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Research

# Fixation of humeral shaft fractures using minimally invasive plate osteosynthesis with two screws on each side, are results promising?

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**Statistics**

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Abstract

Aim: To assess the radiological and funtional outcomes of minimally invasive plate osteosynthesis in treating diaphyseal humeral fractures using a plate with only two screws (relative stability)on either side of the fracture.
Material and Methods: A prospective study was conducted on 20 patients, which included patients with humeral shaft fractures treated by minimally invasive plating from September 2019 to June 2021. All patients were handled using a minimally invasive approach, closed reduction was performed, and 10 to 13 holes 4.5 mm plates were used over the anterior aspect of the humerus in bridging mode. Shoulder and elbow functions were evaluated at every follow-up using the University of California at Los Angeles Shoulder Score (UCLA) and Mayo Elbow Performance Score (MEPS).
Results: 16 men and 4 women comprised the study's twenty patients who were tracked for at least 12 months. Age was 34.2 years on average (range, 18 years-60 years). Eight of 20 patients (40%) had fractures on the dominant side. The average surgical time was 69.1 minutes (range, 50 min-90 min). The average radiological fracture union took 13.6 weeks to occur (range: 12 weeks-20 weeks). According to UCLA scores, shoulder function was excellent in 13 cases (65%), good in 7 cases (35%) at one year follow up.19 patients (95%) had excellent Mayo elbow performance score at one year follow up. Conclusion: The MIPO approach for treating humeral shaft fractures provides good functional outcomes and should be regarded as a successful, cosmetically enhanced surgical option. When the surgeon is skilled in the technique, this approach is a safe and less invasive method for all forms of humeral shaft fractures.
Keywords: Humerus; Screws; Technique

## INTRODUCTION

Numerous studies have shown that nonsurgical therapy is ineffective for AO/OTA type A and long oblique fractures [1]. Surgery has been implemented in patients with humeral fractures to improve rehabilitation and promote early joint mobility [2]. As soft tissues are preserved in MIPO, healing is predictable. Absolute anatomical reduction that compromises soft tissue and, in turn, vascularity, is a trend that is quickly losing favor. There is a biological cost for precise reduction and absolute stable fixation [3]. It is becoming more acceptable for fractures to be biologically fixed when soft tissue is preserved, and the reduction is close to acceptable. The goal should be an early and acceptable functional outcome for the limb, not just healing in the anticipated timeframe [4]. Biological fixation is demonstrably superior to secure mechanical fixation in all relevant respects, and recently, the MIPO method for treating humeral shaft fractures has yielded encouraging outcomes [5-9]. MIPO was initially created for use in the tibia and femur; subsequently, Apivatthakakul promoted its use in the humerus in 2005 [10]. It is centered on Hunter and Haller's theory, which holds that bone nonunion happens as a result of vascular damage at the fracture site [11]. By using the plate as an extra medullary splint, MIPO bridge plating fixes the two major fragments while leaving the intermediate zone unaffected. Minimally invasive osteosynthesis with plates is based on relative stability at the fracture site, with little harm to the surrounding soft tissues. Infection risk and nonunion are decreased by minimal soft tissue manipulation around the fracture, and relative stability at the fracture site (by using two screws on either site of the fracture site) encourages secondary healing and formation of the bone callus [12,13]. Throughout the course of a year-long follow-up, we assessed the radiological and functional results of the MIPO technique for humeral fractures.

## METHODS

This prospective study was conducted in the Department of Orthopedics, Government Medical College, Srinagar, J&K, India, in patients with humeral shaft fractures from September 2019 to June 2021, following approval by the institutional ethical committee. Informed consent was obtained from all patients. This study included patients who had diaphyseal humeral shaft fracture and fulfilled the inclusion criteria. All patients were handled using the minimally invasive approach, closed reduction was done, and 10 to 13 hole 4.5 mm locking compression plates was used over the anterior aspect of humerus in bridging mode with two screws on either side of the fracture.

INCLUSION CRITERIA

1. Age > 18 to < 65 years.
2. AO/OTA type A, B, C
3. Open type 1, 2 and type 3a (Gustilo and Anderson classification)
4. Polytrauma patient
5. Floating elbow
6. Bilateral humeral shaft fractures

EXCLUSION CRITERIA

1. Vascular insufficiency of limb
2. Pathological fractures
3. Grade 3b and c open fractures
4. Fractures more than 3 weeks old

Operative technique:

After a comprehensive assessment of the patient the fractured arm was supported with a side-arm rest that was fixed to the operating table while the procedure was performed with the patient in the supine position. Subsequently, the fractured arm was prepared and draped. To protect the radial nerve and relax the arm muscles, the arm was maintained in full supination with a few degrees of flexion during dissection [5]. Proximal and distal incisions were then marked using a marking pen (Figure 1). Initially, a distal incision of approximately 2 cm-3 cm in length was made, centered above the elbow crease. The musculocutaneous nerve was apparent after retraction of the biceps medially (Figure 2).

**Fig. 1.** Depicts marking of proximal and distal incision

**Fig. 2.** Showing distal incision with musculocutaneous nerve (White arrow)

The brachialis muscle fibers were divided, allowing access to the humerus. The musculocutaneous and radial nerves were retracted along the medial and lateral halves of the brachialis, respectively. Retraction was gently performed to prevent nerve palsy. For the proximal incision, the space between the medial border of the deltoid and lateral border of the proximal part of the biceps was palpated. 5 cm distal to the front portion of the acromion process, a 2 cm-3 cm proximal incision was made, and the dissection was then continued all the way down to the humerus. By advancing the tunneling tool deep into the brachialis from the distal to the proximal incision, a sub brachial tunnel was created (Figure 3). Owing to the close blending of the brachialis and deltoid muscle fibers along the anterolateral face of the tunnel, some difficulties were experienced during the passage of the tunneling tool in the proximal region of the tunnel.

**Fig. 3.** Showing making of sub muscular tunnel using instrument

These muscle fibers were cut at the tip of the tunneling tool, allowing it to pass through. The tunneling instrument was touched and moved along the anterior or slightly anteromedial aspect of the humerus to prevent damage to the radial nerve in the lateral aspect of the distal humerus. The plate was pulled from the proximal to distal incision while being attached to the tunneling tool at the proximal location. Pronation of the forearm brings the radial nerve closer to the plate than supination [14]. The 4.5 mm LCP plate was fixed preliminary to the bone with K-wires (Figure 4).

**Fig. 4.** Showing preliminary fixation of plate using k wires

Fracture reduction was achieved through manual manipulation, traction, and abduction of the shoulder. Reduction of the fracture was confirmed under fluoroscopy (Figures 5 and 6). Because reduction was performed blindly, rotation and alignment were maintained using the step sign utilized in the distal femur [10]. The construct was made less rigid using two screws per fracture fragment [15,16]. By using two screws in each fragment, the overall flexibility of the construct was increased, which increased the micro motions at the fracture site, which in turn promoted secondary healing, which was better than primary healing [17,18]. Patients were followed-up every two weeks for the first 2 months and monthly thereafter. UCLA and MEP scores were used to evaluate shoulder and elbow function during follow-up till one year. The union was defined as visualization of at least three cortices on anteroposterior and lateral radiographs of the humerus [19,20].

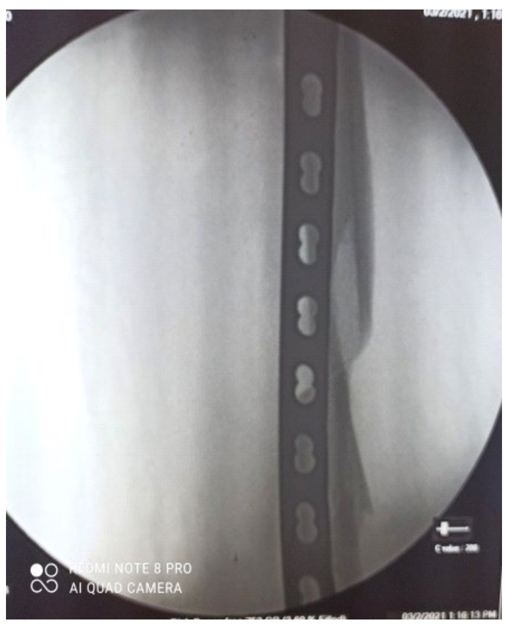



**Fig. 5.** Showing fluoroscopy picture of fracture of alignment in anteroposterior view


**Fig. 6.** Showing fluoroscopy picture fracture alignment in lateral view

Statistical analysis:

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean ± SD and categorical variables were summarized as frequencies and percentages.

## RESULTS

This study included 20 patients with fracture shafts of the humerus. The patient was treated with MIPO for 12 months. The majority of the patients in this study were males. The male-to-female ratio in this study was 4:1, with 16 males (80%) and 4 females (20%). Eight (40%) patients had fractures of the right humerus and 12 (60%) had fractures of the left-sided humerus. The age group ranged from 18 to 60 years, with a mean age of 34.2 years. Of the 20 patients, five (25%) had other associated injuries.1 (5%) had a phalangeal fracture (hand), one (5%) had preoperative radial nerve palsy, one (5%) had compression fracture L1, one (5%) had terrible triad injury elbow (ipsilateral), and one (5%) had femoral shaft fracture. The remaining 15 patients had sustained isolated humeral shaft fractures. Sixteen (80%) patients sustained a fracture due to high-energy trauma, 3 (15%) patients had a fall from a height, and 1 (5%) sustained trauma due to a fall from a standing height. The maximum number of patients was classified as 12A2b 4(20%) and 12B2b 4 (20%). The duration of surgery ranged from 50 to 90 minutes, with an average of 69.1 minutes. The average union time for fractures in this study was 13.6 weeks (range 12 weeks-20 weeks), and the union rate was 100%. Of the 20 patients, 19 (95%) had an excellent MEP score, and only one (5%) had a good score at 1 year (final follow-up). The mean MEP score for the elbow was 91.3. None of the patients developed post-operative elbow stiffness. The plate used in this study was a 4.5 mm locking compression plate and ranged from 11 to 14 holes, with 12 holes being the most commonly used in 13(65%) patients. Shoulder function was assessed by UCLA scoring, with a mean score of 34.3 in this study. In this study of 20 patients, 13 (65%) had excellent scores and 7 (35%) had good scores at the year follow. Two patients developed shoulder stiffness in the early post-operative period because of noncompliance with the postoperative physiotherapy schedule. Supervised physiotherapy was started in these patients, and they all regained normal Range of Motion (ROM), while no patient developed nonunion. One patient showed delayed union due to excessive traction at the time of plate fixation, leading to distraction at the fracture site. No postoperative infections were observed. Two patients (10%) developed postoperative radial nerve palsy which resolved spontaneously in due course of time (within three months). These cases occurred in the initial stages of the study, but with time, when the surgeon became familiar with the technique, no other patient developed this complication. Cock-up splints were provided to these patients until they regained normal function. Two patients developed implant-related complications 1. Plate back out was seen in one patient in the early postoperative period because a larger drill bit was used for screws, which united uneventfully. 2. Plate was placed on lateral surface of humerus instead of anterior surface). One patient developed hypertrophic scarring (Table 1)

**Table 1.** Showing clinical details of patients

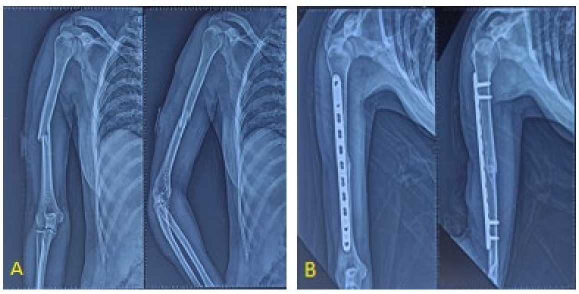
| Side Involving | Associated Injuries | AO Classification | Plate Size (no. of Holes) | Surgical Time(min) | Union Time (Weeks) | MEPS | UCLA Shoulder | Mal Alignment | Complications |
|---|---|---|---|---|---|---|---|---|---|
| R | None | 12A2c | 12 | 90 | 20 | Excellent | Excellent | Nil | Malpositioning of plate |
| L | Phalangeal fracture | 12A3c | 13 | 90 | 12 | Excellent | Excellent | 10 degree angulation | Implant back out |
| R | None | 12B2b | 12 | 80 | 16 | Excellent | Good | Nil | Nil |
| L | None | 12A3b | 12 | 75 | 16 | Excellent | Good | 5 degree varus | Nil |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | Terrible triad | 12B2b | 12 | 70 | 20 | Excellent | Excellent | Nil | Delayed union |
| L | None | 12A2a | 12 | 70 | 12 | Excellent | Good | Nil | Nil |
| R | Compression # L1 | 12A2a | 13 | 60 | 12 | Excellent | Excellent | Nil | Nil |
| L | Radial nerve palsy | 12A2b | 12 | 60 | 12 | Good | Good | Nil | Longer size plate |
| L | None | 12B2b | 12 | 75 | 12 | Excellent | Excellent | Nil | Radial nerve palsy |
| L | None | 12A2a | 12 | 70 | 12 | Excellent | Good | Nil | Nil |
| R | None | 12A2b | 11 | 60 | 16 | Excellent | Good | 10 degree varus | Nil |
| L | None | 12A1b | 12 | 50 | 12 | Excellent | Excellent | Nil | Hypertrophied scar |
| L | None | 12A3b | 12 | 60 | 12 | Excellent | Excellent | 5 degree varus | Nil |
| R | None | 12A1b | 12 | 65 | 12 | Excellent | Excellent | Nil | Nil |
| L | None | 12A2c | 11 | 70 | 12 | Excellent | Excellent | Nil | Nil |
| L | None | 12A3b | 12 | 65 | 12 | Excellent | Excellent | Nil | Radial nerve palsy |
| R | None | 12A1b | 13 | 65 | 12 | Excellent | Excellent | Nil | Nil |
| L | None | 12B2b | 12 | 70 | 16 | Excellent | Good | Nil | Nil |
| R | # Femoral shaft | 12A2b | 14 | 70 | 12 | Excellent | Excellent | 5 degree varus | Nil |
| R | None | 12A2b | 13 | 65 | 12 | Excellent | Excellent | Nil | Nil |

## DISCUSSION

The MIPO approach seems to be repeatable and appropriate for practically all types of shaft humeral fractures, despite the need for high surgical expertise and the length of time required for adaptation. Less disruption of bone vascularity, less soft tissue dissection, and lower risk of iatrogenic nerve injury are advantages over the traditional plate approach. Plates can be safely utilized anteriorly or anteromedially over the humeral shaft, bridging the fracture fragment, with fixation solely at either end of the plate and bone. Indirect reduction and plate placement are technically challenging and require extensive expertise. Because this is an anterior bridge plating, there is very little chance that the neurovascular systems will be harmed. Traditional plating carries a substantially higher risk of nerve damage [4]. Biological plating, which entails relative rather than absolute stability at the fracture site, is the basic idea behind this fixation. The fracture heals in the same way as the nailing callus forms. Moreover, typical plating, when fixation is anatomical, is applicable to the traditional 8 cortical purchase above and below the fracture location. However, the two screws above and below the fracture allow for micro motion at the fracture site, improving healing. This is because the study involved biological plating with secondary fracture healing via callus formation. The humeral shaft fractures in this series that were successfully fixed had indirect reduction fixation, which aimed to maintain bone alignment through a small incision and replace the absolute stability for relative stability. The average union time for fractures in our study was 13.6 weeks (range: 12 weeks-20 weeks), and the union rate was 100%. Concha JM et al. evaluated the reproducibility of MIPO technique in a regional hospital [21]. The union rate in their study was 91.5% (32/35), occurring for an average duration of 12 weeks. Esmailiejah et al. reported better results with MIPO than with open reduction(Figures 7 and 8). The average union time for the fractures in their study was 15.29 weeks [22]. Postoperative radial nerve palsy was observed in two (10%) cases, which was higher than that reported by Esmailiejah et al. and Huri et al., where radial nerve palsy was observed in 3% and 7.14% of patients, respectively [22,23].


**Fig. 7.** (A) Showing anteroposterior and lateral radiograph of fracture; (B) Radiograph showing union at fracture site; (C, D) Clinical pictures of patient at final follow up



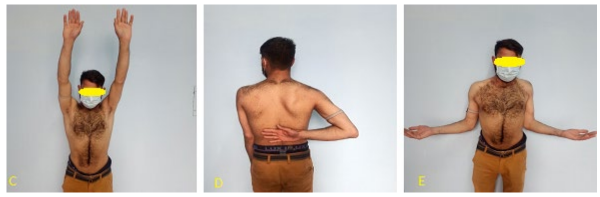




**Fig. 8.** (A) Showing anteroposterior and lateral radiograph of fracture; (B) Radiograph showing union at fracture site; (C, D, E) Clinical pictures of patient at final follow up

## CONCLUSION

Minimally invasive plate osteosynthesis is an effective procedure that yields excellent functional outcomes, with very few complications. The percutaneous technique provides an additional advantage of less operative time, less intraoperative blood loss, no wound complications, less damage to the soft tissues, less chances of nonunion, less incidence of radial nerve palsy, and improved cosmesis than ORIF.

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