The reversed Delta shoulder prosthesis in reconstruction of the proximal humerus after tumour resection

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The authors present two series of six and seven patients respectively, with a tumour of the proximal humerus, who were treated at two different institutions with a Delta type inverted shoulder prosthesis (DePuy International Ltd) after a Malawer type Ia or Ib resection.

The rationale of using an inverted shoulder prosthesis is the aim to improve the functional outcome in rotator cuff deficient shoulders. This type of prosthesis medialises and lowers the centre of rotation, lengthens the lever arm of the deltoid muscle and improves its function.

At one institution the resected part of the humerus was re-implanted after extracorporeal irradiation. It was fixed intramedullarly by cementation of the humeral prosthetic component to facilitate restoration of humeral height. This graft allowed reinsertion of muscles (deltoid, pectoralis, biceps) thus improving power generation postoperatively. The largest glenosphere, size 42, was routinely used to reconstruct the glenoid ; this theoretically improves the functional outcome (increased external rotation) and stability.

At the other institution no graft augmentation was used except in one patient. The height of the humeral prosthetic component was assessed after resection of the tumour by measurement of the resected part. The prosthetic stem was fitted in the remaining part of the humeral diaphysis, in three cases by cementation and in three cases by press-fit (hydroxyapatite coating). Muscle balance was appreciated intra-operatively. Stability of the prosthesis was directly related to the level of resection.

Both techniques resulted in a minimum active abduction of 60°, reaching 90° or more in most patients. When compared to other results in the literature, this is a major functional improvement. The mean adjusted postoperative Constant score was 72.5% (range : 30-90%), and the mean MSTS score was 75.8% (range 36.7-96.7%).

INTRODUCTION

Limb salvage after proximal humeral resection is still a challenge. We present our method for reconstruction of the proximal humerus and the shoulder joint by an inverted shoulder prosthesis (DePuy International Ltd) after tumour resection. Oncological eradication and optimal functional result are difficult to combine. The functional outcome in shoulder reconstruction after tumour resection with an anatomical prosthesis depends directly on the integrity of the rotator cuff.

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Functional results are poor after resection of the rotator cuff. As we previously obtained good functional results when replacing rotator cuff deficient shoulders by an inverted prosthesis, we decided to use this prosthesis in tumour reconstruction. We discuss our preliminary results and the factors influencing the outcome.

PATIENTS AND METHODS

Thirteen patients aged between 26 and 68 years (mean : 48 yrs 9 mos), with tumoral invasion of the proximal humerus were treated at two different institutions between 1990 and 2000. All but two recurrent giant cell tumours were malignant, seven were primary malignant bone tumours. Preoperatively the extent, grade and nature of the tumour were carefully established by laboratory tests, echography, Tc-bone scanning, CT-scanning, dynamic MRI, and by a properly performed biopsy. A multidisciplinary approach decided on further oncological treatment and the need for chemotherapy and/or radiotherapy. All patients underwent resection of the proximal humerus, with preservation of the deltoid muscle. In nine patients the rotator cuff was resected for oncological reasons. All resections were wide. The shoulder joint was reconstructed using the inverted Delta shoulder prosthesis at both institutions. Full postoperative oncological screening was done at preset time intervals.

At the first institution (Gent University Hospital, Belgium) the resected part of the humerus was irradiated extra-corporeally with 300 Gy, and replaced after the bulk of the lesion had been removed (11). Joint reconstruction with an autograft led to collapse of the humeral head and was abandoned to the benefit of the inverted prosthesis. The largest glenosphere 42 was routinely used as glenoid component, and fixed with 4 screws. Intramedullary fixation of the prosthetic stem was achieved through cementation. Progressive mobilisation of the shoulder joint was allowed immediately after the operation.

If desinsertion of the deltoid muscle was necessary, reinsertion onto the irradiated specimen was performed by transosseous sutures. Reinsertion of other muscles such as biceps and pectoralis was also possible. An abduction splint was applied postoperatively for 8 weeks (patients 1-7 in table I).

At the second institution (CHU Dijon, France) the height of the humerus was restored by the stem of the humeral prosthesis, which was fixed intra-medullarly by either cementation or press-fit (three cases each) in the remaining distal part of the humerus. Bone grafts were used in only one patient. Three glenospheres size 36 and three size 42 were used ; they were fixed with screws (patients 8-13 in table I).

Follow-up ranged from 5 months to 10 years and 8 months (mean 3 years) for all patients. Surviving patients had a mean follow-up of 5 years, ranging from 1 year and 3 months to 10 years and 8 months.

RESULTS

In addition to the clinical evaluation by the Constant-Murley and the MSTS scores, all patients were also evaluated radiographically and oncologically.

No local recurrence was seen. However, all but one patient with metastatic disease died on the short term because of progression of the primary tumour.

Radiographically graft resorption was seen in one autograft and in one allograft, without clinical problems. In two cases a thin non-progressive line of bone resorption was seen on the glenoidal side, without any clinical consequences. Because of the large dimensions of the humeral epiphyseal component and because of the extent of the soft tissue resection, impingement between the medial rim of the polyethylene and the inferior border of the scapula was noted in four cases (notching), also without any consequences. Temporary dislocation or subluxation was noted in four patients, which was solved by splinting for 1 to 6 weeks. At the second institution, instability was directly related to the level of resection.

The mean functional Constant-Murley score was 72.5%, ranging from 30 to 90%. The Musculoskeletal Tumour Society (MSTS) score as proposed by Enneking averaged 75.8%, ranging from 36.7 to 96.7%. Patients with a history of dislocation performed worse. Even patients with generalised tumour disease had a significant improvement in comfort and function, increasing their quality of life. Active shoulder abduction and elevation ranged from 80 ° to 150 °, with a mean of 105 ° (fig 1). In two patients active external rotation was noted (fig 2). Several patients could not be scored

Table I

Pat	Age	Sex	Tumour	Stage	#	RC	Height	FU	C pre	C post	MSTS	Rec	Meta	Status	Complications
1	49	M	Giant cell		–	+	10 cm	4 y 3 m	Nd	81.1%	29/30	–	–	NED	
2	65	M	HG Chondrosarcoma	IIIB	+	–	16 cm	5 m	Nd	70%	Nd	–	+	DOD	Dislocation: 6 w abd splint
3	44	F	Meta Renal Cell Ca	IIIB	+	+	10 cm	7 m	Nd	85%	Nd	–	+	DOD	
4	41	F	Synoviosarcoma	IIIB	–	–	10 cm	7 m	Nd	77.5%	Nd	–	+	DOD	
5	54	M	Plasmocytoma	IB	–	–	12 cm	3 y 6 m	Nd	53%	24/30	–	–	NED	Dislocation: 6 w abd splint
6	43	M	Giant cell		–	–	12 cm	3 y 3 m	Nd	86%	29/30	–	–	NED	
7	32	M	Osteosarcoma	IIB	–	–	10 cm	1 y 3 m	100%	90%	29/30	–	–	NED	Accidental finding
8	49	F	Meta Thyroid Ca	IIIB	–	–	9 cm	5 y	25%	82%	23/30	–	–	NED	
9	58	M	Meta Renal Cell Ca	IIIB	+	+	15 cm	6 m	Nd	Nd	Nd	–	+	DOD	Dislocation: 1 w abd splint
10	28	F	Chondrosarcoma	IB	–	+	9 cm	6 y	55%	72%	25/30	–	–	NED	Amyotrophy deltoid muscle
11	50	M	Meta Lung Ca	IIIB	+	+	12 cm	5 m	Nd	Nd	Nd	–	+	DOD	
12	45	M	Chondrosarcoma	IIB	+	–	15 cm	10 y 8 m	< 5%	30%	11/30	–	–	NED	Dislocation : 1 w abd splint, arthrodesis after infection.
13	68	F	Multiple Myeloma	IIIA	–	–	7 cm	4 y	10%	71%	14/30	–	–	DOD	Infection after 3 y IV line

Abbreviations table I :

Fract : pathological fracture proximal humerus
RC : Rotator cuff retained (+) or resected (–)
FU : follow-up
C preop : preoperative Constant-Murley score
C postop : postoperative Constant-Murley score
MSTS : MSTS score as proposed by Enneking
Rec : local recurrence
Meta : development of metastases
HG : high grade
Nd : not done because of rapid deterioration
NED : no evidence of disease
DOD : dead of disease
AWD : alive with disease
Abd : abduction
IV : intravenous

Fig. 1. — Active external rotation in a patient treated by extracorporeal irradiation and Delta prosthesis.

Fig. 2. — Excellent function after one year in a patient treated by extracorporeal irradiation and Delta prosthesis.

because of rapid oncological deterioration. Two patients had an infected prosthesis, of which one had to be removed and arthrodesis was necessary. The other infection occurred after three years due to an infected I.V. line.

DISCUSSION

Four possible strategies are currently available to reconstruct the shoulder joint after tumour resection (3). The first option is no reconstruction at all, resulting in a flail shoulder. The major advantage is pain relief, the main drawback is complete lack of stability and shoulder function. A second option is to use a passive spacer, in order to improve cosmesis, stability and function of the hand and forearm. However, painful dislocation frequently occurs and leads to poor patient satisfaction. A third option is shoulder arthrodesis, which results in a painless, stable joint with an active abduction varying between 60 and 90°, limited rotation, and a powerful forward push. However, if a large segment of bone has to be resected, a graft augmentation is needed in order to avoid severe shortening of the upper limb. This results in complications such as fatigue fractures or failure of fixation. Finally, joint arthroplasty aims at restoring glenohumeral motion, while maintaining a stable joint. Arthroplasty can be achieved by different means : fibular grafting, osteoarticular grafts, or prosthetic replacement. Fibular grafting methods involve complications such as stress fractures and resorption of the fibular head. Functionally, patients can perform abduction to about 45 to 60°, flexion between 60 and 90°, and rotation of 30 to 60° around the neutral position. Osteoarticular (allo-) grafts allow good fit, length restoration, and a stable joint, and especially if rotator cuff insertions are preserved, muscle anchorage is possible resulting in a more functional shoulder joint. Failure of union at the graft-host junction, joint dislocation, articular fractures and signs of rejection compromise these optimistic expectations, leading to a poor functional outcome on the long term (6, 7). Classical hemiarthroplasty or total shoulder replacement has to overcome failure of humeral fixation, superior head migration and lack of muscle insertion, finally acting as a passive spacer. Recently, prostheses especially designed for this pathology have become available, in particular to avoid proximal migration. Shoulder function, however, is directly related to the restoration of rotator cuff function. If this proves to be impossible, the patient ends up with an unstable joint and unsatisfactory

Fig. 3. — Radiographic result of patient in fig 1 after one year and three months.

function with compromised active positioning of the hand and poor lifting ability (1, 9, 10).

In extracompartmental bone tumours of the proximal humerus, the rotator cuff has to be resected (Malawer resection type I or MSTS classification S345) (5, 8). As stated before, a poor functional result is to be expected after insertion of a classical prosthesis. Therefore we use a semi-constrained long-stemmed cemented inverted shoulder prosthesis, with which a good functional outcome can be expected providing deltoid muscle function is good. Deltoid muscle function is theoretically improved by lengthening its lever arm through lowering and medialisation of the centre of rotation of the glenohumeral joint (4) (fig 3). If resection of the axillary nerve is necessary for tumour control, this procedure is not recommended, although one patient in which the anterior branch of the axillary nerve had to be resected recovered fairly good function .

The functional outcome using this prosthesis is similar at two independent institutions, in very different settings. Stability can be improved by meticulous height restoration and by using the largest glenosphere, which increases the surface of contact. Using the largest glenosphere also improves active and passive external rotation, and avoids notching of the inferior border of the glenoid by the humeral prosthetic component. Reinsertion of muscles improves shoulder and elbow power, and provides active joint stabilisation.

CONCLUSION

Although our experience in this specific field is limited and follow-up is still short, we feel that the use of the inverted shoulder prosthesis, especially when augmented with grafting, has several advantages over a classical hemi- or total shoulder arthroplasty. Patients have good active mobility of the upper limb, without the risk of proximal migration of the prosthesis. The shoulder joint is stable during movement, and strength is only mildly affected. Only time will tell us how long the prosthesis will survive, especially in a young patient population. In severely affected patients with disseminated disease and a pathological fracture, this method provides good palliation with minor functional disability and excellent pain relief.

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