Musculoskelet Surg (2009) 93:S35–S39
DOI 10.1007/s12306-009-0006-6

Reverse shoulder prosthesis as revision surgery after fractures of the proximal humerus, treated initially by internal fixation or hemiarthroplasty

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Published online: 16 March 2009

Abstract Complex (3–4 fragments) fractures of the proximal humerus often have a bad outcome, whatever treatment is performed. When revision surgery is required, reverse shoulder prosthesis can improve function and reduce pain in these patients. We analysed whether the choice of the first treatment (hemiarthroplasty vs. reduction and fixation) can influence the outcome of revision surgery. Our data demonstrate that results are not significantly dependent on the choice of the first implant, even though there is a tendency for patients with previous hemiarthroplasty to have a worse outcome.

Keywords Shoulder · Revision · Arthroplasty · Reverse · Fracture

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Introduction

Complex (3–4 fragments) and displaced proximal humeral fractures are considered a real challenge for the surgeon. When approaching this kind of complex fracture, the choice is between joint replacement by use of a prosthesis [1] or reduction and fixation (by use of plates and screws or K-wires) [2]. The surgical technique is demanding and the outcomes are not so good in both cases.

Early and late complications such as malunion, avascular necrosis, arthritis or non-union are frequent after reduction and fixation by plates or K-wires [3, 4].

On the other hand, primary arthroplasty is not a guarantee of better successful outcomes, due to the large number of complications leading to stiffness, instability and pain [5]. In both cases, a revision surgery procedure is sometimes required to improve function of the shoulder and to reduce pain [6–8].

In elderly patients with irreparable rotator cuff tears and tuberosity resorption, reverse shoulder prosthesis is the best choice in revision surgery, and results have been previously discussed in the literature [9, 10]. This type of design completely changes the mechanics of the shoulder and enables the artificial joint to function even when the rotator cuff is absent.

De Wilde et al. were the first to describe reverse shoulder prosthesis as revision surgery after failure of shoulder replacement in the rotator cuff-deficient shoulder, showing good improvement of function [11].

In this paper we report the results of two groups of patients that underwent revision surgery with implant of reverse shoulder prosthesis. In both groups the patients sustained a complex (3–4 fragments) humeral fracture. The first group was treated initially by reduction and fixation and the second by hemiarthroplasty. The aim of this

study is to understand if there are any differences, in terms of outcome, between the two groups.

Materials and methods

Between January 2003 and June 2006 22 patients, with severe pain and loss of function and stiffness after primary surgical treatment for complex fracture of the proximal humerus, were treated with single-stage revision to a shoulder reverse prosthesis. The prosthesis implanted was the Aequalis (Tornier, Montbonnot, France) in all cases.

Fifteen of these patients were followed up for a minimum of 2 years and were included in the study.

In order to be included in the present study, a patient had to have had a previous hemiarthroplasty or a fixation (with plates or K-wires) for the treatment of a complex 3–4-fragment proximal humeral fracture, followed by the development of severe pain and loss of function of the shoulder. All patients had had a failure of all attempts at non-operative measures, including medical management, physiotherapy and cortisone injections.

Inclusion criteria for patients with previous hemiarthroplasty were:

a) on X-ray and ultrasound exam:
   - tuberosity resorption,
   - radiolucencies around the stem of the prosthesis,
   - glenoid and acromial arthritis, and
   - irreparable rotator cuff deficiency (total lesion more than 2 cm, detected on ultrasonography);
b) on clinical examination
   - pain in everyday activities and
   - extremely limited ROM (pseudoparalytic shoulder).

Inclusion criteria in patients with previous reduction and fixation with plates or K-wires were:

a) on X-ray and on ultrasound exam
   - avascular necrosis,
   - malunion with malposition of the tuberosities,
   - nonunion,
   - irreparable rotator cuff deficiency (total lesion more than 2 cm, detected on ultrasonography);
b) on clinical examination
   - pain in everyday activities and
   - extremely limited ROM (pseudoparalytic shoulder).

Patients with previous infection were excluded. Patients were also excluded if revision could be achieved by other means (reparable tuberosities and rotator cuff or isolated glenoid arthritis) and if they were younger than 65 years old.

The mean age of the patients at the time of revision was 68.4 (range 65–80). There were 2 males and 13 females. Nine patients were treated in their dominant arm and six patients in their non-dominant arm.

All patients had primary fracture after low-energy trauma. The initial fracture was classified according to Neer's criteria: in all cases a type three or four Neer fracture was detected (6 type three, 9 type four).

Of the 15 patients, eight had been treated with a cemented hemiarthroplasty and seven with reduction and fixation (five by K-wires, two by plate and screws).

The duration of symptoms before shoulder revision arthroplasty averaged 20.8 months (range 5–56).

Operative technique

All the procedures were performed by the senior author (G.P.). Under general anaesthesia with a supplementary interscalenic block, the patient was placed in standard beach-chair position. Operating time was recorded. A delto-pectoral approach was used, without detachment of the anterior deltoid and pectoralis major. Dissection of the tissue was done carefully, because of thick scar formation. The status of rotator cuff tendons was checked: an important and irreparable cuff tear involving the supraspinatus and the infraspinatus was detected in all cases. The subscapularis, if intact, was dissected from the lesser tuberosity and the axillary nerve was protected. The shoulder capsule was released circumferentially from the humeral neck, then the status of the proximal humerus was checked: we did not record any case of severe bone loss that needed to be treated with allograft. The prosthesis or the plate and screws were detected.

Then, in case of hemiarthroplasty the arm was placed at 0° of adduction; after establishing a circumferential exposure of the proximal portion and removing all soft tissue and bone ingrowth, a punch was placed on the edge on the medial neck of the prosthesis, allowing cautious hammer blows to be delivered to the prosthesis. When available, the appropriate extractor was used and, when needed, it was also hammered to complete the extraction of the prosthesis. The entire cement mantle was carefully removed.

In case of the presence of plate and screws the deltoid muscle was carefully retracted and, after removing all the scar tissue, the screws and the plate were removed. In case of previous K-wire fixation, K-wires were removed at the time of revision surgery.

In all cases, heterotopic ossification and osteophytes were resected, then, when needed, a neck cut was made in 30° of retroversion. This was followed by reaming of the proximal humeral metaphysis. Next the glenoid was exposed with use of a Fukuda retractor on the humerus and a Hohmann retractor on the glenoid neck. Glenoid

Table 1 Comparison between hemiarthroplasty and fixation group

	Hemiarthroplasty group	Fixation group
Pre-op Constant score	15.29	7.29
Post-op Constant score	41	41.57
Constant improvement	27.63	34.29
Pre-op forward flexion grades	44	30
Post-op forward flexion grades	94	106
Pre-op vas	8	9.4
Post-op vas	4.6	2.2
Pre-op DASH	74.8	82.4
Post-op DASH	55.4	49.4
Excellent results	3	1
Satisfactory results	2	5
Unsatisfactory results	3	1

arthritis was always detected intraoperatively.

After finding the centre of the glenoid, we proceeded to glenoid reaming and implanting of the baseplate, fixed by four screws (15–52 mm). A 36-mm glenosphere was chosen in all cases and it was fitted onto the baseplate by means of a Morse taper.

Then, after a trial to check stability of the implant, the stem was cemented into the proximal humerus: a standard polyethylene cup was used in all cases and final reduction was performed.

The subscapularis, if present, was repaired through drill-holes into the native proximal part of the humerus, followed by a routine closure with use of number-2 polyester sutures.

Surgical time averaged 121.66 min (range 100–160).

Postoperative rehabilitation

Patients followed our rehabilitation programme: use of a sling in neutral position for six weeks, allowing passive range-of-motion exercises and elbow mobilisation from the first day after surgery under the supervision of a physical therapist. Active mobilisation with definitive removal of the sling started at 21 days after surgery, initially in water. Resistance exercises for muscle reinforcement usually started at 2 months after surgery.

Preoperative and postoperative radiological assessment

All patients were evaluated preoperatively and at 2-year follow-up, with AP view (in internal and external rotation), Y lateral and axillary plain radiographs (Figs. 1 and 2).

In preoperative X-rays possible reasons of failure of previous surgery were investigated: glenoid arthritis, the condition of the tuberosities, evidence of instability, evidence of humeral loosening of the prosthesis or mobilisation of the screws of the plate.

Tuberosities were investigated for malposition (with acromial impingement), malunion, nonunion or resorption. According to previous anatomic study [12], the greater tuberosity was considered correctly positioned when it was visible, and its summit was between 5 and 10 mm below

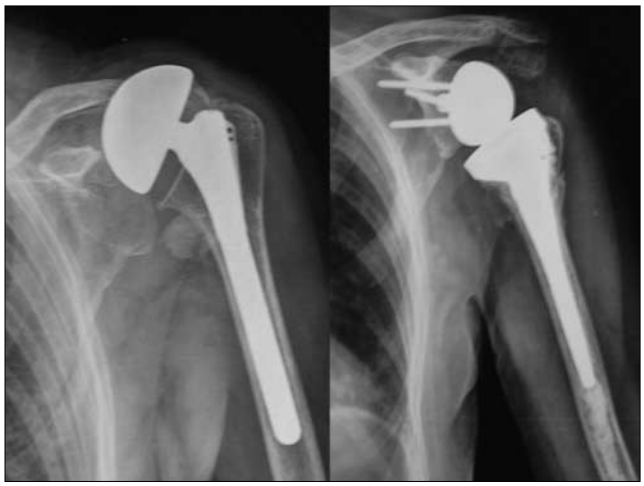

Fig. 1 Reverse prosthesis after hemiarthroplasty

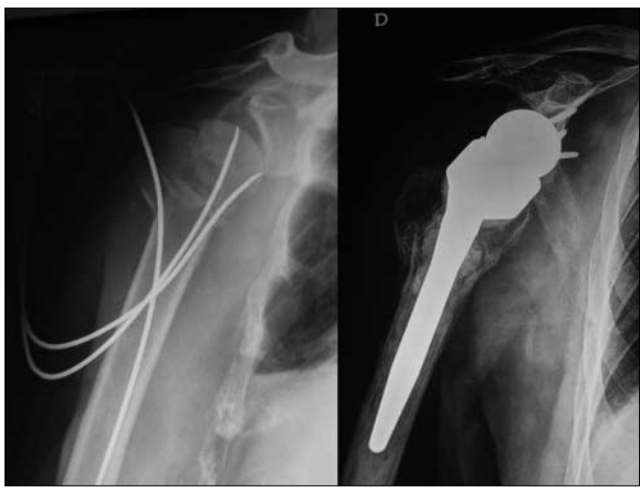

Fig. 2 Reverse prosthesis after reduction and fixation by K-wires

the summit of the head, in AP standard view. Instability was assessed, especially to detect an upward migration of the proximal humerus. Humeral radiolucencies revealed possible humeral loosening of the hemiarthroplasty.

We found greater tuberosity malpositioning in 7 cases, upward migration of the humerus in 9 cases and humeral radiolucencies in 3 cases. Glenoid arthritis was always detected.

In postoperative X-rays reverse shoulder prosthesis was investigated for possible causes of failure: notching of the inferior scapula by the humeral component, dislocation of the prosthesis, loosening of the components, presence of osteophytes and heterotopic ossification [13, 14].

Preoperative and postoperative clinical assessment

Patients were evaluated preoperatively and at 2-year follow-up after surgery, both using the criteria of Constant and Murley [15] and with a visual analogue scale (VAS) to evaluate pain.

The DASH (disability of the arm, shoulder and hand) questionnaire was used at the same time to assess the consequences of revision surgery on daily activities of the patients [16].

Finally, Neer's criteria were used for further evaluation of the results at latest follow-up. The criteria for considering a result as excellent were as follows: little or no pain, normal use of the arm, anterior elevation greater than 130°. Satisfactory results included those cases in which there was an important improvement of pain, and the arm could be elevated in the range of 90°–135°. Unsatisfactory results comprised those cases not fulfilling the above criteria.

Statistical analysis

Constant score, VAS and DASH value were compared preoperatively and at 2 years of follow-up after surgery.

The hemiarthroplasty group and fixation group were compared regarding improvement of Constant score value and of forward flexion, and decrease of pain value and DASH value.

The two independent samples Mann–Whitney test was used to compare the two groups. The level of significance was set at $p < 0.05$.

Results

Regarding post-operative X-ray, examination showed no sign of loosening in either group, two cases of inferior notching in each group and no cases of heterotopic ossification.

Regarding clinical follow-up, the Constant score improved from a preoperative average of 15.3 (range 2–45) to a mean of 41 (range 4–75) after revision in the hemiarthroplasty group and from an average of 7.3 (range 5–15) to a mean of 41.6 (range 5–91) in the fixation group.

Forward flexion improved from a mean of 44° (range 10°–105°) to 94° (range 30°–160°) in the hemiarthroplasty group, and from 30° (range 20°–60°) to 106° (range 30°–135°) in the fixation group.

Pain VAS value decreased from 8 (range 5–10) to 4.6 (range 0–5) in the hemiarthroplasty group, and from 9.4 (range 8–10) to 2.2 (range 1–6) in the fixation group.

DASH value decreased from an average of 74.8 (range 31.6–97.5) to 55.4 (range 25–79.3) in the hemiarthroplasty group, and from a mean of 82.4 (range 67.5–97.5) to 49.4 (range 15–82) in the fixation group.

We found no significant differences regarding Constant score improvement, forward flexion improvement, pain decrease or DASH value decrease comparing patients operated initially by internal fixation and by hemiarthroplasty ($p > 0.05$).

Mean Constant score improvement was 27.6 in the hemiarthroplasty group and 34.3 in the fixation group.

Finally we reported 1 excellent (14.3%), 5 satisfactory (71.4%) and 1 unsatisfactory (14.3%) results in the group of patients treated previously by reduction and fixation.

We reported 3 excellent (37.5%), 2 satisfactory (25%) and 3 unsatisfactory (37.5%) results in the group of patients treated previously by hemiarthroplasty.

The fixation group and hemiarthroplasty group did not significantly differ regarding surgical time ($p > 0.05$).

Complications

One radial nerve palsy occurred after revision of a hemiarthroplasty. Electromyography was performed to check the level of the injury and, two months after the operation, the patient underwent radial nerve surgical exploration and neurolysis by a neurosurgeon. Two cases of postoperative haematoma were detected but they did not need to be treated operatively. No surgical orthopaedic revision occurred after reverse arthroplasty.

Discussion

This study demonstrates that the functional results of revision arthroplasty with reverse shoulder prosthesis, in patients that sustained complex fracture of proximal

humerus, are altogether good, although less satisfactory than those of primary reverse prosthesis implant [17].

This study demonstrates that the results of reverse shoulder arthroplasty in revision surgery after primary fracture do not depend on the choice of the first treatment. Even though we reported better results in revision surgery after humeral fixation than after hemiarthroplasty, the difference is not statistically significant.

If we refer to everyday life, all patients had a good and important improvement in their daily activities after revision shoulder arthroplasty. This was the first study, to our knowledge, to demonstrate and quantify patients' satisfaction after revision surgery with reverse shoulder prosthesis.

These good results, from our data, are independent of the choice of the first treatment.

Levy et al. have shown that reverse shoulder prosthesis offers a salvage-type solution to the problem of failed hemiarthroplasty [10]. Our study supports this idea, and shows that reverse shoulder prosthesis is an important tool in revision surgery.

Boileau et al. have demonstrated that hemiarthroplasty, in sequelae of the proximal humerus fractures, has unpredictable results and that these results are directly associated with tuberosity fixation [18].

The use of reverse shoulder prosthesis bypasses this problem by reducing the role of the tuberosities. We support the idea that, in the presence of an irreparable rotator cuff tear and gleno-humeral post-traumatic arthritis in elderly patients (>65 years), reverse shoulder prosthesis is a useful tool to solve the problems of function and pain of the shoulder. Although the procedure is really demanding and the outcome is not comparable with shoulder reverse prosthesis in patients suffering for gleno-humeral arthritis, we recommend the use of this device as a solution in shoulder revision arthroplasty.

Conflict of interest We confirm that no grants or money have been received by the authors for this work and that it was carried out according to Helsinki Principles.

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