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Six-year experience with the Delta III reverse shoulder prosthesis

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ABSTRACT

Purpose. To report the clinical and radiographic results and complications of the Delta III reverse prosthesis.
Methods. 24 women and 2 men aged 62 to 84 (mean, 75) years underwent total shoulder replacement using the Delta III reverse prosthesis. Patient diagnoses were massive rotator cuff tear (n=20), disabling sequelae of proximal humeral fractures (n=3), and failure of an unconstrained arthroplasty (n=3). Clinical and functional results were assessed using the Constant scale. Active range of motion (ROM) was measured. Scapular notching and radiolucent lines around the humeral component were evaluated using radiographs. Patient satisfaction of the treatment was evaluated by a direct interview.
Results. 23 patients were followed up for 26 to 84 (mean, 42) months. Two patients had loosening of the glenoid component (at 6 months and 5 years) and underwent revision surgery. There were no instances of infection, instability, or acromial fracture. Only active elevation improved significantly after surgery, as did both the absolute and adjusted Constant scores. 12 patients were completely pain-free, 9 complained of slight pain, and one of moderate pain. The severity of scapular notching progressed with time. 15 patients were satisfied with the treatment, 6 were partially satisfied, and 2 were not satisfied.
Conclusion. The Delta III prosthesis restores shoulder function but has biomechanical limits. Its use should be limited to elderly patients with severe impairment of the glenohumeral joint. Scapular notching is a main concern for the long-term survival of the implant.

Key words: *arthropathy, replacement; prosthesis implantation; rotator cuff; shoulder joint*

INTRODUCTION

The primary indication for a total shoulder replacement using a reverse shoulder prosthesis is the 'pseudoparalytic shoulder', a condition characterised by the loss of active arm elevation owing to massive and irreparable rotator cuff tears. Glenohumeral degeneration or even collapse of the humeral head can be attributed to tendon failure and cuff tear

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arthropathy.[1] Other indications include malunions of proximal humeral fractures or failed arthroplasties.[2] The semi-constrained design of the reverse shoulder prosthesis restores a valid fulcrum for the deltoid, enabling overhead elevation of the arm despite the absence of the rotator cuff.[3]

The Delta III prosthesis (DePuy International, Leeds, UK) evolved from the original reverse ball-and-socket prosthesis,[4,5] with 2 new features. First, there was a large hemispherical glenoid component with no neck, which medialises the centre of shoulder rotation and thus reduces stress from the fixed fulcrum on the bone-prosthesis interface and increases the movement arm of the deltoid. Second, there was a 155º inclination of the humeral component, which lowers the humerus and thus the deltoid tension, so as to provide a more stable joint fulcrum. Nonetheless, scapular notching is a potential problem, as the prosthesis has no neck in the glenoid component, the humerus is lowered, and the humeral component has a 155º inclination. Bone resorption is mainly caused by impingement, followed by polyethylene wear of the humeral cup.[6] A progressive extension of the notch may cause loosening of the glenoid component.[7,8] Other problems of the Delta III prosthesis include loss of external rotation, higher risk of dislocation and infection, and limited revision options in case of failure.[2,9–11]

We report the clinical and radiographic results and complications of the Delta III reverse prosthesis.

MATERIALS AND METHODS

Between October 2000 and June 2006, 24 women and 2 men aged 62 to 84 (mean, 75) years underwent total shoulder replacement using a Delta III reverse prosthesis. 19 patients had the dominant arm affected; 12 had undergone previous surgeries. Their diagnoses were massive rotator cuff tear with pseudoparalytic shoulder (n=5), glenohumeral osteoarthrosis (cuff tear arthropathy, n=13), rheumatoid arthritis (n=1), shoulder instability (n=1), disabling sequelae of proximal humeral fractures (n=3), and failure of an unconstrained arthroplasty (n=3). Their comorbidities included hypertension (n=8), type-2 diabetes (n=3), atrial fibrillation (n=2), benign prostatic hypertrophy (n=1), gout (n=1), and major depression (n=1). All patients had undergone conservative treatment (physical therapy, analgesic and anti-inflammatory medications) for at least 3 months. The 20 patients with massive rotator cuff tears were classified according to the Hamada radiographic grading system[12]: grades II (n=4), III (n=6), IV (n=5), and V (n=5).

All arthroplasties were performed by the same specialist via a deltopectoral approach (n=11) or an anterosuperior deltoid-splitting approach (n=15). The glenoid base plate (metaglene) was fixed to the scapular neck with 4 screws (n=19) or 3 screws (n=7). A 36-mm diameter glenosphere was implanted. The humeral component was cemented (n=17) or uncemented (n=9). The retroversion angle was set at 0º (n=7), 10º (n=16) or 20º (n=3). The standard lateralised humeral polyethylene cup was used in 25 patients, whereas a deeper and more constrained cup (to prevent instability) was used in one patient with a failed arthroplasty. Rehabilitation was approach dependent. Active elevation of the shoulder was delayed 4 weeks after the anterosuperior approach, as the deltoid was partially detached from the acromion.

Clinical and functional results were assessed using the Constant scale.[13] The adjusted scores were expressed as a percentage of normal reference values (matched for age and sex).[14] Active range of motion (ROM) for elevation, external and internal rotation was measured.

True anteroposterior and axillary radiographs were taken at postoperative month 3, 6, and 12, and yearly thereafter. Scapular notching was evaluated according to the Nerot classification[15] (grade 0 being absence of notching and grade 4 being impending loosening of the glenoid component). Radiolucent lines around the humeral component were classified according to their width (≤2 or >2 mm) and zones involved (7 zones being described for cemented unconstrained stems).[16]

Patient satisfaction with the treatment was evaluated using a 3-grade scale (satisfied, partially satisfied, not satisfied) via a direct interview. Pre- and post-operative ROM and Constant scores were compared using the paired *t* test. A p value of <0.01 is considered statistically significant.

RESULTS

Three patients were excluded from analysis: one died of lung cancer and 2 developed debilitating neurological complications unrelated to their surgery. The remaining 23 patients were followed up for 26 to 84 (mean, 42) months.

Two complications occurred in the immediate postoperative period; one was a partial detachment of the lateral deltoid following an anterosuperior approach, and the other was a prosthesis dislocation, which was promptly reduced and did not recur. Two patients had loosening of the glenoid component at 6 months and 5 years, for which they underwent

revision surgery (Figs. 1 and 2). There were no instances of infection, instability, or acromial fracture. No complication was related to patient comorbidities.

Owing to biomechanical limitation, only active elevation improved significantly after surgery.[3,10,17] One patient could not reach the horizontal level and underwent conversion to hemiarthroplasty and thus was also excluded from analysis. The absolute and adjusted Constant scores yielded mean improvements of 34 (range, 13–54) and 43% (range, 16%–69%), respectively ($p<0.0001$ in both, Table 1). 12 patients were completely pain-free, 9 complained of slight pain, and one complained of moderate pain.

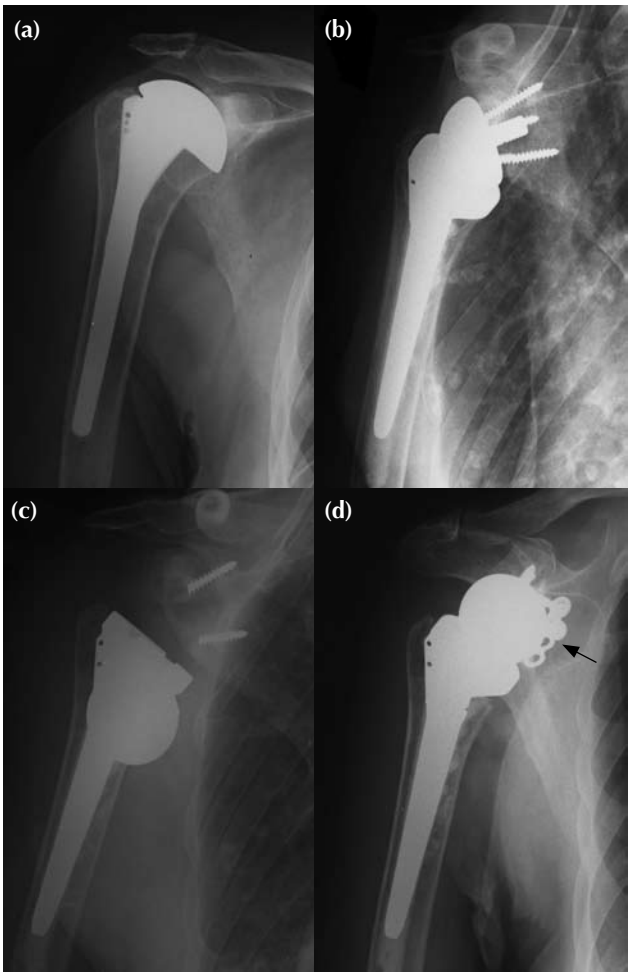

Figure 1 Radiographs showing **(a)** an unstable unconstrained shoulder prosthesis associated with pain and pseudoparalysis in a rheumatoid patient, **(b)** a Delta 3 prosthesis after revision arthroplasty, **(c)** gross loosening of the glenoid component with breakage of 2 screws 6 months later, and **(d)** after replacement of the glenoid component using a special metaglene with a plate for additional screw fixation (arrow). The bone defect in the scapular neck is filled with cancellous bone grafts.

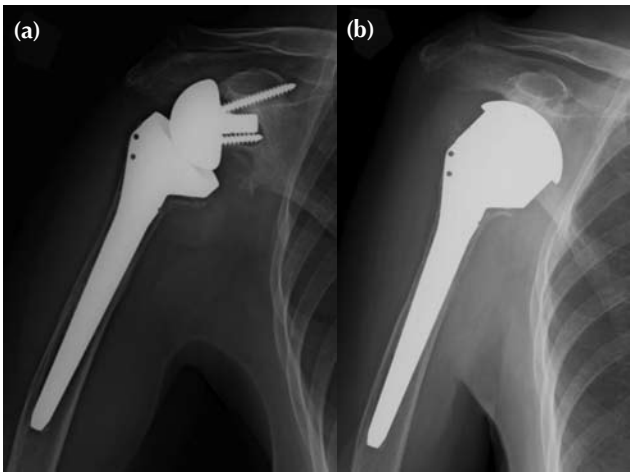

Figure 2 Radiographs showing **(a)** severe glenoid notching (Nerot grade 4) with loosening of the glenoid component 5 years after implantation of the Delta 3 prosthesis, and **(b)** conversion to a hemiarthroplasty owing to the loss of bone stock in the scapular neck.

The severity of scapular notching progressed with time. A notch extending to or beyond the inferior screw (Nerot grade 3 or 4) was observed in 5 of the 10 patients followed up for 5 years (Table 2). Among them, 2 were pain-free, one complained of slight pain and 2 complained of moderate pain. Their mean absolute and adjusted Constant scores were 50 (range, 43–64) and 62% (range, 50%–81%), respectively.

Three patients had scapular notching with radiolucency of >2 mm in the proximal humerus (zones 1 and 7) after 5 years. Four patients had heterotopic ossifications in the axillary pouch of the glenohumeral joint (Fig. 3). Bone resorption remained confined to the metaphyseal area of the humerus and did not lead to loosening.

15 patients were satisfied with the treatment, 6 were partially satisfied, and 2 were not satisfied. One underwent conversion to hemiarthroplasty and had poor functional outcome, the other had impending loosening of the glenoid component (a grade-4 notch) at 6 years, with worsening of pain and function.

DISCUSSION

The Delta III reverse prosthesis restores mobility around a stable centre of rotation and avoids early loosening noted with constrained implants.[18–20] Patients treated for cuff tear arthropathy have lower complication and revision rates than those treated for other disorders.[2,17]

The surgical approach may affect postoperative

Table 1
Pre- and post-operative active range of motion and Constant scores in 22 patients*

	Preoperation Mean (95% CI)	Latest follow-up Mean (95% CI)	p value, *t* test
Active range of motion			
Elevation	65° (53°–78°)	133° (121°–145°)	<0.0001
External rotation	16° (10°–22°)	16° (11°–20°)	<0.8256
Internal rotation	L3	L4	-
Constant score			
Adjusted	27% (23%–32%)	70% (64%–75%)	<0.0001
Absolute	22 (18–25)	56 (52–60)	<0.0001
Subjective variables			
Pain	3.6	12.5	<0.0001
Activities of daily living	8.2	15	<0.0001
Objective variables			
Range of motion	9.5	25.1	<0.0001
Strength	0.6	3	<0.0001

* One patient had the reverse prosthesis converted to hemiarthroplasty and was thus excluded

Table 2
Number of patients having different grades of scapular notching according to follow-up duration

Nerot grade	Follow-up (years)				
	1 (n=23)	2 (n=23)	3 (n=18)	4 (n=13)	5 (n=10)
1	10	12	8	6	3
2	-	4	6	3	2
3	-	-	1	2	3
4	-	-	1	1	2

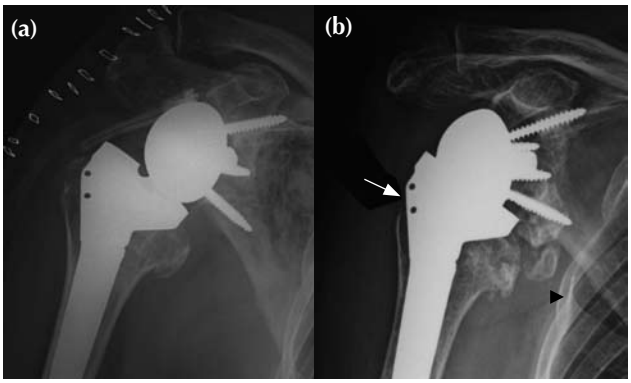

Figure 3 Radiographs showing **(a)** a Delta III prosthesis for an irreparable rotator cuff tear associated with glenohumeral osteoarthrosis, and **(b)** scapular notching (Nerot grade 3), bone resorption in the proximal humerus (arrow), and heterotopic ossifications (arrowhead) at the 6-year follow-up.

internal rotation, as the inferior part of the subscapularis can be preserved using the anterosuperior but not the deltopectoral approach. In our study, the 2 approaches did not result in significantly different ROM. The early contact of the humeral cup with the scapular neck limits internal rotation. Fixing the humeral component with a retroversion of <20° was not sufficient to overcome this problem. In shoulders with the reverse prosthesis, external rotation is mainly affected by the preoperative integrity of the teres minor tendon.[21] Therefore, preoperative assessment of the teres minor and the degree to which it is affected by fatty infiltration should be performed using magnetic resonance imaging. In patients without a functional teres minor, additional transfer of the latissimus dorsi may improve external rotation and elevation.[22,23]

The Delta III prosthesis achieves a comparable level of pain relief to that of unconstrained implants in glenohumeral osteoarthrosis.[24–27] It also achieves better mobility of the deltoid through medialisation of the centre of rotation and lowering of the humerus. Nonetheless, none of our patients was able to lift a weight of >2.5 kg to the horizontal level; their mean Constant score for strength was 3 out of 5. Therefore, it can restore active shoulder ROM for the activities of daily living, but has low capacity.

Sufficient bone stock in the scapular neck ensures correct positioning and adequate purchase of the screws anchoring the metaglene, and thus a stable fixation of the glenoid component. In our study, early loosening that occurred in the patient with rheumatoid arthritis was attributed to insufficient primary fixation of the base plate and lack of secondary fixation of the hydroxyapatite-coated central peg. Rheumatoid shoulders have a higher risk of loosening.[9,11]

Inferior or posterior impingement is the common biomechanical limitation of the Delta III prosthesis. It may cause glenoid notching and jeopardise implant stability.[7] In our study, all 10 shoulders followed up for 5 years presented with an inferior and/or posterior glenoid notch. In the short- and medium-term this has been reported in 50 to 96% of patients.[2,10,15,17,28,29] The evolution of the notch is variable and attributed to 2 pathogenic mechanisms of bone resorption: (1) an initial erosion caused by impingement of the humeral component on the glenoid margin and (2) a secondary osteolysis caused by wear particles from the polyethylene cup.[2,6,8] Although the scapular notch may cease to evolve after a mean of 18 months,[8] in our patients it progressed to a more severe bone defect even after 4 years. Factors predispose to the development of the glenoid notch include the configuration of the axillary border of the scapular neck, the height and inclination of the glenoid component, the position of the humeral cup, and the ROM and activity level of the patient.[8,30] In our study, no predictive factor for scapular notching was identified. Placing the glenoid as low as possible was not sufficient to prevent inferior impingement. To decrease the risk of inferior notching, some suggest implanting the glenoid component with a 15° to 20° caudal tilt,[3] but others disagree.[8] Although 5 of our patients had severe scapular notching, their shoulder function was maintained without glenoid loosening and they were not willing to undergo revision surgery until symptoms became severe. If revision is performed too late, the loss of bone stock in the scapular neck may become too extensive to re-implant the glenoid component. This would necessitate conversion to a hemiarthroplasty (with a poor functional outcome).

New models of reverse shoulder arthroplasty have been developed to overcome the problem of scapular notching, but the follow-up is too short.[31] The Delta III reverse prosthesis is effective in restoring shoulder function for patients with severe impairment of the glenohumeral joint, and attains a high level of patient satisfaction. Nonetheless, it should be restricted to selective cases and particularly to elderly patients not responding to other treatments,[2,10,11] because of concerns about scapular notching and loosening of the glenoid component.

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