Rigid internal fixation of fractures of the proximal humerus in older patients

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In 42 elderly patients, 33 women and nine men with a mean age of 72 years, we treated displaced fractures of the proximal humerus (34 three-part, 8 four-part) using a blade plate and a standard deltopectoral approach. Functional treatment was started immediately after surgery. We reviewed 41 patients at one year and 38 at final follow-up at 3.4 years (2.4 to 4.5).

At the final review, all the fractures had healed. The clinical results were graded as excellent in 13 patients, good in 17, fair in seven, and poor in one. The median Constant score was 73 ± 18 . Avascular necrosis of the humeral head occurred in two patients (5%).

We conclude that rigid fixation of displaced fractures of the proximal humerus with a blade plate in the elderly patient provides sufficient primary stability to allow early functional treatment. The incidence of avascular necrosis and nonunion was low. Restoration of the anatomy and biomechanics may contribute to a good functional outcome when compared with alternative methods of fixation or conservative treatment. Regardless of the age of the patients, we advocate primary open reduction and rigid internal fixation of three- and four-part fractures of the proximal humerus.

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Several studies have shown an increase in the incidence of fractures of the proximal humerus, especially in older age groups.^{1,2} In the elderly population, most of these fractures have been related to osteoporosis and, like fractures of the hip, are an important source of morbidity.^{3,4} Undisplaced

two-part fractures, according to the classification of Neer,⁵ are the most common and it is generally agreed that these have a good prognosis with conservative treatment. The management of comminuted displaced fractures, however, remains controversial.^{6,7} These three- and four-part fractures represent 13% to 16% of fractures of the proximal humerus,^{3,8} and 20% of them may require surgical treatment.³

In the last 25 years open reduction and internal fixation (ORIF) of displaced fractures has become widely advocated. The deformity cannot, in many cases, be corrected and the reduction maintained by closed reduction and immobilisation. The blood supply of the head of the humerus is at risk however, not only from the injury, but also from dissection of the soft tissues at open reduction and fixation.⁹ The incidence of malunion, nonunion, and avascular necrosis (AVN) after ORIF has been reported to be between 12% and 34% for three-part fractures¹⁰⁻¹² and between 41% and 59% for four-part fractures.^{5,13,14} In elderly patients, osteoporotic bone, often in combination with a thin or ruptured rotator cuff, can lead to unpredictable clinical results.

Extensive exposure and the insertion of implants increase the risk of the development of AVN^{9,15} and limited exposure and dissection of the soft tissues at the fracture site with minimal internal fixation have been recommended.^{9,12} Stable reduction is essential for healing of the fracture and allows early movement of the shoulder. In 1995, we started to use a rigid angular blade plate for fixation of displaced fractures of the proximal humerus. Our technique of reduction involves minimal exposure of the fracture. We describe our results in elderly patients after a minimum follow-up of 2.4 years.

Patients and Methods

Between 1995 and 1996, all patients with fractures of the proximal humerus treated at the Orthopaedic University Clinic in Basel were included in the study if they fulfilled the following criteria: over 50 years of age, a displaced three- or four-part fracture of the proximal humerus not caused by high-energy trauma and not pathological, at least 30% contact between the head and shaft of the humerus, no other fractures or deformities in the upper limbs, and no

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Table I. Details of the 42 patients who underwent rigid internal fixation for a fracture of the proximal humerus

	Three-part fracture (n = 34)*	Four-part fracture (n = 8)†	Total (n = 42)
Mean age in years (SD)	71 ± 8.6	74 ± 7.9	72 ± 8.4
Female:male	27:7	6:2	33:9
Right:left side	19:15	5:3	24:18
Dominant limb	11	5	16

* one patient was lost before one year and another two by the final follow-up

† one patient was lost by the final follow-up (see text)

concomitant condition likely to affect the outcome. There were 42 patients, 33 women and nine men, with a mean age of 72 years (52 to 92). The fractures were classified according to Neer.⁵ Table I gives the details.

Operative technique. Surgery was carried out under general anaesthesia, within 24 hours of admission. The patients received prophylactic cephalosporin before operation. An angular hip plate, designed for use in adolescents, with the blade shortened to 30, 35 or 40 mm, was used for fixation. First, the cephalic vein and deltopectoral groove were identified through a longitudinal incision of 5 to 6 cm, starting at the level of the coracoid process. The deltoid was retracted laterally, and the greater tuberosity was identified. It was separated from the head fragment, and temporary reduction was obtained and held by a Kirschner wire. When there was an impacted fracture of the surgical neck with angulation of more than 20° (predominantly anterior) reduction was carried out by abduction and flexion of the arm. Another Kirschner wire was then inserted through the centre of the greater tuberosity into the humeral head. The insertion point was 10 to 15 mm below the top of the greater tuberosity and 10 to 15 mm behind the anterior

margin of the bicipital groove (Fig. 1a). After checking the position of the Kirschner wire under fluoroscopy, the blade was inserted into the head fragment along the wire (Fig. 1b). Indirect reduction of the head fragment to the humeral shaft was then achieved by preliminary fixation of the plate to the shaft with one screw. The long biceps tendon served as a guide for correct rotation of the arm. The plate was then rotated around the screw until correct alignment to the shaft was achieved, and fixed with two further screws (Fig. 1c). The plate was usually placed along the border of the anterior insertion of deltoid. Finally, the lesser tuberosity was reattached with a No. 5 non-absorbable suture (Fig. 1d). Any defect of the rotator cuff was repaired by non-absorbable sutures. Dissection of soft tissue from the fracture fragments and further exposure of the site of the fracture was avoided. The arm was immobilised in a sling, passive movement was begun on the first day after surgery, and active movement beyond 90° of abduction with flexion was started after one week. Active movement with resistance was allowed when there was radiological evidence of bone healing which usually occurred after six to eight weeks.

The patients were reviewed clinically and radiologically six and 12 weeks after surgery, at one year and then after a mean of 3.4 years (2.4 to 4.5). Complications during the first year and the functional outcome were noted.

At final review the patients were examined by one of the authors (HHT) who had not been involved in their primary management. He assessed the outcome using a clinical score (Table II) and the scoring system of Constant and Murley.¹⁶ Functional assessment included clinical criteria of pain (15 points), range of movement (40 points), power (25 points) and activities of daily living (20 points). Pain was assessed using a four-level scale in which no pain

Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Technique of open reduction and fixation of the humeral head with the blade plate showing a) the wire insertion point for the Kirschner wire, b) insertion of the blade c) alignment and fixation of screws and d) reattachment of the lesser tuberosity.

Table II. The criteria used to assess outcome

Grade	Pain	Requirement of analgesics	Limitation of recreational activities	Limitation of daily activities	Patient's assessment
Excellent	None	None	None	None	Satisfied
Good	Mild, occasional	Occasionally	Limited	Limited	Satisfied
Fair	Moderate, frequent	> 1 dose per week	Moderate	Moderate	Satisfied with reservations
Poor	Severe, nearly always	Daily	Severe	Severe	Dissatisfied, or reoperated

Table III. Functional assessment (median $\pm$ SD) for the 38 patients assessed at the 3.4 year final follow-up, compared with that of Zyto et al²²

	Three-part fracture (n = 31)	Four-part fracture (n = 7)	Total (n = 38)	Zyto et al ²²	
				Surgery (n = 14)*	Conservative (n = 15)*
Constant score (max 100)	75 $\pm$ 17	69 $\pm$ 19	73 $\pm$ 18	60 $\pm$ 19	65 $\pm$ 15
Pain (max 15)	14 $\pm$ 4	12 $\pm$ 3	13 $\pm$ 4	10 $\pm$ 5	12 $\pm$ 3
Range of movement (max 40)	33 $\pm$ 3	30 $\pm$ 4	32 $\pm$ 3	26 $\pm$ 4	29 $\pm$ 3
Power (max 25)	11 $\pm$ 5	10 $\pm$ 5	11 $\pm$ 5	8 $\pm$ 5	8 $\pm$ 5
Activities of daily living (max 20)	17 $\pm$ 4	17 $\pm$ 5	17 $\pm$ 5	16 $\pm$ 5	16 $\pm$ 4

* randomised study²² (tension-band repair v conservative treatment) with an average follow-up of 4.16 years

scored 15 points, mild 10 points, moderate five points and severe no points, and also a visual analogue scale from zero (no pain) to ten (maximum pain). The points on the latter were multiplied by a factor of 1.5, and the final subjective score of pain was achieved by subtracting the obtained value from 15. The range of movement was measured by a goniometer. Active painless flexion, abduction and external and internal rotation were recorded. Measurements of power of the muscles of the shoulder were made using the Isobex force device (Cursor AG, Berne, Switzerland). The elbow was extended while the patient maintained resisted elevation against the pull of the elastic band for a period of five seconds. The tests were carried out with the shoulder at 90° flexion or at whatever level below 90° was found to be painless. The mean of three tests was recorded as the power strength of the shoulder. Activities of daily living which were assessed included the ability to work, undertake leisure or sports activities and to have undisturbed sleep.

Anteroposterior and lateral radiographs were taken and used to assess the position of the fracture, nonunion, AVN, and osteoarthritis. They were independently examined by a radiologist and by one of the authors (HHT). Dislocation of the tuberosities, the operative reduction of the fracture and the angulation of the head of the humerus were assessed on both views after operation and at each subsequent review. On the radiograph, a line was drawn between the two projected ends of the articular surface, and a second line along the centre of the shaft of the humerus. Anteroposterior and mediolateral angulation of the head was determined by measuring the angle between these two lines. Malunion was defined as healing of the fracture with a posterior or anterior angulation of more than 20°, and/or a mediolateral angulation of less than 35° or more than 55°.

Statistical analysis. The median and standard deviation

(SD) were calculated using Excel (Microsoft Office, Version 97) for the IBM computer.

Results

One of the 42 patients underwent prosthetic replacement of the head of the humerus after another fall with further displacement of the fracture ten weeks after initial treatment. Three patients were lost to follow-up; two died from unrelated causes, and one could not be contacted. At follow-up at one year there were 41 patients and at the final follow-up 38. There were 30 women and eight men; 31 had had a three-part and seven a four-part fracture.

Operative reduction improved the posterior angulation (Fig. 2) from 58° (30 to 155) to 6° (-5 to +25) and this did not change at final follow-up. The mediolateral angulation (Fig. 2) was 52° (100 to -5) before operation and improved to 39° (30 to 50). Malunion by posterior angulation of more than 20° was found in three patients, and malunion by mediolateral angulation of less than 40° was found in one of these three patients and in one other. In all patients, the position of the greater tuberosity remained unchanged, but in one patient with a four-part fracture, the lesser tuberosity moved slightly, but healed uneventfully.

The mean functional score was higher in those patients with a three-part fracture (Table III), but there was no significant difference between the two groups of patients. There was a little improvement of the overall clinical results after one year (Table IV).

The median Constant score was 73 $\pm$ 18 (Table III). The pain subscale reflected mild pain. The achieved range of movement and power were acceptable to almost all patients and the overall function of the shoulder, with respect to activities of daily living, was good (Table III).

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Radiographs of a 58-year-old man who sustained a four-part fracture during a fall on his left shoulder when ski-ing. Figure 2a – Before operation there was depression of the fragment of the head and marked displacement of the greater and lesser tuberosities. Figures 2b and 2c – After operation the mediolateral angle was 48° (b) and the posterior angulation 25° . Figure 2d – After four years the fracture was completely healed with no evidence of AVN. One screw had been removed after seven months because of loosening.

None of the patients had a perioperative complication, but there were other complications in both groups (Table V). One patient, with problems of alcohol abuse, developed a deep infection which was successfully treated with antibiotics. He had a Constant score of 72 at the time of final follow-up reflecting good function. Another patient also with problems of alcohol abuse, developed AVN within 12 months. Two months later, prosthetic replacement of the head of the humerus was carried out, with an uneventful recovery (Table V). She had a Constant score of 66 at final follow-up. A patient with a three-part fracture developed AVN. At final follow-up, he had some osteoarthritis and stiffness, but the overall function was acceptable (Constant score 56). Four patients developed post-traumatic stiffness. After removal of the implant and manipulation under anaesthesia, the function of the shoulder improved and the

Table IV. The numbers of patients (%) and their clinical outcome at one year and at the final follow-up

	One year			Final follow-up		
	Three-part (n = 33)	Four-part (n = 8)	Total (n = 41)	Three-part (n = 31)	Four-part (n = 7)	Total (n = 38)
Excellent	8 (24)	1 (13)	9 (22)	10 (32)	3 (43)	13 (34)
Good	14 (43)	4 (50)	18 (44)	14 (45)	3 (43)	17 (45)
Fair	10 (30)	2 (25)	12 (29)	7 (23)	0 (0)	7 (18)
Poor	1 (3)	1 (13)	2 (5)	0 (0)	1 (14)	1 (3)

Constant scores were 64, 65, 68 and 74 points, respectively, at final follow-up. Two patients, with no signs of AVN, developed osteoarthritis. In both the reduction achieved was not optimal. All other fractures healed uneventfully with no sign of AVN or osteoarthritis.

Table V. The 11 patients who had complications and/or revision surgery*

Case	Gender	Age (yr)	Fracture (part)	Complications				Revision surgery			
				Infection	AVN	Osteoarthritis	Post-traumatic stiffness	Revision ORIF	Implant removal	Hemi-arthroplasty	MUA†
1	M	76	Three	Yes							
2	F	65	Three				Yes		Yes		Yes
3	F	78	Four				Yes		Yes		Yes
4	M	66	Three		Yes	Yes	Yes				
5	F	78	Three			Yes					
6	F	73	Four		Yes					Yes	
7	F	79	Four				Yes		Yes		Yes
8	M	81	Four				Yes		Yes		Yes
9	F	70	Three			Yes			Yes		
10	M	64	Three						Yes		
11	F	74	Three					Yes‡			

* one patient who had replacement of the humeral head after another fall with more displacement of the fracture ten weeks after initial treatment was not included

† manipulation under anaesthesia

‡ revision of haematoma and removal of one screw

Discussion

Various techniques and devices have been proposed to treat displaced fractures of the proximal humerus including a semitubular straight plate,^{9,12,17-19} screws,¹² Rush nails,²⁰ external fixators²¹ and cerclage wiring alone^{9,20,22} or in combination with a tension-band technique.^{11,23,24} The reported results have varied from excellent to poor. Since many elderly people have osteopenia, plates, screws and Rush nails may not provide sufficient stability.^{11,13,25,26} Alternatively, a blade plate has been proposed.²⁷ Sehr and Szabo²⁶ used a blade plate in seven patients, all of whom achieved clinical and radiological union and a functional range of movement. Moda et al¹⁹ reported satisfactory results and no complications in six patients. To date, however, there have been no reports of its use in the osteoporotic bone of the older patient.

In our study, a modified hip blade plate was used in a consecutive series of 42 older patients. The technique was shown to be successful in terms of restoration of the anatomy and in maintaining the postoperative position of the fractured head of the humerus until healing was established. Active movements were started immediately after operation. The primary stability achieved in the osteopenic bone was sufficient to resist complex loading forces, involving distraction,²⁸ bending and torsion. It has been stated that a key to good functional outcome is undisplaced tuberosities, and that poor results will follow if they are not properly reduced.^{29,30} Our method using a bulky plate may not be ideal because it could lead to subacromial impingement, but this was not common in our patients; removal of the plate was only necessary in six (16%).

At final follow-up, only two patients (5%) had AVN, indicating that the blood supply to the humeral head had not been critically impaired by open reduction. Besides the degree of primary stability, other factors may have contrib-

uted to this low rate of AVN. Our technique of indirect reduction of the head to the shaft of the humerus by abduction and internal rotation of the arm, and manipulation of the fragments only over the plate required very little exposure of the fracture. All the operations were undertaken by two experienced surgeons (BH, DS).

Zyto et al²² reported similar results in 20 patients with a mean age of 74 years of whom 19 had a three-part, and one a four-part fracture. They used semi-rigid fixation with cerclage wires (Table III). The postoperative position of the head was maintained until healing in 18 patients. One patient with a three-part fracture developed AVN, and one with a four-part fracture had nonunion. The functional results were, however, no better than in 20 comparative patients who received conservative treatment and markedly worse than our results (Table III) particularly in relation to range of movement, power, and pain.

Our method of rigid internal fixation produced good results compared with other methods of treatment of these difficult fractures.^{11,13,15,19,22-24,26,31} We had relatively few complications. Nevertheless, at final follow-up, eight patients (21%) had a poor or fair result. Six required further surgery to remove the implant, four required manipulation under anaesthesia, and one had a hemiarthroplasty.

The functional results after rigid fixation of three- and four-part fractures using a blade plate were shown to be better than conservative treatment or semi-rigid fixation without anatomical reduction of the head fragment.^{9,11,12,20-24} Shoulder function continued to improve after one year as the strength and function of the muscles increased. We advocate this technique as the primary treatment when undertaken by an experienced surgeon and as an alternative to prosthetic replacement.

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