



Mid-term outcome of reverse shoulder prostheses in complex proximal humeral fractures

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The functional outcome of hemiarthroplasty in displaced proximal humeral 3- and 4-part fractures or fracture dislocations in elderly patients is frequently unpredictable and depends on the position of the prosthesis and tuberosity fixation. Reverse shoulder arthroplasty represents an alternative in elderly patients.

The purpose of this study was to report the results of a retrospective series of 30 reverse shoulder prostheses in trauma indications. We also compared the results of a less medialized reverse shoulder prosthesis (Arrow®) with those reported for the traditional (Delta III®) reverse prosthesis.

Twenty seven cases were available for analysis. The mean follow-up was 22.5 months. The mean absolute Constant score was 54.9, the score for pain was 13.5, for activities 14, for strength 4.59. The mean active anterior elevation was 112°, abduction 97°, external rotation with the arm at the side : 12.7°, in abduction : 55°. Radiographs revealed no loosening, no glenoid notching.

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Reverse shoulder prosthesis may be a good alternative for displaced three- and four-part proximal humeral fractures in selected patients. The functional results are more predictable than with hemiarthroplasty in elderly patients.

Keywords : reverse shoulder prosthesis ; complex proximal humeral fracture ; tuberosity healing.

INTRODUCTION

Most non-displaced or minimally displaced proximal humeral fractures are treated conservatively with good functional outcome (6,23,14). For displaced proximal humeral 3 or 4 fragment fractures or fracture dislocations in elderly patients,

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hemiarthroplasty or reverse total prosthesis represent the main options. Hemiarthroplasty, often considered as the “gold standard”, remains controversial because results are frequently unpredictable (1). The functional outcome depends on the position of the prosthesis and the possibility to correctly reduce and maintain the tuberosity fixation. Malposition of the tuberosities may occur in up to 50%, tuberosity migration amounts to 39% and non-union is seen in 17% (1).

The current concept, which represents an alternative for the treatment of proximal humeral fractures in elderly patients, is reverse total shoulder arthroplasty. Several studies reported satisfactory results with a mean Constant-Murley score of up to 60 (4), active abduction and anterior elevation up to 120° (4,15,2), external rotation 25°-30° (15,2) and internal rotation up to L4 (15). The results are more predictable than with hemiarthroplasty. Internal and external rotation depend upon reinsertion or reconstruction of the tuberosities (2,9). The major problem of the reverse shoulder prosthesis is scapular notching, which has been noted in up to 25% of cases in mid-term follow-up (2).

The purpose of this study was to analyze the results of a retrospective series of 30 reverse shoulder prostheses in trauma indications. We also compared clinical and radiological results of a less medialized reverse shoulder prosthesis (Arrow®, FH Orthopaedics, Mulhouse, France) with those of the traditional reverse Delta III® prosthesis (DePuy, St Priest, France) in terms of stability, glenoid notching and rotation range.

PATIENTS AND METHODS

Thirty patients were operated on between April 2004 and February 2008 by three senior surgeons (KE, PhV, DK). There were 2 male and 28 female patients, 18 left and 12 right shoulders, 15 on the dominant side and 15 on the non-dominant side. The average delay between injury and surgery was 10 days. All patients were over 66 years of age with a mean age of 78 years ; 50% were over eighty. Co-morbidities included diabetes in 3 cases, hypertension in 8 cases, breast cancer with lymphoedema in 1 case, previous aortal prosthetic surgery in one case, rheumatoid arthritis in 3 cases, cardiac rhythm disorder in 3, coronary heart disease in 3 cases and



Fig. 1. — Preoperative radiographs of a fracture in a 70-year-old patient, smoker. Comminuted 4-fragment fracture with impaction in valgus.

respiratory insufficiency and asthma in one case each. Associated injuries resulting from the same trauma were contralateral distal humerus fracture in one case and distal radius fracture in another case.

Preoperative investigation of the fracture systematically included anteroposterior and lateral radiographs (Fig. 1). There were 22 type 4 (Neer's classification) fractures, 6 type 3 and 2 type 2 fractures ; 4 of these were fracture-dislocations.

Thirteen patients had a CT scan to evaluate the fracture fragment morphology ; the muscular status and fatty degeneration could thus be determined. Seven of them had stage 2, two stage 3 and one stage 1 supraspinatus degeneration (11).

Osteoarthritis was present in 5 cases : one case grade 1 (Hamada) (13), three grade 2 and one grade 4. The grading was confirmed by intraoperative findings. Contralateral shoulder pathology involved 4 shoulders : there were 3 Hamada grade 2 arthropathies and one shoulder was affected by rheumatoid arthritis.

Prior to trauma, 6 patients were dependent on homehelpers and 2 patients needed full time assistance.

The Arrow® reverse shoulder prosthesis (FH Orthopaedics, Mulhouse), which is less medialized than the traditional Delta III® prosthesis (DePuy, France) was implanted for these patients. Indications for reverse shoulder prosthesis were a displaced three- or four- part fracture and fracture dislocation of the proximal humerus in elderly patients with poor bone quality in whom tuberosity migration, resorption or malunion was considered highly probable.

Surgical procedure

All the patients were operated under general anaesthesia with an interscalenic block (post operative analgesia) in a beach chair position. In 29 patients a supero-lateral approach was performed and one patient had a delto-pectoral approach (the fracture extended distally down the humeral shaft). The coraco-acromial ligament was systematically cut and acromioplasty was performed in 15 shoulders to obtain a better exposure of the glenoid. We always resected the tendon of supraspinatus and we removed the humeral head. The lesser tuberosity with the subscapularis muscle was retracted anteriorly with two sutures at the bone tendon junction ; the greater tuberosity with the infraspinatus was retracted posteriorly with two sutures at the tendon bone junction. The teres minor posteriorly was mostly not involved except with a fracture line extending to the diaphysis ; in eleven cases the teres minor was reinserted with two mattress sutures. Tenodesis of the long biceps tendon was performed in five cases and a tenotomy in the others. Exploration of the joint showed a fracture to the anterior (3 cases) or inferior part (one case) of the glenoid and degenerative changes of the glenoid cartilage in 9 cases. In seven patients a cortico-cancellous bone graft was necessary to fill the scapular bone defect and to allow an excellent press fit fixation for the convex glenoid metalback. The size of the base plate was 44 with the exception of two cases (two men) where a 46 was needed to obtain an optimal contact with the concave glenoid preparation. The base plate was implanted vertically or with a slight inferior tilt. The glenosphere was positioned on the base-plate and not embedded as usually done with the Delta®. This results in a lateralization of the centre of rotation of 8.5 mm from the glenoid bone level (15). Two non-locking divergent screws size 5.5 mm directed superiorly to the coracoid foot and inferiorly to the pillar of the scapula ensured base plate stability. The majority of the glenospheres were size 36 ; 4 were size 39.

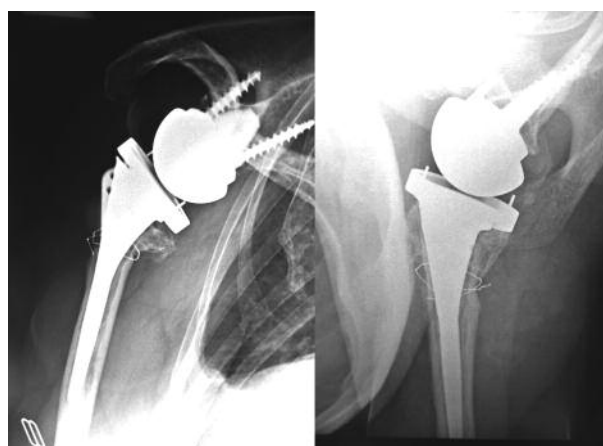


Fig. 2. — Postoperative radiographs showing tuberosity fixation and healing.

The trial humeral component was inserted into the diaphysis with 10° to 30° of retroversion (average 21.88°), to align the humerus with the glenosphere. The difficulty was to determine the adequate height and tension of the deltoid. In most cases the medial part of the plate of the humeral stem was positioned on the “calcar” and this ensured prosthesis stability. It was not necessary to perform a bone cut and we used only two spacers of 5 mm in this series. In the Arrow® prosthesis, the medial part of the polyethylene cup is cut out to prevent impingement with the pillar of the scapula in rotation. The definitive component should be implanted with a small clearance between cup and glenosphere to facilitate deltoid action. The polyethylene cup of the Arrow® design is deeper than in the Delta III. We avoid a tight contact between the glenosphere and the humeral component, particularly in the presence of a weak deltoid, to enhance active anterior elevation recovery. In nine patients a cancellous bone graft from the humeral head was used to fill the humeral metaphyseal bone defect ; it was fixed over the metaphysis implant to accelerate tuberosity healing. The humeral component was always cemented in the diaphysis. The tuberosities were reinserted (Fig. 2). The greater tuberosity was at least partly reinserted in 16 cases ; the lesser tuberosity was reinserted in 12 cases. Good implant stability was achieved intraoperatively in all cases. The anterior deltoid was reinserted to the acromion with non-absorbable transosseous sutures. A subcutaneous suction drain was left in place for 48 hours. A simple arm sling for three weeks in neutral rotation was recommended but early passive



Fig. 3. —

motion was begun immediately after surgery. Active rotation, particularly medial rotation was contra indicated for 6 weeks to avoid tuberosity migration. After an average hospital stay of 6 days, patients continued physiotherapy in a rehabilitation centre (20 patients) or at home (10 patients) if their autonomy was quickly restored. Physical therapy was continued during three to seven months.

Patient assessment

The modified Constant- Murley function pain score related to gender and age was used for clinical evaluation at the latest follow-up (7). Subjective assessment was made using the degree of satisfaction of the patient (very satisfied ; satisfied, acceptable, disappointed).

Radiological evaluation included an anteroposterior view under three positions in rotation (neutral, external and internal) and Lamy's lateral view. We looked for signs of glenoid component loosening (radiolucent lines around the base plate, hardware failure, change in base plate position) and for the presence of scapular notching. We used Nerot's classification (21) with five grades according to the size of the defect seen on the radiograph.

Statistical analysis

Student's t-test was used for statistical analysis when two groups had to be compared. When comparison involved more than two groups, a variance analysis was applied. The level of significance (p) was set at 0.05.

RESULTS

Three patients were lost to follow-up, so that the series included 27 cases for analysis. The mean follow-up was 22.5 months (range : 12 to 39). None of the patients had moderate or severe pain. The mean Constant-Murley score for pain was 13.5 (10 to 15). Activity of daily living had an average score of 14 (8 to 20). The mean active anterior elevation was 112° ($85-150^{\circ}$), and the mean active abduction 97° (80 to 160°) ; the Constant-Murley score for anterior elevation and abduction was 6.48 and 5.86 respectively. All the patients had more than 85° of anterior elevation. The mean active external rotation with the arm at the side was 12.7° (0 to 40°) and 55° (20 to 90°) in 90° of abduction. Constant-Murley scores for external and internal rotation were respectively 6 (4 to 8) and 4.62 (2 to 10). The mean Constant-Murley score for power was 4.6 (1 to 12). The mean absolute Constant-Murley score was 54.9 pts (44 to 71pts) and the modified Constant-Murley score (age, gender) was 79.8% (63 to 111%).

One patient developed a paresis of the deltoid two months postoperatively. Radiologically the tuberosity had migrated. He had recovered a satisfactory function after one year : 100° of active anterior elevation, 20° of external rotation with the arm at the side and an absolute Constant-Murley score of 54 points.

Subjectively 17 patients were very satisfied ; the remaining 10 were satisfied.

Radiographic examination at the latest follow-up did not show any component loosening. There were no glenoid notches with the less medialized reverse prosthesis (Arrow®, FH Orthopaedics, France) and there was only one case of progressing radiolucent lines at the glenoid component. There were 2 cases of tuberosity resorption and 14 cases of ectopic ossifications. There were no instances of infection or dislocation.

Further analysing our results we found that the patients who did not develop ectopic ossifications had a statistically significantly better internal rotation (5.25 compared to 3.85).

Patients who had their greater tuberosity reinserted had a significantly better external rotation with the arm at the side : 16.7° versus 8.6°.

Patients who had their minor tuberosity reinserted also had a significantly better external rotation with the arm at the side : 17.9° versus 9.1°. Other differences in ROM in relationship with ossification

and tuberosity reinsertion were not statistically significant.

Table I compares our results to other reported results of reverse shoulder prostheses in fracture indications.

DISCUSSION

Treatment of three or four-part fractures or fracture-dislocations of the proximal humerus ranges from conservative treatment to prosthetic replacement. Conservative treatment in these displaced fractures frequently results in mal-union with limited range of motion but with a relatively pain free shoulder (8).

Open reduction and fixation is usually proposed to younger patients with a good quality of the bone because of a risk of avascular necrosis or non-union of the tuberosities.

Hemiarthroplasty is currently the best way of treatment for these complex fractures in elderly patients : Mighell *et al* (18) reported a forward

Table I. — Comparison of our series and other series of fractures treated with reverse shoulder prostheses

	This series	Bufquin <i>et al</i>	Caseneuve & Cristofari
Follow-up	22.5 months	22 months	86 months
Number of patients	27	40	16
Age (years)	78	78	75.5
Ossifications present	52%	90%	*
Notching	0	25%	69% (after 4.7 years on average)
Dislocations	0	1	1
Abduction	97°(80 to 160°)	86° (35-150°)	6.5 Constant Murley
Active anterior elevation	112° (85-150°)	97° (35-160°)	6.5 Constant Murley
External rotation at the side	12.7°	8° (-40 – +40°)	1.1 Constant Murley (2.4 when tuberosities reconstructed)
External rotation in abduction	55.7°	30° (0-80°)	*
Constant-Murley score for internal rotation	4.71	*	2.4 (4.6 when tuberosities reconstructed)
Constant-Murley score for pain	13.5	12.5	14.1
Constant-Murley score for activity	14	10.9	13.3
Constant-Murley score for mobility	23.07	17.6	16.5
Constant-Murley score for strength	4.59	3.6	16.1
Constant-Murley absolute score	54.8	44	60
Modified Constant-Murley score	80.27	66	*

elevation of 128° (range, 45°-180°), external rotation of 43° (range, 0°-80°), and internal rotation to L2 (range, T11 to greater trochanter); Gronhagen *et al* obtained a Constant and Murley score for ROM of 18 (0-40) (12); S.Fallatah *et al* (9) reported forward elevation of 87° (range 15°-160°), active abduction of 63° (range 10°-120°), active external rotation of 22° (range -15° to 120°); active internal rotation was between L1 and L3. So clinical results appear to be variable with a significant rate of complications such as migration or non-union of the tuberosities (1). Newer designs of the humeral stem and new methods of fixation of the tuberosities increased the rate of healing in good position of the tuberosities and have improved clinical results (22). A recent review of the literature by Kontakis *et al* (17) found tuberosity complications in 11.15%, affecting shoulder function and the mean active anterior elevation was 105.7° but with a range of distribution from 10° to 180° and the mean external rotation is 30.4°. Hemiarthroplasty, they concluded, could provide a pain free shoulder but mobility was non-predictable. Elderly patients with poor bone quality, a limited possibility to cooperate, living in institutions, dependant from caregivers or homehelpers run a higher risk of these problems and have a poorer functional result.

The first series of reversed total shoulder prostheses (2,4,10,20) in carefully selected patients showed that they may give good functional outcomes. This operation may be technically demanding, but it has good short and midterm results. It is indicated in those elderly patients who have a poor bone quality, have a high risk of tuberosity migration or non-union and have deficient rotator cuff. Axillary nerve paralysis- a rare complication in patients having sustained proximal humeral fractures- is a contraindication for the reversed total shoulder prosthesis.

Sirveaux *et al* (20) in a comparative study of hemiarthroplasty and reverse prosthesis for displaced fractures showed that active anterior elevation ranged from 10° to 180° in hemiarthroplasty and clustered around 110° in reverse total arthroplasty. Gallinet *et al* (10) confirmed a better range of motion with a reverse prosthesis. In our series all the patients are more than 85° of anterior elevation. In elderly patients with comminuted tuberosities

and osteopenic bone, the capability to predict the minimal functional outcome with a good reliability represents a decisive factor in the choice of the best treatment.

The reported global Constant-Murley functional score obtained in complex fractures with reverse prostheses is similar (54.8 in our study and 44 to 68 in others) (4,15,2) to the score obtained with hemiarthroplasties (56 to 64) (17,19). The mean ROM is also comparable, as the mean active anterior elevation in our study was 112° and it was 97° to 122° in other studies on reverse total shoulder prosthesis for fractures (2,4,15) compared to 105.7° for hemiarthroplasties (17); the mean active abduction was 97° in our study (112°-120° in other studies) (4,15) and 92.4° in hemiarthroplasties. The mean active external rotation in our study was 12.7° with the elbow at the side and 55.7° in 90° abduction, as compared to a maximum of 25° (15) or 30° (2) in previous studies.

Gallinet *et al* (10) in a retrospective comparative study concluded that the patients who had a reverse total prosthesis had better anterior elevation, better abduction but worse external and internal rotation on short follow-up. They also had a better overall Constant-Murley score, better score for mobility, activity and pain, but not for strength.

The major complication specific to the reverse total shoulder prosthesis is scapular notching. This has been reported in 5% to 53% (2,5,15). Since we did not find notching in our group of patients, we tend to conclude that inferior scapular notching may be related with implant design.

Cazeneuve *et al* (3) reported 4 dislocations in 35 reverse prostheses implanted for fracture. In three cases the cause was a remaining tubercle which was responsible for a cam effect with a superior dislocation; in one case it was a malposition of the humeral stem with excessive anteversion. The authors attributed the dislocation of a reverse prosthesis to improper tension on the deltoid, as a result of the medialisation of the rotation center. In our series, with this new prosthetic design we did not encounter dislocation or notching. Moving the centre of rotation 8.5 mm away from the glenoid bone creates a lateralisation of the humerus and increases tension of the deltoid. Furthermore, the

polyethylene cup is deeper than in the Delta III and the medial side of the humeral polyethylene insert is contoured to avoid medial impingement with the neck of the scapula and glenoid notching.

The supraspinatus tendon is frequently torn or fibrotic and not functional in elderly patients. Moreover the supraspinatus is not crucial for abduction in reverse shoulder arthroplasty which depends on the deltoid. Resection of the supraspinatus can therefore be recommended to create some space and to avoid a reverse prosthesis being too tight.

The present study had several limitations. The size of this series is too small to ascertain significant differences in terms of external and medial rotation with respect to the traditional Delta prosthesis. The minimum duration of follow-up of twelve months is relatively short to eliminate glenoid or humeral loosening at mid or long term follow-up.

CONCLUSION

Reverse shoulder prosthesis may be a good alternative for displaced three-and four-part proximal humeral fractures in selected patients. The functional results are more predictable and more reliable than for hemiarthroplasty in elderly patients with a narrow range of distribution. Nevertheless indications for reverse shoulder prosthesis in fracture treatment should be limited. Poor bone quality, a deficient rotator cuff, comminuted tuberosities with a high risk of non-union, malunion or resorption represent poor prognostic factors for hemiarthroplasty in terms of functional results. A more lateralized center of rotation in a reverse shoulder prosthesis seems to address the issue of glenoid notching which is a factor influencing the survival rate of the prosthesis. Reinsertion and fixation of the tuberosities improves external rotation and is preferable to a large resection of the tuberosities. Longer follow-up in traumatic indications is needed to confirm these good early results.

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