Minimally-invasive treatment of three- and four-part fractures of the proximal humerus in elderly patients

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The surgical treatment of three- and four-part fractures of the proximal humerus in osteoporotic bone is difficult and there is no consensus as to which technique leads to the best outcome in elderly patients. Between 1998 and 2004 we treated 76 patients aged over 70 years with three- or four-part fractures by percutaneous reduction and internal fixation using the Humerusblock.

A displacement of the tuberosity of > 5 mm and an angulation of > 30° of the head fragment were the indications for surgery.

Of the patients 50 (51 fractures) were available for follow-up after a mean of 33.8 months (5.8 to 81). The absolute, age-related and side-related Constant scores were recorded. Of the 51 fractures, 46 (90.2%) healed primarily. Re-displacement of fragments or migration of Kirschner wires was seen in five cases. Necrosis of the humeral head developed in four patients. In three patients a secondary arthroplasty had to be performed, in two because of re-displacement and in one for necrosis of the head. There was one case of deep infection which required a further operation and one of delayed healing.

The mean Constant score of the patients with a three-part fracture was 61.2 points (35 to 87) which was 84.9% of the score for the non-injured arm. In four-part fractures it was 49.5 points (18 to 87) or 68.5% of the score for the non-injured arm.

The Humerusblock technique can provide a comfortable and mobile shoulder in elderly patients and is a satisfactory alternative to replacement and traditional techniques of internal fixation.

Fractures of the proximal humerus are common in the elderly. The overall prevalence is about 70 per 100 000 population/year, representing about 5% of all fractures.¹⁻³ The prevalence rises to 405 per 100 000 population/year over the age of 70 years.⁴⁻⁶

In elderly patients, restoration of muscle power to the injured arm is not the prime objective. The main requirement is to handle activities of daily living which do not need much strength, but require a reasonable range of movement. There is a particular need for sufficient external rotation for washing and combing hair and enough internal rotation for eating and for personal hygiene.

In these patients, pre-existing osteopenia or osteoporosis can lead to highly comminuted fractures which are difficult to treat.^{1,7-12} Non-operative management is associated with poor results.^{11,13}

Whilst arthroplasty in these patients gives good relief from pain,¹⁴ the outcome in terms of function is often poor.¹⁵⁻¹⁷ Following arthroplasty after fracture about 50% of primarily-reduced

tuberosities are secondarily resorbed.¹⁸⁻²⁰ This in turn impairs post-operative function because of cranial migration of the prosthesis.²¹ Because of these unsatisfactory results,^{7,21,22} open reduction and stabilisation of such fractures has become more common. However, a major problem of open reduction is that it carries the risk of further deterioration in the blood supply to the fracture fragments.

In an attempt to address these problems, many different techniques such as cerclage wires, T-plates, intramedullary nails, tubular plates and arthroplasty have been used.^{8-10,14,23-33} However, osteosynthesis is often compromised by pre-existing osteopenia.^{12,34} Implants which are too rigid may lead to delayed healing or nonunion by preventing dynamic bone contact or may simply cut out of the osteopenic bone.³⁵ In elderly patients flexible implants which can minimise the load of the implant-bone interface have shown advantages in biomechanical tests.³⁶ A dynamic fixation construct is important in the elderly who will also benefit from early restoration of function.³⁶

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Fig. 1a

Fig. 1b

Fig. 1c

Photographs showing the Humerusblock.

However, the ideal type of fixation in such cases has not yet been established.

We present the results of percutaneous reduction and minimally-invasive fixation of three- and four-part fractures of the proximal humerus using the Humerusblock technique (Synthes, Oberdorf, Switzerland) in a group of patients aged 70 years or older.

Patients and Methods

Between 1998 and 2004, we treated 351 displaced fractures of the proximal humerus surgically. There were 16 fractures of the head which were treated by open reduction and fixation using blade plates and ten by a primary arthroplasty. The remaining 325 fractures were treated by percutaneous reduction and minimally invasive fixation using the Humerusblock technique. Tuberosities were reduced percutaneously and fixed by cannulated screws.

Subacromial impingement and marked limitation of movement are common complications of conservatively-treated three- or four-part fractures of the proximal humerus.³⁷ In our experience this often requires surgical treatment. A displacement of the greater tuberosity of

> 5 mm or an angle of $\geq 30^\circ$ between the shaft and head fragment were indications for surgery.

From the 325 patients, we identified 76 (23.4%) aged ≥ 70 years with a three- or four-part fracture. There were 63 women and 13 men with a mean age of 79.6 years (70 to 96). The mean follow-up was for 33.8 months (5.8 to 81.0). The mechanism of injury had been a fall when walking in 74 patients and a bicycle accident in two. The mean time between the injury and surgery was 2.1 days (0 to 11).

Operative technique. The technique has been published previously.^{23-26,28,38-40} Briefly the device consists of a metal block which is fixed to the humeral shaft by a cannulated cortical screw. Two crossed Kirschner (K)-wires holding the head fragment are passed through the block at an angle of 45° and are held in place by a locking screw (Fig. 1).

The patient is placed in the beach-chair position and an image intensifier is used. A skin incision 3 cm in length is made on the lateral side of the upper arm, about 4 cm to 5 cm below the fracture. The deltoid muscle is split and the block fixed to the humeral shaft by a cannulated cortical screw. This screw is not initially completely tightened to allow varus or valgus adjustment of the block. With the

Table I. Mean (range) absolute Constant scores for both groups

Constant score	Three-part (n = 32)	Four-part (n = 16)
Pain	14 (5 to 15)	12 (5 to 15)
Range of movement	27 (6 to 40)	21 (4 to 40)
Power	6 (0 to 12)	5 (0 to 12)
Activities of daily living	14 (2 to 20)	12 (3 to 20)
Total	61 (35 to 87)	50 (18 to 87)

arm in neutral rotation the block is adjusted in the anteroposterior (AP) view so that the centre between both K-wires aims at the lateral humeral epicondyle. Directed by guiding sleeves, both 2.2 mm K-wires are introduced just below the subcapital fracture.

In three-part fractures, the subcapital fracture is reduced percutaneously with the arm in adduction and internal rotation. In cases of excessive internal rotation of the head fragments, a bone hook is inserted through a separate stab incision for derotation. The greater tuberosity is then manipulated using a hook. When anatomically reduced, the K-wires are passed through the humeral head to subchondral bone. If needed, one or more 2.7 mm titanium screws (Stryker Leibinger Micro Implants, Freiburg, Germany) are inserted to hold the greater tuberosity.

In valgus-type four-part fractures, an elevator is inserted between the fragments and the head raised to its anatomical position as indicated by the greater tuberosity. The reduced head is secured by both 2.2 mm K-wires of the Humerus-block as described above. The greater tuberosity in most cases regains its anatomical position when the articular fragment is elevated. Next, two cannulated 2.7 mm screws, are inserted to hold the greater tuberosity, one directed superiorly into the articular segment close to the subchondral bone and the other in an inferior direction towards the medial cortex. The lesser tuberosity is also reduced and fixed as described above. Finally, both K-wires are locked inside the block, shortened and the wound closed.

After operation the arm is immobilised with a light bandage for three to four weeks. Depending on the degree of stability achieved, passive exercising in the scapular plane without rotating the arm is started on the first post-operative day. Active exercises are allowed at the start of the fourth week. After five to six weeks the metal is removed. In slim patients removal is possible under local anaesthesia.

The patients were assessed clinically and radiologically at follow-up. The function of the shoulder was evaluated using the score of Constant and Murley⁴¹ and compared with the uninjured side. Pain was assessed on a visual analogue scale ranging from 0 to 15 points. The ability to perform activities of daily living was scored with a maximum of 20 points.⁴¹ Range of movement (maximum 40 points) was measured with a goniometer. Muscle strength (maximum 25 points) was determined by a spring-scale. Radiological examination included anteroposterior (AP) and axial views. In addition, the results were compared with

age- and gender-matched normal values. Finally, patients were asked whether they were satisfied with the result.

Results

Of the 76 patients, 23 had died and three were lost to follow-up leaving 50 with 51 fractures available for review. Three patients had undergone revision to an endoprosthesis for avascular necrosis of the humeral head in one and secondary displacement of the fragments in two. A hemiarthroplasty was performed in all three patients and they were excluded from the analysis. Of the remaining 48 patients one had a bilateral fracture and another two had injuries or lesions of the other arm. Therefore, a relative Constant score was not applicable in these cases, although the absolute Constant score as well as the age- and gender-matched values were recorded. Of the 48 patients, 32 had a three- and 16 a four-part fracture.

In the 32 with a three-part fracture the mean absolute Constant score at follow-up was 61.2 points (35 to 87). This was 84.9% of the score for the uninjured arm (mean 72.1 points (43 to 89)). Compared with age- and gender-matched normal values, this equated to 94.9% of the anticipated score.

In four-part fractures the mean absolute Constant score at follow-up was 49.5 points (18 to 87). This was 68.5% of the score for the uninjured arm (mean 72.3 points (56 to 91)). Compared with age- and gender-matched normal values, this equated to 75% of the anticipated score.

Of the 16 patients with four-part fractures, two also had an injury to the brachial plexus. The Constant score for these two shoulders was considerably lower at 29 and 38 points, respectively.

With regard to pain, patients with three-part fractures had a mean of 14 points (5 to 15). Of these, 30 had no or mild pain, one had moderate and another severe pain. Patients with four-part fractures had a mean of 12 points (5 to 15). Of the 16 patients 14 had no or mild pain, one moderate and one severe pain. Of the four patients with moderate or severe pain, one had post-operative necrosis of the humeral head and the other three had previously sustained rotator-cuff tears (Table I).

The mean score for the range of movement was 27 points (6 to 40) in three-part and 21 points (4 to 40) in four-part fractures (Table I).

The mean flexion in three-part fractures was 127° (50° to 175°). The mean abduction was 122° (50° to 170°) and the mean external rotation from the neutral arm position was 31° (10° to 45°). In internal rotation 13 patients could reach the thoracic spine and 13 were only able to reach the sacroiliac joint or lumbar spine. The remaining six patients reached the buttock or lateral thigh.

In four-part fractures the mean flexion was 103° (50° to 175°). The mean abduction was 97° (45° to 170°) and the mean external rotation from the neutral arm position was 23° (0° to 40°). In internal rotation four patients could reach the thoracic spine and nine the sacroiliac joint or lumbar spine (Table II). Another three patients reached the buttock.

Table II. Mean (range) range of movement for both groups

Direction	Three-part (n = 32)	Four-part (n = 16)
Flexion (°)	127 (50 to 175)	103 (50 to 175)
Abduction (°)	122 (50 to 170)	97 (45 to 170)
Internal rotation (points)	5.9 (0 to 10)	4.9 (0 to 10)
External rotation (°)	31 (10 to 45)	23 (0 to 40)

Fig. 2a

Fig. 2b

Anteroposterior (a) and axial (b) views of a three-part fracture of the proximal humerus in a 74-year-old woman.

All the patients with three-part fractures and 81.3% (13 patients) of those with four-part fractures were satisfied or very satisfied with the result (Figs 2 to 4).

Complications. A total of 46 fractures (90.2%) healed primarily. Secondary displacement of fragments or migration of the K-wires was seen in five (10.4%). In three of these revision surgery using the Humerusblock was carried out successfully. In the remaining two a hemiarthroplasty was performed. There was one case of deep infection and one of delayed wound healing.

Avascular necrosis of the humeral head developed in four patients (7.8%) of whom three initially had a four-part fracture; three were satisfied with the outcome, and in one a hemiarthroplasty was performed. Out of the total of 51 fractures, three hemiarthroplasties (5.9%) were performed secondary to the Humerusblock, two because of fragment dislocation and one because of avascular necrosis of the head of the humerus.

Discussion

Our findings showed that in comparison with other surgical methods good relief from pain and movement were achieved using the Humerusblock. One disadvantage of semi-rigid techniques of fixation has been the need for post-operative immobilisation of the arm. Because our procedure is performed percutaneously, there was minimal

soft-tissue disruption and the shoulder could be mobilised early, as in non-operative treatment.

The technique preserves remaining periosteal bridges, which may represent the last link of perfusion to the articular fragment. Consequently, the incidence of necrosis of the humeral head was only 7.8% in our series, whereas rates of avascular necrosis of 14% to 35% have been reported following open reduction.⁴²⁻⁴⁴ The minimum follow-up was, however, too short for a definitive conclusion to be reached.

There were no cases of nonunion which may be related to the preservation of contact between the bone fragments throughout the fixation process. As the tips of the K-wires have to be placed just below the joint surface in order to grip the humeral head they can penetrate the articular cartilage and in these cases they have to be withdrawn before mobilisation is started. This additional intervention is a slight disadvantage of the technique, although it can be done under local anaesthesia.

Closed reduction in three- and especially four-part fractures is a technically-demanding procedure. Before using this technique the nature of the injury should be understood, the number and position of the fragments determined and the potential periosteal links between the fragments noted. In this respect, CT with three-dimensional reconstruction may be helpful.³⁸

Fig. 3a

Fig. 3b

Anteroposterior (a) and axial (b) views after reduction and fixation with the Humerusblock and two cannulated screws in the patient shown in Figure 2.

Fig. 4a

Fig. 4b

Anteroposterior (a) and axial (b) views of the same patient at follow-up at three years. The Humerusblock had been removed six weeks after operation.

Complications of arthroplasty for fractures of the proximal humerus include displacement, nonunion and malunion or resorption of the tuberosities, especially in osteoporotic bone. All of these cause limitation of movement.^{21,22,34,43,45} We observed avascular necrosis of the humeral head but not malunion of either the greater or lesser tuberosity. If a secondary arthroplasty is required an anatomical shoulder prosthesis can be used.

During the last few years the introduction of angle-stable plates has proved to be popular but stability of the implant does not necessarily lead to union of the fracture. In osteoporotic bone, fixed-angle screws can cut out and penetrate the joint. They may also increase bone resorption by preventing contact between the shaft and head fragments.³⁵

Furthermore, open anatomical reconstruction and plating results in a higher rate of avascular necrosis^{29,43,46,47} than that seen when using the Humerusblock.

Percutaneous reduction and minimally-invasive fixation of subcapital humeral fractures using the Humerusblock technique gives good results with satisfactory relief from pain and range of movement.

Supplementary material

A further opinion by Professor G. Kontakis 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.

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