

Bridge Plating of Humerus Shaft Fractures by Minimally Invasive Plate Osteosynthesis Technique: A Short-term study

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ABSTRACT

Background: Fractures of humerus shaft account for between one to three percent and 20 percent of all humeral fractures. Minimally Invasive Plate Osteosynthesis (MIPO) is a burgeoning therapeutic approach utilized to treat humeral shaft fractures. One of the primary advantages of MIPO is that it promotes fracture healing by maintaining soft tissue and periosteal circulation. **Objective:** The aim of the work was to determine the efficacy of bridge plating for humerus shaft fractures using the minimally invasive plate osteosynthesis method.

Patients and Methods: This short-term research study included a total of 15 patients presented with a recent humeral shaft fracture, chosen from the Department of Emergency, Misr University Hospitals, and received care surgically with MIPO.

Results: The present study showed that there was one patient had delayed union and no other postoperative complications. The MEPI scoring system. It is measured at patients' last follow-up. In the MIPO patients, 7 (46.7%) showed excellent results, 7 (46.7%) showed good results, 1 (6.7%) showed fair, and no case showed a poor outcome. According to the UCLA scoring system, 6 (40.0%) individuals showed excellent outcomes, 8 (53.3%) individuals showed good outcomes, 1 (6.7%) patient had a fair outcome, and no patient had a poor outcome.

Conclusion: depending on the result of our research it can be concluded that the MIPO method should be considered as a good choice for surgical treatment of diaphyseal humerus fractures.

Keywords: MIPO, Humerus shaft fracture, Bridge Plating

INTRODUCTION

Shaft humerus fractures account for about twenty percent of whole humeral fractures and one to three percent of all fractures in grownups⁽¹⁾.

Conservative control is still prevailing approach for humeral shaft fractures,⁽²⁾ despite the unsatisfactory outcomes associated with this method, such as shoulder impairment and non-union⁽³⁾.

A total of fourteen percent of the patients who underwent this treatment exhibited a restricted range of motion, while 12.6 percent demonstrated unification, characterized by angulation exceeding 8 degrees⁽⁴⁾.

Surgical techniques include plate osteosynthesis via minimally invasive method, internal fixation with compressive plate, and interlocking nail. When comparing rigid fixation with a plate to intramedullary anchoring, discomfort in the shoulder and limitations in movement are observed⁽⁵⁾. Contemporary gold standard for humerus shaft fractures is ultimate stability fixation with a dynamic compression plate via the posterior approach and open method⁽⁶⁾.

But there is a biological cost associated with precise reduction and absolute stable fixation. In contrast to a stable mechanical fixation, biological fixation has been demonstrated to be more effective^(6,7).

As a consequence, advancements and refinements were made to fissure biological fixation techniques, alongside the creation of stabilization systems that facilitate the attainment of biological fixation. MIPO is designed to achieve a stable fixation, that may increase union rate and decrease complications, for example

infection and radial nerve palsy induced by open plating. In contrast to IM fixation procedures, MIPO may offer potential benefits regarding shoulder function and intraoperative fracture management^(8,9).

The aim of our investigation was to assess the efficiency of bridge plating during minimally invasive plate osteosynthesis for humerus shaft fractures.

PATIENTS and METHODS

This short-term research study included a total of 15 patients presented with a recent humeral shaft fracture, chosen from the Department of Emergency, Misr University Hospitals, and received care surgically with MIPO. This study was conducted between (mention period e.g., June 2021 and January 2023).

Inclusion criteria: Fractures that were recent (within a week at most), displaced fracture with an angulation of more than 20° anterior, 30° varus, valgus, and more than 3 cm shortening, Patients Patient age ranged between 20-55 years. closed fracture without any neurovascular damage.

Exclusion criteria: Cases with fractures amenable for conservative treatment, old fracture, compound fractures and Concomitant other medical disease like malignancy, vascular insufficiency of upper limb, DM.

All the patients were subjected to the following: Clinical evaluation (General and Local examination), Laboratory investigations and X-Rays. Method of MIPO

Position of the case: individuals were in a supine position on operating table, with forearm in complete supination and the arm abducted to a 90° angle. On the operating table, image intensifier was positioned on the same side as the arm to be operated. (10, 11)

Incision: location of the incision was verified using an image intensifier and, if required, modified to be at a maximum distance from the site of the fracture.

Initially, palpation was performed on the distance separating medial border of deltoid muscle and lateral border of proximal portion of the biceps. Subsequently, a 3 cm proximal incision was created, situated approximately six cm distal to anterior portion of acromion process. Dissection was continued until reaching proximal humerus. A distal incision measuring 3 cm was performed along the lateral border of the biceps muscle, precisely five cm in proximity to flexion fissure of elbow.

It was possible to determine the distance among the brachialis and the biceps brachii. By retracting the biceps medially, the musculocutaneous nerve situated on the brachialis was exposed. After dividing brachialis longitudinally along its midline, the periosteum of the anterior cortex of the distal humerus was reached. Along with the medial half of the divided brachialis, the musculocutaneous nerve underwent retraction. In contrast, lateral half of brachialis functioned as a support to safeguard radial nerve.

Application of the plate:

After that, an extraperiosteal tube was made beneath the brachii. The distal to proximal incision was used to pass a conventional DCP or locked plate deep to brachialis. Bone quality and fracture comminution were considered while choosing the plate type. Because the brachialis and deltoid muscle fibers mix so closely along lateral side of tunnel at this point, the plate may have trouble passing through the proximal portion of the tunnel.

following preparation of anterior sub-brachialis tunnel; The picture enhancer showed the location and reduction of the plates. The patient's length was restored, and their varus or valgus angulation and rotation were corrected using manual traction. Using 2 mm K-wires, the plate was temporarily attached to the bone. The distal fragment's plate was secured with a locking screw once its location was verified to be central. The proximal fragment was similarly fastened. We added more screws to finish fixing it after we confirmed the reduction alignment on the picture intensifier.

Postoperative follow up:

Slings were utilized to support the arm. vascularity and carefully radial nerve function was inspected. Gently moving the individual's hand and elbow is often started after they are comfortable enough.

Quickly, aided range of motion exercises for the shoulder and elbow were included, although vigorous arm activity was avoided.

The cases came for a weekly follow up throughout 1st two weeks; At the two-week mark, the sutures were removed, and continued monthly for the following six months. Every visit was comprised of clinical and radiographic assessments to identify complications and determine the union and recovery of elbow and shoulder function as well as movement.

Ethical Considerations

The Ethics Board of Helwan University gave approval to the research. Written informed consent of all the participants was obtained. In line with the Declaration of Helsinki, which is the Code of Ethics of the World Medical Association, this research has been done in compliance with the principles that govern research including human subjects.

Statistical Methods

Both IBM's SPSS Statistics version 26 (IBM© Corp., Armonk, NY) and MedCalc® Statistical Software version 20 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2021) were utilized in order to conduct the analysis of the data under consideration. Categorical variables are presented in the form of counts and percentages, and the Pearson chi-squared test or Fisher's exact test is utilized to evaluate the variances that exist among the groups. The chi-squared test for trend was utilized to contrast ordinal data. Numerical variables are represented by their mean and standard deviation, and variances amongst groups are assessed utilizing the unpaired t-test. The Kaplan-Meier technique was employed for doing time to event analysis. The log-rank test is employed to contrast Kaplan-Meier curves. P-values below 0.05 are deemed to be statistically significant.

RESULTS

Table (1) illustrates the sociodemographic pattern of cases with humeral shaft fractures who had been admitted to the Hospital during the period of the study and treated with MIPO techniques. The mean age of the MIPO cases was 38.6 ± 10.4 years ranged between 20 and 55 years. Regarding sex, 60% of studied patients were females and 40% were males.

Table (1): Demographic characteristics of studied patient.

Variable		MIPO (n=15)
Age (years)	mean ± SD	38.6 ± 10.4
	Min-Max	20-55
Sex	Male	9 (60%)
	Female	6 (40%)

SD = standard deviation.

Table (2) and figure (1) demonstrate the AO grading of MIPO cases. in which, 26.7% was A1, 13.3% was A2, 20.0% was A3, 6.7% was B1,13.3% was B2, 6.7% was C1 and there was no one at C2 grade.

Table (2): Characteristics of fracture in two groups

Variable	MIPO (n=15)
Operated side	
Left	Six (40.0%)
Right	Nine (60.0%)
The mechanism of harm	
RTA	Eleven (73.3%)
FFH	Four (26.7%)
AO classification	
A1	Four (26.7%)
A2	Two (13.3%)
A3	Three (20.0%)
B1	One (6.7%)
B2	Two (13.3%)
C1	Two (13.3%)
C2	One (6.7%)
C3	zero (0.0%)

FFH= fall from height, RTA= road traffic accident

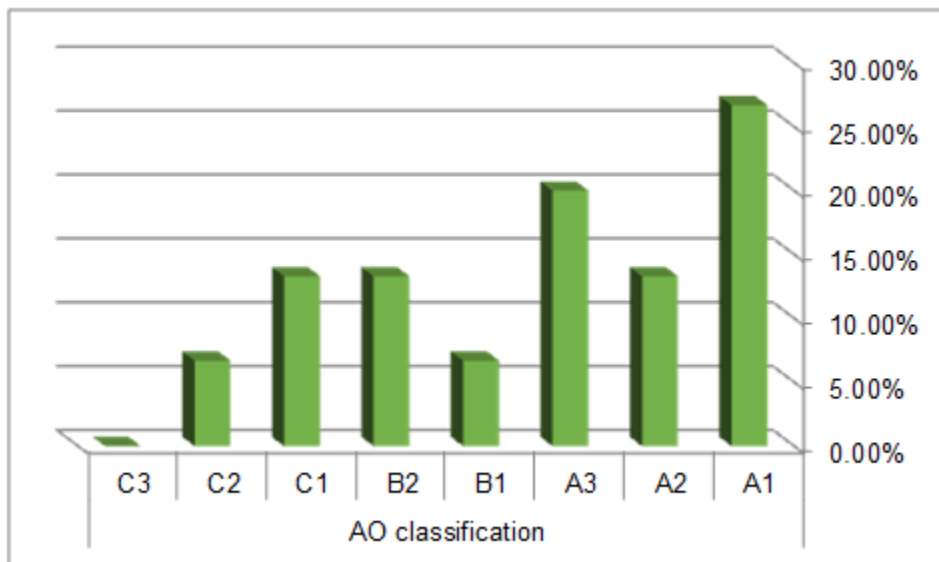


Figure (1): AO classification of the studied patients

Table (3) illustrates operative characteristics in studied patients. Operative time was with a mean value of 89.3 ± 14.2 min, Intraoperative radiation time was with a mean value of 84.3 ± 11.9 min and Operative blood loss was with a low mean value of 109.0 ± 10.0 .

Table (3): Operational data in studied patients.

Variable	MIPO (n=15)
	mean \pm SD
Operative time (min)	89.3 ± 14.2
Intraoperative radiation time (s)	84.3 ± 11.9
Operative blood loss (ml)	109.0 ± 10.0

SD = standard deviation.

Table (4) illustrates that, on examination of the cases in the follow-up period, the meantime taken to bone union was 16.1±2.2 weeks and the meantime taken to recommence routine daily activities was 3.9±0.5 months.

Table (4): Time to recommence routine daily activities and Time to bone union in two groups.

Variable	MIPO (n=15)
	Mean± SD
Time to bone union (weeks)	16.1±2.2
Time to recommence routine daily activities (months)	3.9±0.5

Table (5) and figure (2) reveal the MEPI scoring system. It is measured at patients' last follow-up. In the MIPO patients, 7 (46.7%) showed excellent results, 7 (46.7%) showed good results, 1 (6.7%) presented fair, and no case presented a poor outcome. According to the UCLA scoring system, 6 (40.0%) individuals presented excellent outcomes, 8 (53.3%) individuals presented good outcomes, 1 (6.7%) patient had a fair outcome, and no patient had a poor outcome.

Table (5): Functional result in studied patients.

Score	MIPO (n=15)
MEPI score, n (percent)	
Fair	one (6.7%)
Good	seven (46.7%)
Excellent	seven (46.7%)
UCLA score, n (percent)	
Poor	zero (0.0%)
Fair	one (6.7%)
Good	eight (53.3%)
Excellent	six (40.0%)

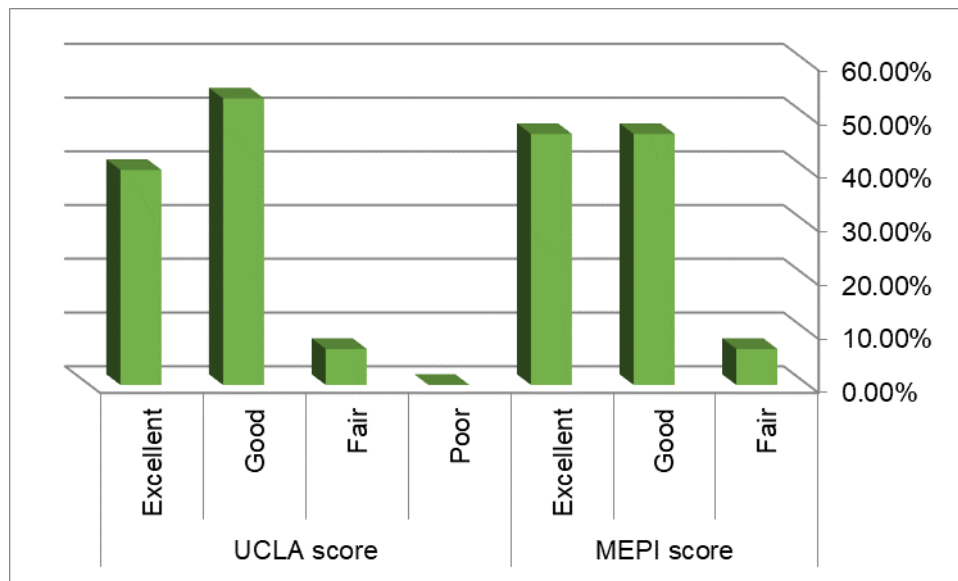


Figure (2): MEPI scores and UCLA scores of the studied patients.

Table (6) illustrates the Incidence of postoperative complications in studied patients. In which there was one patient had delayed union and no other postoperative complications.

Table (6): Occurrence of complications in studied patients.

Complication	MIPO (n=15)
Infection, n (%)	0 (0.0%)
Iatrogenic nerve injury, n (%)	0 (0.0%)
Non-union, n (%)	0 (0.0%)
Delayed union, n (%)	1 (6.7%)
Malunion, n (%)	0 (0.0%)
Need for bone graft, n (%)	0 (0.0%)

CASE PRESENTATION (figures 3a, 3b, and 3c)

- **Patient profile:** A female patient, 42 years old, housewife, had fallen from height. No pre-existing medical disorders and no previous operations.
- **Fracture grading:** fracture shaft humerus –AO grading: 12-A3
- **Treatment modality:** MIPO
- **Intra-operative complications:** None
- **Follow-up period:** six months
- **Complication:** None
- **Final result:** no infection, fracture united. After the operation, UCLA scoring of shoulder was excellent. MEPI scoring of elbows was excellent.

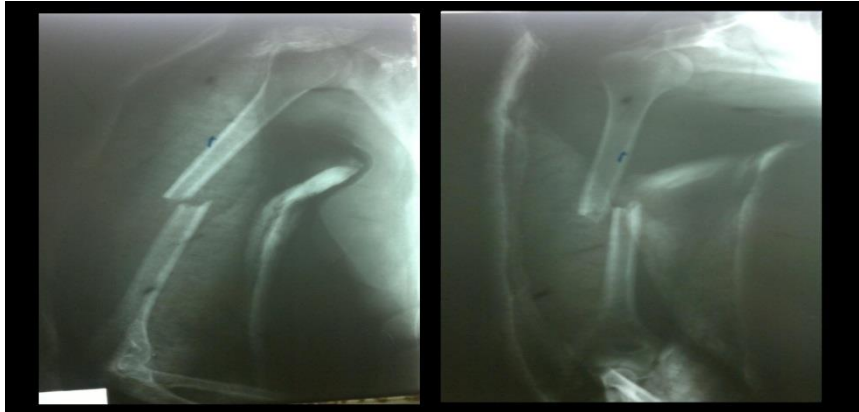


Fig. (3 a): prior operation X-ray

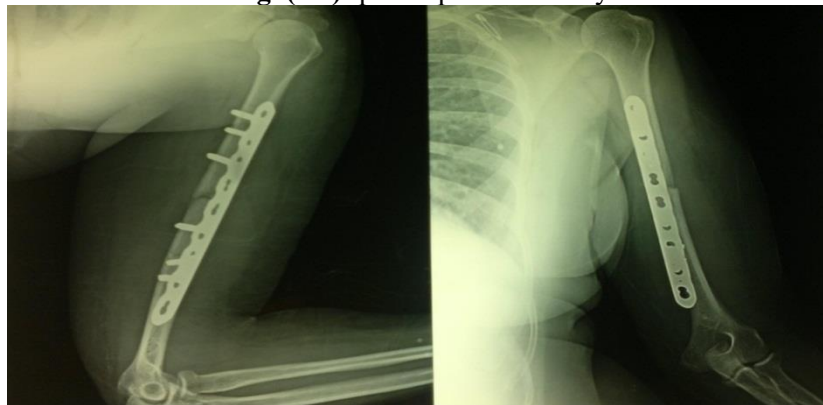


Fig. (3 b): Immediate after operation X-ray

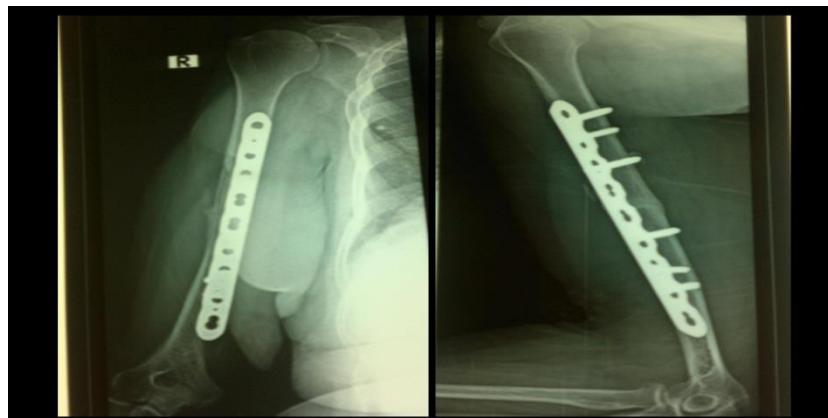


Fig. (3 C): X-ray of 6 months follow up showing full union of the fracture

DISCUSSION

The present study showed that ages of MIPO cases ranged between 20 and 55 years, with average value of 38.6 ± 10.4 years. Regarding sex, 60% of studied patients were females while 40% were males.

These results were agreed with **Patil et al.**⁽¹²⁾ who demonstrated that eighteen cases were man and seven were woman. The average age of cases was 37.7 years (variety eighteen to eighty years).

Also, our results were consistent with **Matsunaga et al.**⁽¹³⁾ who stated that that the mean ages of MIPO patients were 37.3 ± 14.7 . Otherwise, they reported that most patients were males (60%).

As well our results were also supported by **Kim et al.**⁽¹⁴⁾ who aimed to contrast the radiologic and clinical effects of MIPO and COP when treating noncomminuted humeral shaft fractures. Randomization divided 68 consecutive cases into two groups: those who received COP treatment (COP group; $n = 32$) and those who received MIPO treatment (MIPO group; $n = 36$). They reported that the mean age of MIPO cases was 40.6 (15–86) years and most of them were males.

The current findings observed that the AO grading of MIPO cases. in which, 26.7% was A1, 13.3% was A2, 20.0% was A3, 6.7% was B1, 13.3% was B2, 6.7% was C1 and there was no one at C2 grade. The most common operated side was right (60%). RTA was the most common injury.

These results were agreed with **Patil et al.**⁽¹²⁾ who demonstrated that A straightforward fall on the outstretched hand caused trauma in six cases, RTA in eighteen individuals, and an assault history in one patient. Each involved a closed fracture. A2 type accounted for eight individuals (thirty-two percent), A3 type for ten individuals (forty percent), and B1-B3, C1-C3 group for the remaining individuals, as classified by the AO.

Also, our results were consistent with **Matsunaga et al.**⁽¹³⁾ who reported that OTA/AO fracture type in MIPO cases (no. (%)) 38 (68%), 15 (27%), and 3 (5%) A, B, and C respectively.

Moreover, our results supported with **Kim et al.**⁽¹⁴⁾ who found that AO-OTA classification Type A, A1, A2, A3, Type B, B1, B2, and B3 was 19, 3, 4, 12, 17, 5, 8, and 4 cases respectively.

We found that operative time was with a mean value of 89.3 ± 14.2 min, intraoperative radiation time was with a mean value of 84.3 ± 11.9 min and Operative blood loss was with a low mean value of 109.0 ± 10.0 .

As well, our results were agreed with **Kim et al.**⁽¹⁴⁾ who found that the average surgery duration was 105 minutes in MIPO groups. In MIPO group, the average intraoperative radiation exposure time was sixty-eight seconds.

Zhiquan et al.⁽¹⁵⁾ stated the utilization of closed reduction in MIPO required the repetitive confirmation

of reduction states with an image intensifier, which required intraoperative radiation.

During fracture management, surgeons ought to exercise caution regarding their radiation exposure. With adequate personal radiation protection, such as the consistent usage of a thyroid shield and a radio-protective garment, radiation exposure can be reduced.⁽¹⁶⁾

Regarding the contrary of our findings **Patil et al.**⁽¹²⁾ demonstrated that the radiological exposure ranged across cases, with an average of 125.16 seconds with minimum of 98 shoots (=seconds) and maximum of 165 shoots per case.

The present study showed that the meantime taken to bone union was 16.1 ± 2.2 weeks and the average time taken to resume normal daily activity was 3.9 ± 0.5 months.

Our results supported with **Kim et al.**⁽¹⁴⁾ who found that mean union time was 14.6 weeks in MIPO group.

Our results in consistent with **Patil et al.**⁽¹²⁾ who found that the union duration was less than twelve to fourteen weeks for thirteen (52 percent) and 14–16 weeks for nine (36percent) cases.

Our results showed that the MEPI scoring system. It is measured at patients' last follow-up. In the MIPO patients, 7 (46.7%) showed excellent results, 7 (46.7%) showed good results, 1 (6.7%) presented fair, and no case showed a poor outcome. According to the UCLA scoring system, 6 (40.0%) individuals presented excellent outcomes, 8 (53.3%) individuals presented good outcomes, 1 (6.7%) patient had a fair outcome, and no patient had a poor outcome.

Our results were consistent with **Patil et al.**⁽¹²⁾ who demonstrated that the complication rate was 12 percent (3/25). 2(8 percent) patients callus was visible in less than four weeks, 12(48%) cases had callus visibility among six to eight weeks and 11(44%) cases had callus visibility in more than eight weeks. It was noted that the majority of the individuals had excellent seventeen (68%), Good five(20%) UCLA and three(12%) had fair UCLA.

Moreover, our results supported **Kim et al.**⁽¹⁴⁾ who found that even in cases of minor fractures, MIPO demonstrated an outstanding union rate. This may have been the result of the physiologic superiority that was associated with less stripping and the maintenance of vascularity. The present research showed that there was single case had delayed union and no other postoperative complications.

Our results were agreed with **Patil et al.**⁽¹²⁾, who showed that union was stated in all the twenty-five individuals, union rate was hundred percent.

Also, our results were consistent with **Matsunaga et al.**⁽¹³⁾ who reported that that 100% union in their cases.

Moreover, our results corroborated those of **Kim et al.**⁽¹⁴⁾ regarding open plating, where they observed no instances of nonunion and one delayed union for a 3.1 percent rate; however, nonunion was not observed in

MIPO, despite the limited sample size of participants in this investigation.

These findings align with prior research that has documented a nonunion rate ranging from 0% to 8.6% for MIPO (15, 17).

CONCLUSION

Depending on the result of our research it can be concluded that the MIPO method should be considered as a good choice for surgical treatment of diaphyseal humerus fractures.

DECLARATIONS

- **Consent for publication:** All authors agree to submit the work.
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of interest:** no conflicts of interest.

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