Original Article
Orthopaedics

A PROSPECTIVE STUDY TO EVALUATE FUNCTIONAL OUTCOME OF MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS (MIPO) IN DIAPHYSEAL HUMERUS FRACTURE

Nameet Panwar[1], Anurag Jain[1]

[1] - Senior resident, Department of Orthopaedics & Traumatology, MY Hospital, Indore

Corresponding Author
Dr. Anurag Jain
Senior resident,
Department of Orthopaedics & Traumatology, MY Hospital, Indore

Article submitted on: 11 October 2019
Article Accepted on: 12 October 2019

Abstract

Introduction: This study assessed clinical outcomes and complications in patients with humeral diaphyseal fractures treated using MIPO by means of plating.

Patients and Methods: 30 patients were treated with MIPO. Assessment of patients is done on the basis of union time, complication rate, blood loss, range of movement and activity by means of UCLA and MAYO Scores.

Results: Primary union was achieved in all patients. Mean time to union was 11.73 ± 3. Mean operation time is 60 min. We had 3 patients with complication which includes superficial infection in 1 patient which get resolved after culture specific antibiotics, Shoulder stiffness in 1 patient and delayed union in 1 patient which got united in 29 weeks. Functional outcome was good as per UCLA and MAYO Scores.

Conclusion: The MIPO technique achieves good results and less time for union in simple and complex fractures of humeral shafts. Although MIPO potentially has a radiation hazard, there is less blood loss and it reduces peri-operative complications with shortened operation time and minimal soft tissue dissection.

Keywords: *MIPPO, Diaphyseal Humerus Fracture, Anterior Bridge Plate*

Introduction:

Diaphyseal humerus fractures are common in orthopaedics, accounting for approximately 3% of all fractures and represent 20% of all humeral fractures[1–3].

Fractures of the shaft of humerus have been treated conservatively since ages, with good results. Sir John Charnley in his treatise "The closed treatment of common fractures "even states"it is perhaps one of the easiest major long bone fractures to treat by conservative methods"[3]. Most of the humeral shaft fractures are best treated non-operatively with fairly high union rates[4,5]. However not all humeral shaft fractures are eligible for conservative treatment and indications for operative management in some situations remains apart[6,7].

Historically used methods of conservative treatment include skeletal traction,abduction cast, coaptation splint, velpeau dressing, and hanging arm cast. All has its own advantages and disadvantages like joint stiffness and also it needslong period of rehabilitation to restore motion in the immobilized joints[6,8].

Operative intervention is indicated in special circumstances including failure of closed reduction, intra-articular extension, neurovascular compromises, floating elbow, pathological fractures, open fractures, bilateral humeral shaft fractures, and poly traumatized patients. With recent advances, encouraging results following internal fixation had led to the expansion of surgical indications.

There are various surgical intervention by which fracture shaft humerus is treated by means of plating osteosynthesis[9,10], intramedullary nails, or external fixation[10–12]. Although controversy exists over which is the better technique and implant, most authors believe that open reduction and internal fixation with a dynamic compression plate is a more reliable method.

The advantages include anatomical reduction of fractures and less interference to elbow and shoulder function[9,13]. The major disadvantages of this technique, however, are extensive soft tissue stripping and disruption of periosteal blood supply, which increase the risk of non-union and iatrogenic radial nerve palsies[14,15]. Humerus intramedullary nail is also consider as good implant as it is less invasive procedure but it associated with impingement at shoulder joint. It has been reported that humeral shaft fractures can be successfully treated with minimally invasive plate osteosynthesis (MIPO)[16–19.] This technique has advantages of less soft tissue dissection and avoids the need to expose the radial nerve; thus, there is also low risk of iatrogenic radial nerve palsies[17]. These advantages appear to indicate that MIPO is superior to conventional plating osteosynthesis.

In this study, we will review our experience of treatment of diaphyseal humerus fractures with Minimally invasive percutaneous plate osteosynthesis (Anterior Bridge Plate) to analyse the functional outcome.

Aims and Objective:

- To study and assess the end result in terms of functional outcome of the patients with diaphyseal humerus fractures treated by Minimally invasive percutaneous plate osteosynthesis (Anterior Bridge Plate).
- To evaluate the effectiveness and pitfalls of treatment of diaphyseal humerus fractures by Minimally invasive percutaneous plate osteosynthesis in terms of rate of union, complication rate, blood loss.

Material and Methods:

This study was done prospectively in the Department of Orthopaedics and Trauma Centre in J. A. Group of Hospitals, Gwalior (M.P.) from December 2015 to August 2017.

Sample Size:

Patients among the age group 16 years to 60 years were included in this study based on inclusion criteria and exclusion criteria and they were followed up, after the intervention till union. In this Prospective Study we study 30 diaphyseal humerus fractures treated with Minimally invasive percutaneous plate osteosynthesis (MIPPO) .

Inclusion criteria:

1. Age: >16yrs to <60yrs of both sexes.
2. Diaphyseal Humeral fractures (between 2 cm distal to surgical neck and 3 cm proximal to the Olecranon fossa) treated within 2 week by MIPPO
3. Patients with GA Grades I open fractures.

Exclusion Criteria:

1. Patients with GA grade II and III compound fractures.
2. Patients with pathological fractures.
3. Patients with neglected fractures of the humerus, with periprosthetic fractures or neurovascular compromise.
4. Fracture treated with any implant other than Minimally invasive percutaneous plate osteosynthesis (anterior bridge plate).

Pre-operative planning:

Detailed clinical history including mechanism of injury and patient's overall medical status, age and function and economical demands was taken and clinical examination was done for each patient. Routine blood and radiological investigations were carried out. Radiological examination included Antero-Posterior and lateral view of arm. The fractures were classified according to the AO/OTA classification[20], Gustilo-Anderson classification[21]

Data collection procedure included detailed study variable like preoperative and postoperative clinical, radiological, surgical and functional status of involved extremity.

Minimally Invasive Percutaneous Plateosteosynthesis (MIPPO):

Minimally invasive percutaneous plate osteosynthesis (MIPPO) means that plate is placed through small incision with as little dissection and stripping of soft tissue envelope as possible. It is also known as sub muscular, minimal incision and less invasive plating. Measures like smaller incisions, less soft tissue dissection, less periosteal stripping, use of intra-operative imaging or intra operative navigation preserve local blood supply, improving healing rates and reduce complications. In this study we did Anterior Bridge Plate by minimally invasive percutaneous plate osteosynthesis (MIPPO) technique. Both DCP and locking plates can be applied through MIPPO technique[22].

In this technique since there is no disturbance of fracture haematoma so there is no need of absolute reduction so there is relative stability due to which healing take place by secondary intention (indirect healing), it is also known as biological fixation.

Plate length should be two to three times bigger than length of the fracture in comminuted fractures and eight to ten times higher in simple fractures[23,24].

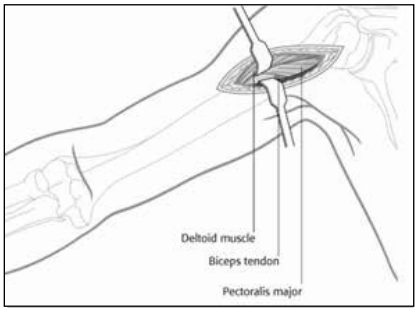
Number of screws:

Two screws on each side of the fractures are prerequisite for a stable construct. But, being on the safer side it is recommend to use three screws on either side so as to take care of chances of failure due to screw breakage. A plate screw density below 0.4 to 0.5 is recommended, this implies that less than half of the plate holes are occupied by screw[23,24]

Surgical Approach[25]:

Patient is in supine position, with arm resting on surgical table and elbow flexed to approximately 70 degree

A 3-cm incision between the proximal biceps and the medial border of deltoid, 6 cm distal to the anterior part of the acromion process was made. The cephalic vein lies in this interval. Identify the vein and protect it while dissecting through the interval. Dissect bluntly to the periosteal surface. Distally, a 3-cm incision was made along the lateral border of the biceps, approximately 5 cm proximal to the flexion crease. The site of incision was confirmed under the image intensifier and altered, if necessary, to be as far as away as possible from the fracture site. The biceps was retracted medially to expose the musculocutaneous nerve, which overlies the brachialis muscle. The brachialis muscle was split and the musculocutaneous nerve retracted medially, and the radial nerve was protected by the lateral half of the brachialis muscle. A sub-brachialis, extra-periosteal tunnel was created by passing an artery forceps, used as a tunnelling instrument, deep to the brachialis muscle from the distal to the proximal incision. Care was taken to pass the tunnelling instruments anteriorly or anteromedialy to avoid the chances of injury to the radial nerve. After creating the tunnel, anarrow locked compression plate or dynamic compression plate was passed deep to the brachialis. The plate position and reduction was visualized on the image intensifier. Manual traction was applied to restore length and correct varus or valgus angulation and rotation. The plate was temporarily fixed to the bone with 2-mm K-wires. Ensuring that the position of the plate on the distal fragment was central, it was fixed with a locking screw and, similarly, the proximal fragment was also fixed. After confirmation of the reduction, alignment on the image intensifier other screws were inserted to complete the fixation.



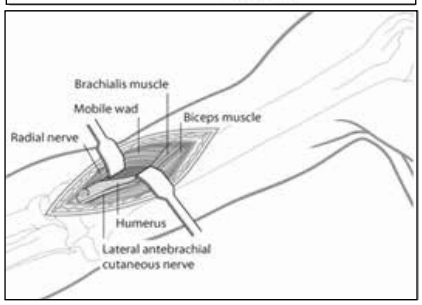


Figure 28 : Clinical Images of Surgical Techniques of MIPPO

Follow-up:

- Patient discharged on 3rd or 5th day of post op depending on suture line condition. Suture removal was done at 12-14 days in and from second day, isometric exercises were carried out.Regular follow up at every fortnight up to 2 months then monthly follow-up up to 6 to 8 months / till union

During follow-up:

- Evaluation of any possible loss of reduction.
- Assessment and analysis of any complication.

Outcome Measures:

The Patient were assessed using

- **UCLA** Shoulder rating scale for shoulder movement function
- **MAYO** Elbow Score for elbow movement function
- Range of movement is compared with opposite side

Observation And Results

Table 1: Gender Distribution

Sex	Number of patients	%
Male	25	83.33%
Female	05	16.66%
Total	30	100%

Out of 30 patients, 25 (83.33%) patients were male and 05 (16.66%) patients were female, showing male preponderance.

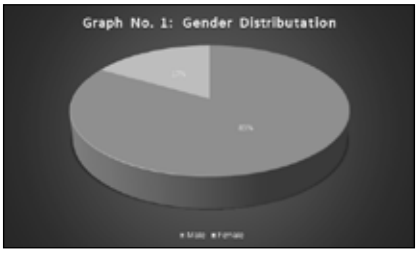


Table 2: Age Wise Distribution

Category (years)	MIPPO
16-29	15
30-39	03
40-49	06
50-60	06
Total	30

The age of patients ranged from 16 to 60 years with the fracture being most common age group is between 16-29 years of life.

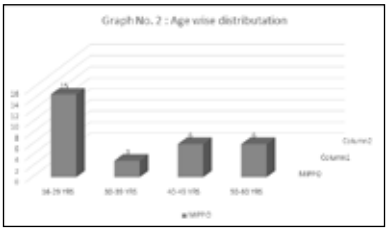


Table 3: Side Affected

Handedness	MIPPO	%
Right (Rt)	16	53.33%
Left (Lt)	14	46.66%
Total	30	100 %

There were 14 (46.66%) patients with left side fracture in the study and 16 (53.33%) patients with right side fracture in the study.

Table 04- Mode of Injury

Mode of injury	MIPPO	%
Road Traffic accident (RTA)	17	56.66%
Assault	02	6.66%
Fall	11	36.66%
Total	30	100

In our study most of the injuries were caused by road traffic accidents affecting mostly males. We had 17 (56.66%) RTA injuries, 02(6.66%) due to Assault, and 11(36.66%) due to Fall on outstretched hand.

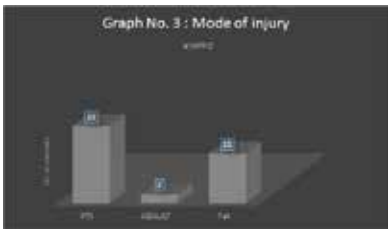


Table :05 Facture Pattern

AO Classification	MIPPO	%
AO12A1	2	6.66%
AO12A2	11	36.66%
AO12A3	13	43.33%
AO12B1	0	0
AO12B2	3	10%
AO12B3	0	0
AO12C1	0	0
AO12C2	0	0
AO12C3	1	3.33%

Out of 30 patients 02(6.66%) had AO12A1 type injuries, 11(36.66%) had AO12A2 type injuries ,13(43.33%) had AO12A3 type injuries, 03(10%) had AO12B2 injuries, 01(3.33%) had AO12C3 type injuries, in which AO12A3 type fracture is most common followed by AO12A2 type fracture.

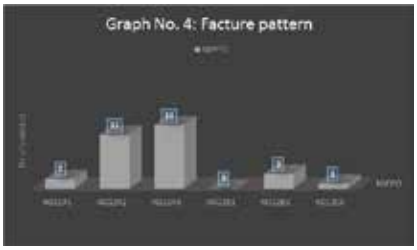


Table 06: Time Interval Between Trauma And Surgery

Interval	Number of Patients	%
0-3 days	17	56.6%
3-7 days	09	30%
7-14 days	04	13.3%
Total	30	100%

17 patients (56.6%) operated within 3 days of trauma, 09 patients (30%) operated in 3-7 days of trauma and 04 patients (13.3%) operated in 7-14 days of trauma.

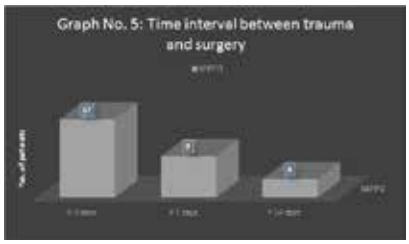


Table:07 Amount Of Blood Loss

Amount of Blood Loss (ml)	MIPPO Group
00-100 ml	15
101-200 ml	15
201-300 ml	00
301-400 ml	00
Average blood loss in ml	114

In our study average blood loss for MIPPO procedure is 114 ml.

Table:8 Duration Of Surgery

Duration of surgery	MIPPO Group
30-60 min	20
61-90 min	10
91-120 min	00
Average time	60 min

In our study average operative time for MIPPO procedure is 60 minutes.

Table: 9 Time Of Union

Time of Union	MIPPO	Group
	No.	%
8-12 Weeks	28	93.33%
12-16 Weeks	01	3.33%
16-20 Weeks	00	00
>20 Weeks	01	3.33%
Non Union	00	00

In MIPPO Group average time for union is 11.73 weeks in which 28 patients (93.33%) got united in between 8-12 weeks, 1 patient (3.33%) have union in between 12-16 weeks and 1 patient (3.33%) have union takes more than 20 weeks.

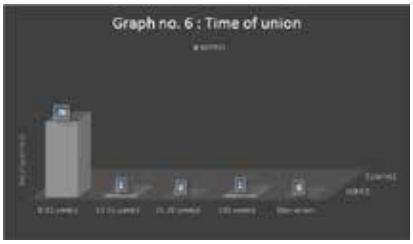


Table:10 UCLA And Mayo Score

	MIPPO Group
UCLA Shoulder Score	33.3±3.22
MAYO Elbow Score	97.33±6.12

Average of UCLA Shoulder Score is 33.3±3.22 and of MAYO Elbow Score is 97.33±6.12.

Table:11 Result

	MIPPO (N=30)
Excellent	22 (73.33%)
Good	07(23.33%)
Fair	01(3.34%)
Poor	00
Total	30(100%)

We observed that out of 30 cases Excellent result in 22(73.33%) cases, Good in 07(23.33%)cases, and Fair in 01(3.33%) cases. No Poor outcome is seen.

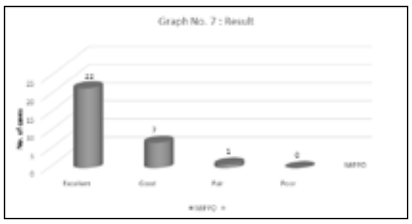


Table: 12 Complications

Complications	MIPPO
Radial nerve palsy	00
Superficial infection	01 (3.33%)
Deep infection	00
Shoulder stiffness	01 (3.33%)
Elbow stiffness	00
Pain	00
Malunion	00
Delayed Union	01 (3.33%)
Non Union	00
Scar Mark	00
Total	3 (10%)

We had 3(10%) patients with complication includes Superficial infection in 1(3.33%) patient, Shoulder stiffness in 1(3.33%) patient and Delayed union in 1 (3.33%) patient. There is no malunion and non-union in this group.

Case

Fig. A. Pre op. X-ray, B. Post op. X-ray, C. 10 Weeks follow up, D Final Follow up at 24 Weeks

Fig Clinical Images Showing Range of Motion at Final Follow up

Discussion:

The goal of fracture management is restoration of physiological function at the earliest. Conservative treatment of humeral shaft fractures represents an effective method of fracture management and has sustained critical evolution throughout the literature. However, the incidence of non-union, malunion, residual angulation, limb length inequality and significant loss of function was shown to be high with non-operative management.

Operative treatment is proven to have greater strength, with improved functional outcome and earlier return to work at 6 weeks.

Surgical intervention includes closed reduction and internal fixation by humerus interlocking nail, open reduction and internal fixation by narrow DCP or LCP and Minimally invasive percutaneous plate osteosynthesis. As the gold standard method for the treatment of humerus shaft fracture is open reduction and internal fixation with a plate and screws is well recognised.

It has been reported that humeral shaft fractures can be successfully treated with minimally invasive percutaneous plate osteosynthesis (MIPPO). This technique has advantages of less soft tissue dissection and avoids the need to expose the radial nerve; thus, there is also low risk of iatrogenic radial nerve palsies and deep infection.

(1) Age and Gender:

In our study average age of patients is 33.86(range 18-60).

In study by **M Shantharam Shetty et al**.[26] the mean age was 39 years (range 22-70 years)

In our study out of 30 patients, 25(83.33%) patients were males and 05(16.66%) patients were female, showing male preponderance.

In study by **MShantharam Shetty et al.**[26] 19(59.3%) were males and 13(40.6%) were females.

(2) Side affected:

In our study 14 (46.66%) patients had left sided fracture and 16(53.33%) patients had right side fracture.

In study by **M Shantharam Shetty al.**[26] 27 (84.3%) cases had injury in dominant arm.

(3)Mode of Injury:

In our study, out of 30 patients 17 (56.66%) sustained injury due to road traffic accident, 02 (6.66%) sustained injury following assault and 11(36.66%) sustained injury due to fall. Showing that road traffic accident is most common cause of fracture shaft humerus.

In study by **M Shantharam Shetty et al.**[26] 26(81.2%) cases sustained road traffic accident

(4) Fracture pattern:

The fracture pattern was classified on AO Classification for fracture of shaft humerus. In our study we had 26 (86.66%) cases of AO12A type fracture in which 2(6.66%) cases of A1 type, 11(36.66%) cases of A2 type and 13(43.33%) cases of A3 type. 3(10%) cases of AO12B type fracture in which 3(10%) cases of B2 type. 1 (3.33%) of AO12C3 fracture type. So we have most common AO12A2 and A3 type of fracture pattern.

In study by **M Shantharam Shetty et al.**[26] there were 8 cases of C2 type; 5 cases of C1 and A2 type ; 4 cases of B2 type ; 3 cases of B3,B1and A1 type; and one case of A3 type of fracture.

(5) Trauma to surgery interval:

In our study out of 30 cases 17 (56.6%) case were operated within 3 days of trauma. 09(30%) cases were operated in between 3 to 7 days of trauma. 04(13.4%) cases were operated in between 7 to 14 days of trauma.

(6) Amount of Blood Loss during surgery:

In our study average blood loss

during surgery for MIPPO technique is 114 ml.

(7) Duration of Surgery:

In Our study 30 cases of fracture shaft humerus studied with MIPPO. Operative time for 20 cases was between 30-60 minutes, 10 cases took 61-90 minutes. The average operative time was 60 minutes.

In study by **M Shantharam Shetty et al.**[26] the mean surgical time was 91.5 minutes (range 70-120 min).

(8) Duration Of Union:

In our study average time of union was 11.73 ±3.53 week ranging from 08 to 29 weeks. There was no case of non-union. 1 patient had delayed union.

M Shantharam Shetty et al.[26] studied 32 patients of shaft humerus fracture operated with MIPPO ,in this study average time of union is 12.9 weeks (range: 10-20 weeks).

Outcome and Result:

In our study 30 cases of diaphyseal humerus fractures treated with MIPPO. Result is based on assessment of radiological union and functional outcome using UCLA and MAYO scoring. Average time of union was 11.73 ±3.53 weeks ranging from 08 to 29 weeks. There was no case of non-union. 1 patient had delayed union. We observed Excellent result in 22(73.33%) cases, Good in 07(23.33%) cases, and Fair in 01(3.33%) cases. No Poor outcome was seen. Average of UCLA Shoulder Score was 33.3±3.22 and of MAYO Elbow Score was 97.33±6.12.

In the study of **M Shantharam Shetty et al.**[26], 27 cases (84.3%) had excellent outcome and 5 cases (15.6%) had good shoulder function on the UCLA score. With regard to elbow function, 26 cases (81.2%) had excellent outcome, 5 cases (15.6%) had good outcome, and 1 case (3.1%) (who also had an associated olecrenon fracture that was fixed with tension band wiring) had fair outcome.

In the study of **Zhiquan An et al.**[17] the functional outcomes assessed by UCLA end-result score and Mayo elbow performance score systems in the affected shoulder and elbow in the two groups were also consistent.

Complications:

We had 3(10%) patients with complication which includes superficial infection in 1(3.33%) patient which get resolved after culture specific antibiotics, Shoulder stiffness in 1(3.33%) patient and delayed union in 1 (3.33%) patient which get united in 29 weeks. There was no malunion and non-union.

In 1 patient during surgery MIPPO was converted to ORIF surgery because there is unseen long splinter of fracture which was excluded from the study.

M Shantharam Shetty et al.[26] had two cases with postoperative sensory blunting over the lateral half of the forearm due to injury to musculocutaneous nerve, but this recovered within 3 months of surgery without any intervention.

Zhiquan An et al.[17] found One case (6.3%) of delayed union occurred in group B which resulted from loosening of the screws in the proximal end of the plate. The patient was treated non-operatively and the fracture united 17 months after operation. There was no incidence of infection or implant failures in either group. All five iatrogenic radial nerve palsies spontaneously recovered with mean onset time of 22.4 weeks (range 12–52 weeks) without any surgical intervention. The implant was removed in five cases in group A and three cases in group B without any complications.

Limitation Of The Study:

The only limitation of the study was small sample size and less time for long term follow up.

Conclusion:

Out of various operative methods available today minimally invasive percutaneous plate osteosynthesis has showed many promising result of our study regarding management of diaphyseal humerus fracture with minimally invasive percutaneous plate osteosynthesis versus open reduction and internal fixation with the available literature.

Various operative methods are available today's for diaphyseal humerus fractures with variable rate of complication and union rate. Our results of management of these fractures with minimally invasive percutaneous plate osteosynthesis have been evaluated and compared with available literature.

We treated 30 cases in our study with minimally invasive percutaneous plate osteosynthesis (MIPPO) technique and found a rapid healing by secondary fracture union with few complications and hence achieving strong bone union across the fracture site due to inherent benefits of less tissue damage and minimal disturbance of fracture site biology.

In this study union rate was significantly higher and faster with minimal complications, less blood loss and less duration of surgery, it is cosmetically acceptable for the patients, but this technique is associated with radiation exposure, on other hand it requires skilled hands. As the procedure involves meticulous

soft tissue handling and minimally exposure the procedure is considered technically demanding and a longer learning curve is required.

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