# Surgical Results of Open Reduction and Plating of Humeral Shaft Fractures

H T Hee,* *MBBS, FRCS (Edin), FRCS (Glas)*, B Y Low,** *FAMS, FRCS (Edin), FRCS (Glas)*, H F See,*** *FAMS, MBBS, FRCS (Glas)*

**Abstract**

***Thirty-five patients who sustained humeral shaft fractures were treated by open reduction internal fixation using AO techniques between 1992 and 1997. Open fractures occurred in 8 patients. Primary radial nerve palsy was present in 5 cases. In 16 patients an open fracture or multiple trauma, or both were indications for surgery. Eight osteosynthesis were performed after failed conservative treatment. The complications encountered were non-union (2 cases), osteomyelitis (2 cases), secondary radial nerve palsy (3 cases) and repeat surgery (4 cases). Bony union averaged 5.3 months radiographically. All cases of radial nerve palsy recovered eventually. Twenty-seven patients reported no pain. Twenty-six patients had full range of motion in the shoulder and elbow. Thirty-three patients had full muscle strength. Open reduction internal fixation gives good results provided correct indications and principles of fixation are adhered, and is a good alternative to conservative treatment. We advocate operative reduction internal fixation and nerve exploration in fractures associated with radial nerve palsy.***

***Ann Acad Med Singapore* 1998; 27:772-5**

***Key words: Internal fixation, Radial nerve palsy, Union***

## Introduction

Management of humeral shaft fractures has been the subject of controversy (Böhler,[1] Ekkernkamp and Muhr,[2] Nast-Kolb and Schweiberer[3]). The problem of non-union, wound infection and most important of all iatrogenic radial nerve palsy led many to favour a conservative approach. Furthermore, good outcome of humeral shaft fractures was reported by Sarmiento et al[4] using functional brace.

Analysis of this issue in a closer perspective will reveal misconceptions. It is unfair to compare the results of the two groups (surgically treated and conservatively managed) simply because of different patient characteristics between the two. The surgically treated group tends to include the multiply and severely injured, those with open fractures and / or vascular compromise. These patients were more ill to start off with, and hence would have a slower recovery period and higher complication rate. The conservatively managed group usually includes those with isolated, closed and relatively undisplaced fractures, which will heal well regardless of the treatment choice.

There are only a few reports on the surgical results of rigid plating of the humeral shaft in the English literature.[5-8] Thus, the objective of our paper was to study the outcome of open reduction and surgical plating of humeral shaft fractures. We will also discuss certain issues, including the management of associated primary and secondary radial nerve palsy.

## Materials and Methods

In the period between January 1992 and January 1997, 47 humeral shaft fractures were treated by open reduction and internal fixation using AO principles. Twelve patients were lost to follow up. The remaining 35 patients were reviewed after an average of 3.5 years follow-up.

The average age of these patients at the time of injury was 37 years (range 15 to 86 years). Majority of the patients were male (26 cases). With regards to the mechanism of injury, 19 fractures were sustained after road traffic accidents, 15 fractures were due to falls and 1 fracture was sustained after arm wrestling. There were nearly equal proportions of fractures occurring on the right humerus (16 cases) and the left humerus (19 cases).

Twenty-one fractures occurred over the middle one third of the shaft of the humerus. Thirteen cases occurred over the distal one third of the shaft of the humerus. One case was a segmental fracture, involving both the middle and distal thirds of the humerus.

Nineteen fractures had no comminution. Nine cases had minimal comminution, involving a small butterfly

* *Registrar*
*** *Senior Consultant and Chief, Department of Orthopaedic Surgery*
** *Senior Consultant, Department of Orthopaedic Surgery*
*Chief, Department of Accident and Emergency*
*Changi General Hospital*
*Address for Reprints: Dr H T Hee, Department of Orthopaedic Surgery, Changi General Hospital, 2 Simei Street 3, Singapore 529889.*

fragment. Seven cases had significant comminution and bone loss. Six of these 7 cases were open fractures.

With regards to the pattern of fracture, 27 cases were transverse in nature and 8 cases were oblique.

Six patients presented initially with neurovascular deficits. Five of these were primary radial nerve palsy present before surgery. The remaining case involved a transected median nerve and brachial artery.

Eight cases were open fractures. Three were grade 1, 4 were grade 2 and the remaining 1 was grade 3C, according to the classification by Gustilo.

In 16 patients an open fracture or multiple trauma, or both were indications for surgery. Eight osteosynthesis were performed after failed conservative treatment. Of these, 4 were delayed or non-union after a trial of plaster treatment. The other 4 were failure to maintain satisfactory alignment using casts.

An anterolateral approach was utilised in 27 cases. Seven patients had their fractures plated using a posterior approach. These 7 fractures occurred over the distal third of the shaft of the humerus. A medial approach was utilised in 1 patient who had an open fracture of the middle third of the humeral shaft associated with a wound located medially.

The radial nerve was positively identified in 16 cases. Primary radial nerve palsy, open fractures or humeral shaft fractures requiring posterior approach were the reason for radial nerve exploration. An anterolateral approach was used in fracture fixation and radial nerve exploration in those 5 cases that presented with primary radial nerve palsy, as these fractures occurred over the middle third of the shaft of the humerus.

The majority of the implants (32 cases) used were 4.5 mm narrow dynamic compression plates. One case had a 3.5 mm dynamic compression plate used because the 4.5 mm narrow dynamic compression plate was too prominent. One case had 4.5 mm low contact dynamic compression plating (LCDCP) done. One patient had her fracture plated using a one third tubular plate because both the 3.5 mm and 4.5 mm plates were too prominent. The average duration of surgery was 86 minutes.

Associated ipsilateral upper limb fractures ("floating elbow") occurred in 3 cases, opposite upper limb fractures occurred in 2 cases, femoral fractures occurred in 3 cases, fractures of the tibia / fibula occurred in 4 cases and other injuries (pelvic fractures, intra-abdominal injuries requiring laparotomy, rib fractures, haemo / pneumothorax) occurred in 12 cases.

## Results

The average hospitalisation stay was 10 days. Twenty-nine patients had an uneventful postoperative course. Non-union of the fracture was reported in 2 cases, both of which were open injuries. Both required bone grafting as additional operations and both fractures eventually united on follow-up. There were 2 cases of osteomyelitis, the pathogen being responsible was Methicillin-resistant *Staphylococcus aureus* (MRSA). Both cases were open fractures to begin with. One was a grade 3C open fracture involving transected median nerve and brachial artery, and the other was a grade 2 open fracture in an elderly diabetic man aged 86 years old at the time of injury. They were treated aggressively with a course of intravenous vancomycin followed by oral clindamycin and fusidic acid. The patient who had grade 3C open fracture developed non-union which required bone grafting (mentioned earlier). One patient who had an open humeral shaft fracture and ipsilateral open Monteggia fracture dislocation which required repeat surgery for recurrent dislocation of the radial head. Secondary radial nerve palsy was reported in 3 cases, 1 of which had re-exploration via the posterior approach. This fracture occurred over the distal third of the shaft of the humerus, and had open reduction and plating done using the posterior approach. The radial nerve was discovered to be intact intraoperatively. All 3 cases eventually recovered on follow-up.

Postoperative evaluation of the patient included assessment of time to bony union (as determined radiographically), presence of pain, joint stiffness, scar hypertrophy and weakness.

The average time to bony union was 5.3 months, with a range of 3 to 12 months. One case of hypertrophic scar was reported.

With regards to the presence of residual pain, 27 reported no pain on review. Eight patients had mild residual pain. None had severe or constant pain.

Twenty-six patients had full range of motion of both their shoulder and elbows. Seven patients had residual elbow stiffness, the average arc of motion being 15° to 100°. Two patients had reduced shoulder abduction, the average being 105°.

In our review, all radial nerve palsies (primary and secondary) recovered eventually. Thirty-three patients had full muscle power when tested, and were able to perform duties as well as previously. Two patients had weakness of both the shoulder and elbow. The muscle power was graded as 4 out of 5.

When asked to rate their surgical outcome, 31 patients (89%) were satisfied or very satisfied with their surgical outcome. The patient that presented with open grade 3C fracture involving transected median nerve and brachial artery was dissatisfied with the surgical outcome. He had osteomyelitis and non-union, both of which resolved with appropriate treatment. On follow-up, he had stiffness and weakness of the elbow (grade 4 out of

5). He had residual pain of mild intensity. There was no shortening nor scar hypertrophy.

## Discussion

Indications for open reduction and internal fixation of humeral shaft fractures can be based on 2 criteria: fracture characteristics and presence of associated injuries.[8] The indications for surgery based on fracture characteristics have been described as: open fractures; displaced fractures (Klenerman[9]); fractures located proximally or distally which are more difficult to manage conservatively; delayed or non-union of the fracture and pathologic fracture. Associated injuries include ipsilateral forearm fractures ("floating elbow"), multiple trauma and presence of neurovascular deficits. The most frequent indication for internal fixation of the shaft of the humerus in several studies was the presence of associated multiple trauma. In our series, 16 out of 35 (46%) who had surgery had open humeral shaft fracture or multiple trauma, or both.

It is difficult to manage conservatively fractures of the humeral shaft in patients with multiple trauma.[5,7,8] A good example is a patient with floating elbow. Many of these are open fractures which will require wound debridement and skeletal stabilization. Non-union is reported to be higher in these cases. Therefore open reduction and internal fixation will allow faster soft tissue recovery, relieve pain and facilitate nursing as well as rehabilitation of the patients. Subsequent reconstructions to cover the soft tissue defect if any will be easier too.

Conservative treatment of humeral shaft fractures is acceptable if there is less than 20° of anterior bowing and 30° of medial angulation, according to Klenerman.[9] There should not be more than 3 cm of shortening too. In our series, displaced fractures that had open reduction and plating were those fractures that had one or more of the following criteria: no cortical contact at fracture site; more than 20° anterior bowing; more than 30° medial angulation; more than 3 cm shortening.

Fractures located very proximally or distally,[8] if treated conservatively in a cast, may affect the functional range of motion of the shoulder and elbow. Thus open reduction and plating of these fractures will allow for earlier rehabilitation and mobility.

Delayed or non-union of the fracture[6,8] is also a justification for open reduction and internal fixation. According to Foster et al,[6] humeral shaft fractures that do not unite by 4 months are considered as having delayed union. Those that do not unite by 8 months are considered as having non-union. In our series, 4 patients had surgical plating for delayed or non-union after a trial of conservative treatment. These patients were plated an average of 3.5 months after the initial injury. We believe that surgical plating is indicated in those cases that do not show radiographical evidence of consolidation after 3 months from the time of injury.

The main controversy surrounds the issue of radial nerve palsy.[1,6,10-13] Several series reported around 90% recovery within a few months regardless of the method of treatment.[1] Others quoted a low incidence of actual nerve lacerations and good recovery after conservative treatment.[6,10,11] Many concluded that isolated radial nerve palsy in humeral shaft fractures should be managed non-operatively. On the other hand, other authors[14] questioned the issue of the remaining 10% of radial nerve palsies that did not recover. They felt that the proportion of persistent nerve palsies is too high to ignore. The efficacy of radial nerve decompression by open reduction internal fixation is still unknown. One series reported that 7 out of 23 initial radial nerve palsies[8] did not recover completely. In our series, we had 5 reported cases of primary radial nerve palsy. The recovery rate was 100% on follow-up. Significant improvement was evident at 3 to 4 months follow-up. We therefore advocate open reduction internal fixation in humeral shaft fractures with isolated radial nerve palsy, especially if the fracture was displaced. Open reduction and plating of these fractures will relieve the compression on the radial nerve by the displaced bony fragment, allowing for potential recovery.

We also advise exploration of the radial nerve in these cases, as the radial nerve may be trapped beneath the bony fragment. We explored all our initial radial nerve palsies via an anterolateral approach. The type of approach for radial nerve exploration would depend on the location of the fracture site. In our series, all our primary radial nerve palsies occurred over the middle third of the shaft of the humerus. In our series, none had an actual laceration. Three had evidence of slight contusion of the nerve. The radial nerve was found entrapped between the bony fragments in the other 2 cases.

The issue of secondary radial nerve palsy[7,8] i.e. nerve palsy that develops after surgery is less controversial. The risk of nerve entrapment at the fracture site is real. Unless the surgeon was confident that the radial nerve was free and intact intraoperatively, he should perform an open exploration should radial nerve palsy occurred after surgery. In our series, we had 3 reported cases of secondary radial nerve palsies. One had re-exploration, via the posterior approach two days later. The radial nerve was found to be intact intra-operatively. The other 2 cases were observed and did not have radial nerve exploration as the surgeon was sure that the cause was transient neuropraxia due to traction intra-operatively. Follow-up of these 3 cases revealed full return of radial nerve function.

In contrast, median nerve palsy did not have such a good outcome on follow-up. The only patient in our series who had transected median nerve and brachial

artery had a poor outcome. On follow-up, there was only partial recovery of his median nerve. There was residual weakness of his wrist and hand as well as numbness of his hand over the median nerve distribution.

The majority of our patients were operated on via an anterolateral approach[8] (27 out of 35 cases). This approach is ideal for the proximal two-thirds of the shaft of the humerus. In patients with multiple trauma, this approach is advantageous for the patient and the anaesthetist because the patient is in a supine position. One must be aware of the radial nerve which traverses laterally and pierces the lateral inter- muscular septum to lie in an anterior plane. The musculocutaneous nerve must be protected too. One must place the plate anterolaterally and not medially because of two reasons: medial plate position may endanger the musculocutaneous nerve and brachial artery because of dissection in a medial direction to allow the placement of the plate. Plates positioned medially may not effectively counteract the forces of the biceps. The posterior approach involved splitting the triceps. It is usually indicated in the distal third of humeral shaft fractures. The patient needs to be in a lateral position for this approach, which may pose a problem in multiple injuries. It is important to isolate the radial nerve completely before placement of the plate, otherwise there is a risk of nerve entrapment beneath the plate. The posterior surface of the distal third of the humeral shaft is flat and allows for easy plate placement. In contrast, it is difficult to position a plate anterolaterally in the distal third of the shaft of the humerus.

The traditional choice of implant used is the broad 4.5 mm dynamic compression plate,[8] similar to the one used for femoral shaft fractures. It has been mentioned that screws on a broad 4.5 mm dynamic compression plate are placed in different planes, reducing the possibility of splitting of the humeral shaft. Furthermore, the broad dynamic compression plate is said to withstand torsional forces better than a narrow 4.5 mm dynamic compression plate.

However, recent series quoted good results using AO narrow 4.5 mm dynamic compression plate.[15] Furthermore in our Asian population, the dimension of the humerus is considerably similar, especially in females. In our experience, the broad 4.5 mm dynamic compression plate sits too proud on the humeral shaft, especially on the anterolateral position. We have now utilized AO narrow 4.5 mm dynamic compression plate in most of our cases. In our series, 32 cases (91%) were plated using the narrow dynamic compression plate.

Our patients, like other series on operative treatment, were different from those treated conservatively. The presence of open fractures, multiple trauma and neurovascular deficits constitute risk factors for higher postoperative complications. A good surgical outcome could be compromised.

The results of surgical plating of humeral shaft fractures in our series are comparable to other series[5-8] using AO plating techniques, as well as those treated conservatively, or other AO techniques e.g. intramedullary nailing. The incidence of complications (non-union, infection, repeat surgery and radial nerve palsy) was low and comparable to other reported studies. Return to function was good in the majority of cases (89%), comparable to other similar studies.

In conclusion, open reduction internal fixation of humeral shaft fractures gives good results provided correct indications and principles of AO fixation are adhered to. It provides greater patient comfort and is a good alternative to conservative treatment in a selected group of patients: open fractures, multiple trauma, displaced fractures, proximal or distal fractures, delayed or non-union, pathologic fractures and fractures with neurovascular deficits.

REFERENCES


1. Böhler L. Gegen die operative Behandlung von frischen Oberarmschaft br(chen. Langenbecks Arch Klin Chir 1964; 308:405.
2. Ekkernkamp A, Muhr G. Ist die operative Behandlung frischen, geschlossener oberarmschaft—brüche ais Routinererfahren vertretbar? Zentralbl Chir 1987; 112:81.
3. Nast-Kolb D, Schweiberer L. Wandel und Fortschritt in der FrakturBehardlung des Oberarmschaftes. Orthopäde 1989; 18:208.
4. Sarmiento A, Kinmann P, Galvin E. Functional bracing of fractures of the shaft of the humerus. J Bone Joint Surg 1977; 59A:596-601.
5. Bell M J, Beauchamp C G, Kellom J K. The results of plating humeral shaft fractures in patients with multiple injuries: The Sunnybrook experience. J Bone Joint Surg 1985; 67B:293-6.
6. Foster R J, Dixon G L, Bach A W, Appleyard R W, Green T M. Internal fixation of fractures and non-union of the humeral shaft. J Bone Joint Surg 1985; 67A:857-64.
7. Griend R V, Tomasin J, Ward E F. Open reduction and internal fixation of humeral shaft fractures. J Bone Joint Surg 1986; 68A:430-3.
8. Heim D, Herkert F, Hess P, Regazzoni P. Surgical treatment of humeral shaft fractures—the Basel experience. J Trauma 1993; 35:226-32.
9. Klenerman L. Fractures of the shaft of the humerus. J Bone Joint Surg 1966; 48B:105.
10. Packer J W, Foster R R, Garcia A, Grantham S A. The humeral fracture with radial nerve palsy: Is exploration warranted? Clin Orthop 1972; 88:34-8.
11. Pollock F H, Drake D, Borill E G, Lorraine D, Trafter P. Treatment of radial neuropathy associated with fractures of the humerus. J Bone Joint Surg 1981; 63A:239-43.
12. Rüedi T, Moshfegh A, Pfeiffer K M, Allgower M. Fresh fracture of the shaft of the humerus—conservative or operative treatment? Reconstr Surg Traumatol 1974; 14:65-74.
13. Titze A. The operative treatment of fractures of the shaft of the humerus. Reconstr Surg Traumatol 1974; 14:75-83.
14. Nast-Kolb D, Schweiberer L, Betz A. Die Operative Versorgung der Humerusschaft frakturen. Unfallchirurg 1985; 88:500.
15. Bezes H, Massart P, Faitg B. 273 osteosyntheses de la diaphyse humerale par plaque vissee. Bande video. Montreal: SICOT, 1990.