

# Minimally invasive percutaneous osteosynthesis for complex metaphyseo-diaphyseal humeral fractures

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## Abstract

### Background

Complex metaphyseo-diaphyseal fractures of the humerus shaft are difficult to treat with closed intramedullary nails. On the other hand, open reduction and fixation by classic plates require large incisions with negative effect on vascularity and vitality of bone fragments. The purpose of the current study was to assess the outcome of minimally invasive percutaneous plating of complex metaphyseo-diaphyseal humeral fractures.

### Patients and Methods

Eighteen patients with complex proximal humeral fractures with diaphyseal extension were operated upon using long PHILOS plates, through percutaneous minimally invasive technique. There were 12 males and 6 females with average age of 45 years (range 32 to 56 years). All fractures were acute with average time to fixation 3.2 days (range 1-6 days).

### Results

complete union was obtained in all cases in good alignment and with good shoulder and elbow function. Average time of union was 15 weeks (range 9-21 weeks). Two cases developed post-operative radial nerve palsy that was recovered after 3 weeks in the first case and 9 weeks in the second case. There were no obvious neurovascular injuries, nor major complications.

### Conclusion

Mini-invasive percutaneous plating for complex metaphyseo-diaphyseal humeral fractures is feasible, safe, with good clinical outcome. There were no obvious neurovascular injuries, nor major complications.

### Keywords

Minimal invasive plate osteosynthesis, humeral fractures, percutaneous plating, complex humeral fractures.

## Introduction

The main line of treatment of most humeral shaft fractures is conservative by using different humeral braces and splints[1, 2]. However operative fixation is indicated in certain patient's groups; poly trauma, obese, in compliant with long splinting periods, and in certain fracture types; unacceptably reduced fractures, and other complex and segmental fractures[3].

Complex metaphyseo-diaphyseal fractures of the humerus are difficult to treat with closed intramedullary nails[4, 5]. On the other hand, open reduction and fixation by classic plates requires large incisions with negative effect on vascularity and vitality of bone fragments.

Understanding of the biology of fracture healing has led to change of the philosophy of internal fixation with more respect to the soft tissue and the vascularity of fracture fragments. Minimally invasive plate osteosynthesis (MIPO) principles have been used for more than 2 decades in almost all long bone fractures. Con-

trary to fractures of tibia and femur, MIPO application in fracture humerus was not popular. This may be due to surgeons' concern from neurovascular injury and safe zones.

Many anatomic, cadaveric studies have shown safe anterior and anterolateral percutaneous plating of the humerus[6-8]. However, there is paucity in clinical case series. The aim of the current study is to assess outcome of minimally invasive plate osteosynthesis in complex metaphyseo-diaphyseal humeral fractures.

## Patients and methods

A prospective study conducted in Benha University hospital between May 2012 and January 2015. Eighteen patients with acute, complex proximal humeral fractures with diaphyseal extension were included in the current study. The study was approved by ethical committee review board of Benha university and all patients were consented preoperatively. Exclusion

criteria included associated radial nerve palsy, open fractures, and fractures extending to humeral head or elbow joint.

There were 12 males and 6 females with average age of 45 years (range 32 to 56 years). All fractures were acute with average time to fixation 3.2 days (range 1-6 days). The mechanism of injury was motor car accident in 14 cases and fall outstretched hand in four cases. All patients were operated upon in Benha University hospital, using long proximal humeral internal locking system (PHILOS) plates.

### Surgical technique

The patients were positioned supine on a translucent orthopedic table with the arm held in abduction 30 degrees, with access to intraoperative image intensifier.

The proximal incision was about 5cm from anterolateral angle of the acromion in line of the humerus. The deltoid was splitted between anterior and middle fibers and stopped 5cm from the acromion to avoid axillary nerve injury, with dissection and elevation of the deltoid muscle from the proximal humerus. The axillary nerve was not exposed but palpated and gently elevated and protected by surgeon's index finger while submuscular tunneling was done gently using long periosteal elevator or the plate with attached sleeves proximally.

The distal incision was done between lateral border of the biceps and the brachioradialis muscles, followed by splitting the brachialis with the lateral half protecting the radial nerve that was not dissected. No bone elevators were used but only gentle retraction to avoid radial palsy. Tunneling was completed from distal to proximal followed by application of the plate from proximal to distal while elevating and protecting axillary nerve by surgeon's finger.

Reduction was achieved by traction and manipulation while the position was checked by image (Fig 1B,C). The plate was positioned 1 cm lateral to the bicipital groove and fixed first proximally using k wires (fig 1D). A cortical none locked screw was then fixed distally. If reduction is not satisfactory, a cortical reduction screw may be used through stab incision to improve reduction by pulling the humerus to the plate (fig 1E). A proximal screw was then inserted fol-

lowed by application of the rest of proximal and distal screws either locked or none locked (Fig 1 F,G).

A: Preoperative xray showing the fracture, B: Intraoperative Fluoroscopic image, C: Intraoperative Fluoroscopic image after trial reduction, D: Intraoperative Fluoroscopic image after tunneling of plate and insertion of proximal K wire, E: Intraoperative Fluoroscopic image with drilling of the distal screw, F Intraoperative Fluoroscopic image with proximal screws fixation, G: Intraoperative Fluoroscopic AP view after fixation, H: Intraoperative Fluoroscopic Lateral view after fixation.

### Postoperative follow up

Postoperatively, patients used a humeral brace and gentle active range of shoulder and elbow motion (ROM) was allowed as tolerated. Patients were evaluated postoperatively at 2, 6weeks then every 3 weeks till union and then at 6 and 12 months.

Radiographic evaluation included anteroposterior and lateral radiographs. Union was defined by crossing callus in at least three cortices. Anatomic alignment was defined as 5 degrees or less angulation of the humerus axis. ROM of the elbow and the shoulder as well as DASH score were recorded at 12 months.

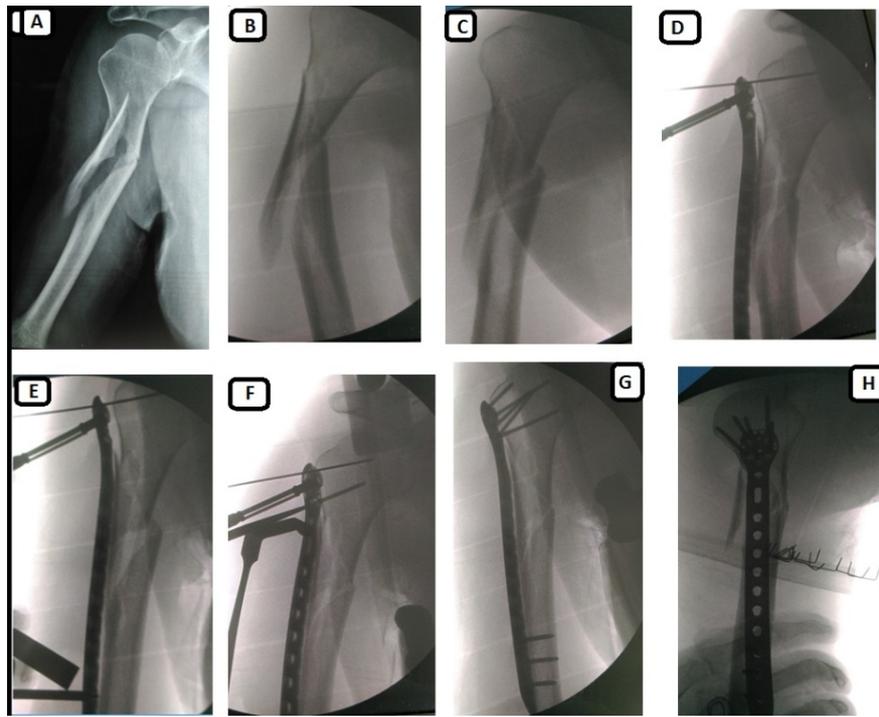
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### Results

The average operative time was 57.8 minutes (range, 45 to 78). All fractures united at an average time of 15 weeks (range, 9 to 21). Alignment was anatomic in 10 patients, 10 degrees' valgus in six patients and 10 degrees varus in two patients.

The average postoperative elbow flexion was  $131.3 \pm 13.6$ , and elbow extension  $6.3 \pm 3.9$ . The average postoperative shoulder flexion was  $153 \pm 36.6$ , and abduction  $158 \pm 10.6$ . The average postoperative Quick DASH score was  $25.3 \pm 6.6$ .

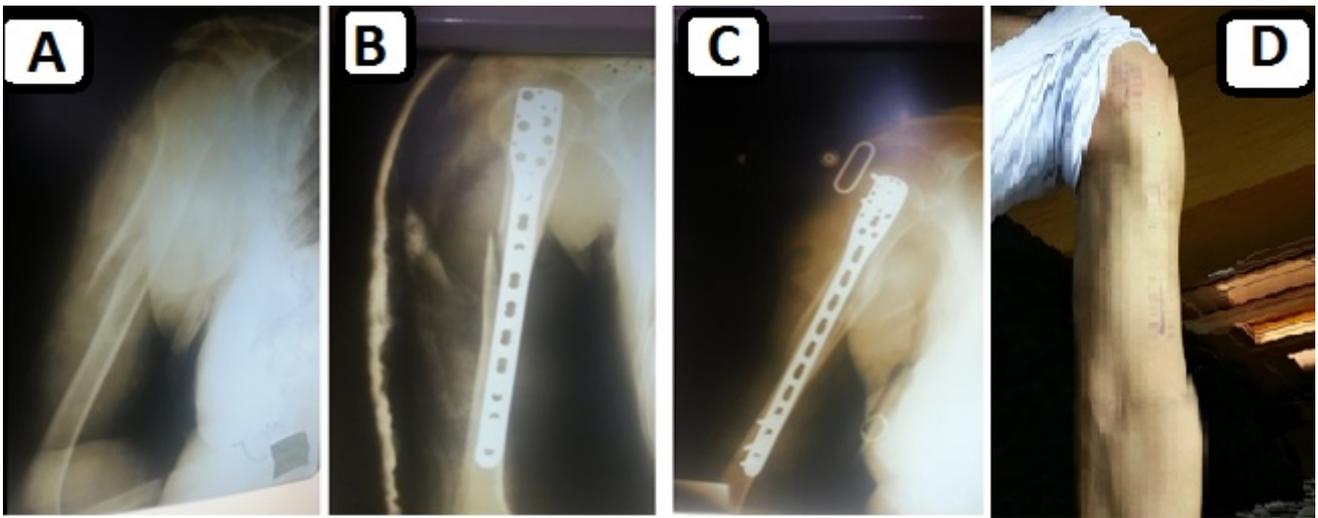
Two cases developed post-operative radial nerve palsy that was recovered after 3 weeks in the first case and 9 weeks in the second case. No axillary nerve injuries were recorded. Other complications included superficial infection in one case that was treated by early local debridement and antibiotics. Fig 2,3 demonstrate 2 cases of the series.



**Figure 1:** Intraoperative radiographs demonstrating percutaneous humeral plating technique



**Figure 2:** A: Preoperative AP radiograph  
B: Preoperative lateral radiograph  
C: immediate postoperative radiograph  
D: postoperative AP radiograph after union  
E: postoperative lateral radiograph after union



**Figure 3 :** A: preoperative xray, B immediate postoperative x ray, C: xray after union, D: photograph showing the scars.

## Discussion

Percutaneous submuscular plating of long bones have gained popularity in the last decades especially with the introduction of locked plates and MIPO techniques with the advantages of relative stability and biological fixation and less soft tissue compromise. Anatomical studies well described the course of axillary and radial nerve[9], and cadaveric studies have demonstrated safety of submuscular plating of the humerus[6-8]

Fernandez[10] published the first case series of MIPO of the humerus with good clinical results. However, he demonstrated that a helical plate should be used to fit the lateral surface of the proximal humerus and the anterior surface of the humeral shaft. Such helical plate is not commercially available in many places and twisting conventional plates is very difficult. With the popularity, of locked plates and PHILOS plates, precise molding of the plate was not needed and straight plates could be used in percutaneous plating of the humerus.

In the current series, we treated 18 complex proximal humeral shaft fracture extending to the head and the diaphysis using long PHILOS plates applied using MIPO technique, avoiding extensive soft tissue dissection and minimizing damage to the periosteal blood supply of the comminuted bony fragments, achieving union in all cases at an average time of 15 weeks (range, 9 to 21) that is comparable to time obtained in conservatively treated fractures.

Recent studies using long PHILOS plates have shown comparable results. Rancan et al. used Long PHILOS plates in management of 29 patients with metadiaphyseal fractures of the proximal humerus using MIPO technique. Union was achieved in all patients. He re-

ported one revision and no neurovascular injury[11]. Brunner et al. treated 15 patients with percutaneous PHILOS plates, and achieve union in 14 cases with no secondary displacement or neurovascular complications[12].

Iatrogenic radial nerve injury is a major concern in the treatment of humeral shaft fractures. Rates of postoperative radial palsy of about 7% have been reported after open reduction and internal fixation[13]. Observation for a minimum of 4 months was recommended before exploration as most injuries are neuropraxia that recover spontaneously[14]. In the current series, two cases (11%) of postoperative radial palsy were reported that were completely recovered at 3 and 9 weeks. Similar minimally invasive anterior humeral plating studies reported no cases of radial palsy denoting safety of the technique with low risk of permanent iatrogenic radial nerve injury.

The main limitation of the current study is the relatively small number of patients ( $n = 18$ ), and the study design being non-controlled providing a low level of evidence. Comparative studies using alternative implants, and larger number of patients is recommended.

## Conclusion

The results obtained in the current study have shown that mini-invasive percutaneous plating of complex metaphyseal-diaphyseal humeral fracture is feasible, safe, and efficient, with complete union in all cases in good alignment and with good shoulder and elbow function. There were no obvious neurovascular injuries, nor major complications.

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