The reverse shoulder prosthesis in the treatment of fractures of the proximal humerus in the elderly

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We have previously described the short-term outcome of the use of reverse shoulder arthroplasty in the treatment of acute complex proximal humeral fractures in the elderly. We now report the clinical and radiological outcome of 36 fractures at a mean of 6.6 years (1 to 16). Previously, at a mean follow-up of 6 years (1 to 12) the mean Constant score was 58.5; this was reduced to 53 points with the further follow-up. A total of 23 patients (63%) had radiological evidence of loosening of the glenoid component. Nevertheless, only one patient had aseptic loosening of the baseplate at 12 years’ follow-up.

The reduction in the mean Constant score with longer follow-up and the further development of scapular notching is worrying.

New developments in design, bearing surfaces and surgical technique, and further follow-up, will determine whether reverse shoulder arthroplasty has a place in the management of complex proximal humeral fractures in the elderly.

The reverse shoulder arthroplasty relies on the deltoid muscle. With reverse geometry, the fixed centre of rotation is medialised, the humeral shaft is lowered and the torque of the deltoid muscle is improved. In 1993, we started using the Grammont prosthesis in elderly osteoporotic patients with acute complex proximal humeral fractures when it was impossible to obtain satisfactory anatomical fixation of the tuberosities using standard techniques. Their non-union, malunion, migration or resorption significantly jeopardises the outcome. In 2006 and 2008, we reported the early results. In this paper we include 11 further patients and extend the mean period of follow-up.

Patients and Methods

Between February 1993 and October 2009, 47 patients with an acute fracture of the proximal humerus were treated using the Grammont prosthesis. The indication was a three- or four-part fracture or a fracture-dislocation, according to Neer’s criteria, in an elderly patient with osteoporosis, diagnosed by pathology. A total of nine patients died and two left the area, leaving 36 patients with a mean follow-up of 6.6 years (1 to 16). There were 34 women and two men, with a mean age of 75 years (58 to 92), 26 fractures and 10 fracture-dislocations, 16 on the right and 20 on the left. A total of 25 of the patients have been previously reported, with a mean follow-up of six years (1 to 12).

There was a past history of severe rotator cuff disease in six patients (six shoulders), five patients had diabetes, four were morbidly obese, and three gave a history of alcohol abuse. Pre-operative radiographs included anteroposterior (AP) and lateral views for diagnosis and classification, and CT scans for surgical planning.

Operative technique. An anterolateral approach was used. The humeral head was removed for measurement and histological analysis. There were no pathological fractures, but osteoporosis was common. The anterior, inferior and posterior capsule was excised and the humeral shaft was retracted distally with bone-holding forceps to allow exposure of the glenoid, which was reamed to bleeding subchondral bone. Stable fixation after impaction of the base plate was observed in all cases. The convergent equatorial screws were introduced, the superior screw into the base of the coracoid process, the inferior screw into the scapular pillar. The remnants of the tuberosities were excised to prevent limitation of adduction and possible instability of the humeral component. Adduction and slight flexion of the humerus facilitated its preparation. It is possible, with the trial implants to adjust the height and soft-tissue balance. The tension was considered ideal if the tip of the fifth finger could pass easily between the trial sphere and polyethylene. Retroversion of the humeral component ranged between 20° and 10°, except for one case in which it was deliberately placed in...
10° anteversion to try to improve internal rotation. Except for the first case, all humeral components were introduced with low-viscosity antibiotic-loaded cement and a cement restrictor. The tendon of the long head of the biceps was sutured to the lateral fin of the humeral component. A redi-vac (Peters Surgical, Bobigny, France) drain was used. The arm was immobilised post-operatively in a sling, and active physiotherapy commenced as comfort permitted.

The clinical results were evaluated using the Constant-Murley scoring system and compared to the contralateral side. AP and lateral radiographs were carried out monthly for three months, then quarterly during the first year and then once a year and were assessed by the authors. Every year patients were also asked about their satisfaction and graded on a four point scale; very satisfied, satisfied, no better and no worse, and worse.

**Results**

In the initial series, there were four complications: two patients had a complex sympathetic dystrophy which resolved after six and nine months, respectively; one diabetic patient had an early post-operative *Acinetobacter* infection which resolved after irrigation and debridement; and one patient had an anterior dislocation because of anteversion of the humeral component, which resolved following realignment of the component. Three patients had a superior dislocation due to impingement on the remnants of the tuberosities, which were subsequently systematically removed. Thus the principal complication was dislocation (11%), which should be preventable by improved surgical technique.

**Clinical outcome.** In our initial series, the mean raw Constant score was 58.5 (20 to 84) points at a mean follow-up of 72 months (1 to 144), with a mean score of 81 points (56 to 86) for the contralateral shoulder. The enlarged series of 36 patients had a mean absolute Constant score of 55 points (20 to 84) at one year, and 53 points (20 to 80) at the last examination. This represented 67% of the mean score for the uninjured side (79 points). The mean modified Constant score was 69.3 (61 to 83) points. The results for the subjective and objective assessments are shown in Table I.

**Radiographic findings.** There was one case of aseptic loosening of the baseplate at 12 years (Figs 1 to 3), but we observed two new complete radiolucent lines: one at the glenoid and one at two years between bone and the cement of the humeral component, suggesting chronic infection. This latter patient was asymptomatic. The number of scapular notches increased from 14 to 19, according to Nérot’s classification. There were two distinct patterns of notch: 1) mechanical (10 of 19) (Fig. 4), caused by impingement between the humeral component and the inferior scapular pillar; and biological (9 of 19) (Fig. 5), caused by polyethylene wear. The former were stable without associated proximal humeral bone loss, and the latter were progressive with associated bone loss. At final follow-up, there were 14 inferior spurs with a stable radiological appearance without functional impact (Fig. 6). Finally, one articular ossification appeared at six months and was stable by six years.

**Discussion**

In elderly patients with acute complex proximal humeral fractures, poor outcomes follow treatment with hemi-arthroplasty due to migration, nonunion, malunion or resorption of the tuberosities. There may be good relief of pain, but with persistent functional limitation. Locking plates may provide adequate stability, promoting revascularisation and allowing...
early rehabilitation, but with uncertain results in patients with severe osteoporosis.

Assuming meticulous surgical technique, antegrade nailing with locking screws may give good and reproducible results,\textsuperscript{11,12} but in patients with osteoporosis, prosthetic replacement remains the treatment of choice.\textsuperscript{13} The ‘Bilboquet’ implant (Stryker, Newbury, United Kingdom) promotes consolidation of the tuberosities in an anatomical position and the preservation of bone stock allowing early post-operative mobilisation. The operative technique is demanding, and a few cases of secondary osteonecrosis have been reported.\textsuperscript{14} Prosthetic replacement using standard components gives good results in terms of pain relief, with function being related to the anatomical consolidation of the tuberosities.\textsuperscript{15–19} The Aequalis prosthesis (Tornier, Saint-Ismier, France) was designed to encourage consolidation of the tuberosities in an anatomical position, to restore the lateral offset and the humeral length. It also has an inner window to allow the addition of bone graft.\textsuperscript{20–23} Good results at a mean follow-up of 3.3 years have recently been reported.\textsuperscript{24} Good results have also been reported with the Prospon prosthesis (Tornier), which allows fixation of the fragments of the tuberosities.\textsuperscript{25}
However, in patients with severe osteoporosis the use of this type of implant is limited, and the reversed concept can be an alternative. There are only a few publications dealing with the use of a reverse prosthesis for fractures.\textsuperscript{3,4,26-30} They show that a normal range of movement is not obtained, with particular restriction of rotation. Patients should be very carefully selected. Associated procedures such as a latissimus dorsi transfer\textsuperscript{31} may improve external rotation. Newer prosthetic designs such as the Duocentric prosthesis (Aston Medical, St Etienne, France) with a less medialised centre of rotation and a more lateralised humeral component may recruit more anterior deltoid muscle to improve internal rotation.\textsuperscript{32} The use of a sphere with a centre of rotation further from the surface of the glenoid and inferior placement on the glenoid provides a greater range of movement. Adduction can be improved by selecting a prosthesis with a varus humeral neck-shaft angle of 130° and by inferior placement.\textsuperscript{33} Scapular notching without loosening, which is not a problem at mid-term follow-up, may contribute to glenoid migration. The cause of notching is not well established: latent sepsis,\textsuperscript{34} micro-movement of the lower screw, or impingement between the scapular neck and the humeral component during addition may contribute. The humeral component can contact the inferior screw of the base plate, causing local damage and eventually loosening of the implant.\textsuperscript{35,36} Furthermore, the significance of severe notching remains unknown. Type 4 notching is considered by Valenti et al\textsuperscript{32} to indicate definite loosening, but not by Werner et al.\textsuperscript{35} For Sirveaux et al\textsuperscript{37} loosening can be established only if there is a radiolucent line of 1 mm between the bone and a screw. In order to prevent notching\textsuperscript{35} newer designs of spheres have been developed with protection of the pillar,\textsuperscript{31} and modification of the polyethylene with an inferior cut-out in order to avoid impingement. Specific surgical technique requiring implantation of the baseplate just below the equator of the glenoid with a horizontally directed asc screwn has been described.\textsuperscript{33}

For patients with acute complex proximal humeral fractures, our new series, with a mean follow-up of 6.6 years (1 to 16), gives further information. It is important to remove the tuberosities completely and to avoid anteverision of the humeral component, both of which may lead to dislocation.

There is some reduction in functional outcome with the passage of time. The radiological outcome is different from that which has been reported for patients with arthritis. Simovitch et al\textsuperscript{34} reported stable notching (not progressive in time or size) and progressive pillar spurs, whereas we find unstable notching and non-progressive spurs. The reduction in the mean Constant score and the further development of scapular notching is worrying.

A total of 63% of the patients had radiological evidence of loosening of the glenoid. However, only one patient developed aseptic loosening at 12 years. Nevertheless, new developments in design, bearing surfaces and surgical technique, and further follow-up, will determine whether reverse shoulder arthroplasty has a place in the management of complex proximal humeral fractures in the elderly.

**Supplementary material**

A further opinion by Mr S. Copeland is available with the electronic version of this article on our website at www.jbjs.org.uk

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

**References**

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