	12.9/40 (4—24)
Activity	13.2/20 (3—20)	8.6/20 (4—12)
Strength	4.8/25 (2—9)	8.3/25 (2—23)
DASH	37.4 (11.7—65)	41.2 (18.3—60.7)

The two groups did not significantly differ in DASH score.

X-ray results

In the hemiarthroplasty group

In the hemiarthroplasty group, abnormal tuberosity positioning was found in three patients: two migrations in patients suffering immediate postoperative spatiotemporal disorientation and one malunion due to a defect in initial tuberosity positioning. There were also five cases of ectopic ossification. Tuberosity consolidation was judged to be good in the other 14 patients.

In the reverse prosthesis group

In the reverse prosthesis group, there were:

- 15 cases of glenoid notching: six grade 1, six grade 2 and three grade 3, on Nérot's classification;
- five cases of humeral radiolucency, without signs of loosening.

Discussion

Management of complex proximal humerus fractures in elderly patients by screwed plate osteosynthesis [3,21] or anterograde nailing [2,22] provides good initial reduction, but with a risk of secondary loosening in severely osteoporotic bone [23] or of humerus head necrosis [5,24], leading to catastrophic functional impairment and reintervention — in what is a fragile population. The reference treatment, in elderly patients, is therefore hemiarthroplasty; however, it is clear that clinical results get poorer with increasing age (above 70 years) [25,26]. These poor results may be attributed to poor physiological or mental status, major osteoporosis, associated cuff tearing, tuberosity comminution or a technical defect, such as implant mispositioning or defective tuberosity reduction or fixation. Reverse prosthesis management, relying exclusively on deltoid muscle function, ought to resolve the tuberosity issues underlying the functional catastrophes sometimes encountered.

In a matched population (age, gender, follow-up time, and fracture type), the present study sought to highlight any advantage of reversed prostheses over hemiarthroplasty. The limitations of the study obviously lie in its retrospective nature and the fact that the two series were consecutive as such. Comparison was hindered by the small size of the two populations, and follow-up time was too short for proper implant assessment. The aim, however, was not so much to assess results over time as to discern any advantage of reverse prostheses in terms of speed of functional recovery and predictability of clinical results, in a fragile elderly population for whom the recovery of autonomy can be said to be the prime consideration.

The active mobility results were in favor of reverse prostheses in terms of abduction and anterior elevation. There was a rather large incidence of tuberosity mispositioning in the hemiarthroplasty group (Fig. 4), deteriorating the functional results. The reason for this probably lies in the patients' age, as demonstrated by Kralinger et al. [25] and Wretenberg and Ekelund [26] (abduction and anterior elevation of respectively 50° and 55° in a population with a mean age of 82 years), but also in an immediate postoperative state of confusion and agitation. Hemiarthroplasty results thus appear to be variable, as also reported by Sirveaux et al. [9] in a comparative study in which hemiarthroplasty results in abduction and anterior elevation were distributed evenly from 10 to 180° compared to reversed prosthesis results which clustered around 110°. Inverse prostheses thus provided a much more reliable and predictable range of useful mobility, at least in terms of abduction and anterior elevation. This is in line with our present findings: there was just one functional catastrophe (Constant score less than 40, abduction 10° and anterior elevation 20°) in the reversed prosthesis group, in a patient presenting with associated axillary palsy; 13 of the 16 patients, on the other hand, showed greater than 90° anterior elevation and 11 showed greater than 90° abduction. In contrast, seven hemiarthroplasty patients had Constant scores less than 40. We consider the reliability of results with reverse prostheses to be a decisive factor in the choice of traumatology treatment in elderly patients.

Figure 4 Tuberosity migration in hemiarthroplasty for four-part (Neer) fracture [17].

On the other hand, the results obtained with reverse prostheses in case of fracture are not as good as in case of excentric omarthritis or massive rotator cuff tearing [15,27]. Our patients' shoulder mobility, however, resulted entirely from the action of the deltoid, as tuberosities had not been reinserted (except in one patient).

The second important point is whether there is residual postoperative pain. This was estimated by the Constant scores and again favored reverse prostheses (mean = 13.1/15 versus 9.2/15 with hemiarthroplasty).

Management by reverse prosthesis thus adds benefit as compared to hemiarthroplasty, at least in the short term, with respect to abduction and anterior elevation mobility and to pain.

The last point in favor of reverse prostheses concerns how quickly autonomy is restored in elderly patients. In the hemiarthroplasty group, active rehabilitation did not begin before the 45th postoperative day, when the protective immobilization was removed. Moreover, only 11.7% of these patients were able to undertake rehabilitation at home, all the others going to a specialized center. In the reverse prosthesis group, on the other hand, active rehabilitation began on day 10, with most patients wearing a simple sling. Thus, 62% of them could undertake rehabilitation at home, with clinical results comparable to those obtained via a specialized center. This seems to us to be a fundamental point in traumatology in elderly patients, where the aim is to restore autonomy as quickly as possible, minimizing time away from the patient's usual everyday life situation.

However, reverse prostheses also showed limitations in this indication.

The main problem encountered was an almost systematic postoperative lack of active (notably, external) rotation (Fig. 5), despite compliance with rehabilitation: 12 of the 16 patients showed 0° external rotation with the elbow at the side. Crucially, this impairment affected daily life: despite the reverse prosthesis group's better Constant scores, there was no significant difference in DASH score between the two groups. Thus, while the clinical results are better overall with a reverse prosthesis, the patient will not necessarily experience benefit in daily life.

We believe that the solution is probably to reinsert the tuberosities, which we did in only one case — with a spectacularly good result at six months: 150° abduction and anterior elevation, and 80° external and 60° internal rotation. Obviously, no conclusion can be drawn from just one case, but reinserting the tuberosities (especially, the subscapular and the posterior cuff) is probably a strategy to be looked into. Boileau et al. [28] stressed the importance of preoperative

Figure 5 Loss of external rotation after implantation of reversed prosthesis.

Figure 6 Nérot grade-3 glenoid notch [15].

teres minor status for postoperative recovery of external rotation. Sirveaux et al. [27] also demonstrated the importance of teres minor function for external rotation results and Constant score: in case of teres minor rupture, the latter was no more than 58, close to our present findings. Rehabilitation after such reinsertion should not be delayed to allow consolidation, but rather be immediate so that autonomy can be recovered as quickly as possible. Should the reinsertion give way, the situation will just be that first obtained with reverse prostheses, with function ensured exclusively by the deltoid muscle.

The second problem encountered was the incidence of glenoid notching (Fig. 6) due to mechanical conflict between the humeral polyethylene and the pillar of the scapula. This is a problem that has long been recognized [15,27,29], but which seems to have set in very early in the present series, where just one patient did not show notching, even on so short a follow-up. This was not the case for Cazeneuve and Cristofari [10], who reported first notches appearing around the second postoperative year. All the notches in the present series were asymptomatic, but threaten trouble to come, even if Cazeneuve and Cristofari [10] reported notches to be well tolerated clinically at a mean 86 months' follow-up. Favard et al. [29], in contrast, reported lower Constant scores in case of notches extending to the inferior screw.

The solution probably lies in redesigning the implant, to have a less medialized center of rotation or implantation lower in the glenosphere, as proposed by Nyffeler et al. [30]. Results, however, await long-term confirmation.

Conclusion

A patient presenting with a three- or four-part displacement fracture of the proximal humerus is probably not going to recover his or her pretrauma shoulder, especially when elderly. The choice is therefore of the treatment option,

which most reliably and predictably restores a range of useful mobility, improving the patient's everyday comfort as rapidly as possible with increasing age. Anatomic hemiarthroplasty gives good, but variable functional results and at the cost of often-prolonged immobilization. A reverse prosthesis gives reliable, predictable and rapid results in terms of abduction, anterior elevation and pain, but with issues relating to rotation and long-term outcome (glenoid notches). Reverse prostheses would thus seem to provide benefit in the surgical management of complex three- or four-part displacement fracture of the proximal humerus, once these two problems can be resolved. Meanwhile, however, the present results are not such as to validate its indication in patients under the age of 70. Our current attitude is therefore to opt for reverse prosthesis in patients over the age of 75. In patients below this age, physiological age and functional requirements are analyzed and discussed with the patient so as to select the optimal implant, with a preference for hemiarthroplasty in patients whose physiological status is good.

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