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Being minimally invasive is the way forward? A comprehensive study of functional outcome of humerus diaphyseal fractures treated with MIPPO technique

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Abstract

Background: The Internal Fixation of Shaft Humerus Fractures Has Evolved In Recent Years With A Change Of Emphasis From Mechanical To Biological Priorities. One Such Biological Internal Fixation Is MIPPO (Minimally Invasive Percutaneous Plate Osteosynthesis).

AIM: The Aim Of This Study Was To Evaluate The Clinical Results And Functional Outcome Of Humeral Shaft Fractures Treated With MIPPO Technique.

Materials and Methods: The Retrospective Study Included 30 Patients (Mean Age: 41.7 Years; Range: 19 To 66 Years) With Humerus Mid-Shaft Fractures Treated With The MIPPO Technique Between JUNE 22- JUNE 24.

- Implant- 4.5- mm Locking Plates Were Applied Via An Anterior Approach
- Fracture Healing Was Evaluated Using Plain Radiographs.
- Objective Outcomes Were Assessed In Terms Of Range Of Motion And

Subjective Outcomes Using The American Shoulder and Elbow Society (ASES), University of California, Los Angeles (UCLA), Mayo Elbow Performance Index (MEPI) and The Disability of The Arm, Shoulder and Hand (DASH) scores.

Results: The Advantage Of MIPPO Technique Is Not Only About The Small Incision Size But Also About The Fracture Reduction And Soft Tissue Dissection From Remote Site Which Does Not Disturb The Normal Biological Healing Of Fractures And Enhances Faster Healing. The Union Rate Was One Hundred Percent With Mean Time Of 14.5 Weeks And Early Return To Work. The Significant Drawback Of This Technique Is Risk Of Radial Nerve Palsy Which Recovered Almost Within 3 Months Post-Surgery. Thus, MIPPO Technique Of Humerus Fracture Provides Early Functional Recovery To The Patients.

Conclusion: In Conclusion, This Study Supports That MIPPO Is A Decent Method Of Treating Humeral Shaft Fractures But It Requires Adequate Imaging And Surgical Experience. In Comparison With Non Surgical Treatment For Humerus Fracture And With Conventional Plating MIPPO Technique Has Very Good Clinical And Functional Outcome And Also There Is Less Chances Of Failure Of The Procedure.

Keywords: Humerus shaft, minimally invasive surgical procedures, biological fixation, internal fracture fixation, MIPPO

Introduction

Fractures of The Humerus Shaft Account For Approximately 3% Of All Fractures And Represent 20% of All Humeral Fractures [1] Primary Causes of Humerus Shaft Fractures Include Traffic Accidents, Falls Or Violent Injuries [2]. Although Conservative Treatment Is Considered The Gold Standard [3-5] Controversy Still Exists About The Ideal Method of Surgical Fixation. Biologic Fixation And Minimally Invasive Surgery Have Become Highly Accepted Alternatives In Addition To Conventional Plating and Intramedullary and External Fixation

Minimal Invasive Percutaneous Plate Osteosynthesis (MIPPO), Primarily Described For Comminuted Fractures Of The Tibia And Femur, Has Also Gained Popularity In The Treatment of Humerus Shaft Fractures [7-11]. Access to The Bone Is Through Soft Tissue Windows (Not Only Small Skin Incisions But Also Careful Gentle Handling of Deep Layers Of Soft Tissues) With Minimal Trauma To The Injured Soft Tissue and The Bone.

MIPPO Has The Advantages Of Less Soft Tissue Dissection, Lower Nonunion Rates And Low Risk Of Iatrogenic Radial Nerve Palsy, Unlike Open Surgical Procedures ^[12]. It Allows Earlier Functional Treatment And Higher Postoperative Range Of Motion In Adjacent Joints ^[13, 14]. These Have Superseded The Disadvantages Of MIPPO Like Difficulties In Indirect Bone Reduction And Increased C-Arm Exposure. Locking Compression Plate Has Been The Implant Of Choice For Mipo. In The Last Few Decades, There Have Been Shift Of AO Principles Of Fractures Treatment From Rigid Internal Fixation To Biological Fixation. The Future Of Fracture Treatment Is Biological Fixation. It Is An Elastic Fixation System That Stimulates Natural Callus Formation.

Objective

The Aim Of This Study Was To Evaluate The Clinical Results And Functional Outcome Of Humeral Shaft Fractures Treated With MIPPO Technique.

Material and Methods

We Have Done A Retrospective Study Of The 30 Patients Of Fracture Humerus Treated With Minimally Invasive Percutaneous Plate Osteosynthesis From Jan 2021- Dec 2023 At Shadan Institute Of Medical Sciences, Hyderabad. Clinical, Radiology And Functional Outcomes Were Carried Out In All Cases.

Inclusion Criteria

- Age of 18 years or Older
- Mid Shaft Humerus Fracture
- Displaced Unstable Fracture
- Comminuted Fracture

Exclusion Criteria

- Open Type III Fracture
- Fracture With Neurovascular Injury
- Segmental Fracture With Proximal and Distal Intraarticular Extension
- Pathological Fracture
- Patients In Which Time Lag Between Injury
- Surgical Intervention Exceeded 3 Weeks
- Another Ipsilateral Fracture Of The Upper Limb

Institutional review board approval was obtained before the retrospective study was initiated.

Patients were followed-up for a period of 12 months.

Scoring Systems for Functional Outcome (4, 5)

University of California & Los Angeles (UCLA) scoring for shoulder and Mayo Elbow Performance Score (MEPS) for elbow The Disability of the Arm, Shoulder and Hand (DASH) score were produced to them at every follow-up and evaluated at the end of 12 months

Surgical Procedure

After The Anesthesia, Patient Is Positioned Supine on

Operating Table With Forearm In Supination And Arm In 90 Degree Abduction. Supination Reduces The Risk Of Radial Nerve Palsy By Increasing The Interval Between The Radial Nerve And The Plate. After Preparation And Draping, The Surgeon Stands On The Caudal Side Of The Patient With The C - Arm Coming From The Contralateral Side.

Traction Is Given and Fracture Reduction Is Confirmed Under C - Arm Guidance

Two Incisions Made One Proximal and One Distal, Atleast 5-7cm on Either Side of Fracture. The Proximal Incision Is Made Between The Medial Border Of Deltoid And The Lateral Border Of Biceps. The Distal Incision Was Made Between The Biceps And Brachioradialis Muscle.

The Radial Nerve Is Protected By The Substance Of The Brachialis Muscle (7) And Carefully Placing The Retractors Over The Muscle. The Langenbeck Retractors Are Used In The Distal Exposure As The Hohmann Retractors Inserted Deep May Cause Neurovascular Injury. After The Dissection And Guarding The Nerve, A Sub Muscular Tunnel Is Created Through The Proximal Incision To The Distal Incision Through A Cobb Elevator Or Through The Plate Itself. The Sub Periosteal Tunnel Should Be Created Carefully Avoiding Injury To The Surrounding Soft Tissues, Atraumatic As Much As Possible.

Then Gentle Traction Is Given By Assistant With Elbow Flexed To 90 Degrees And Forearm In Supination To Maximize The Distance Between The Nerve And The Plate. And Reduction Is Checked With C-Arm And The Plate Is Introduced In A Graceful Manner Cautiously Avoiding Nerve Injury.

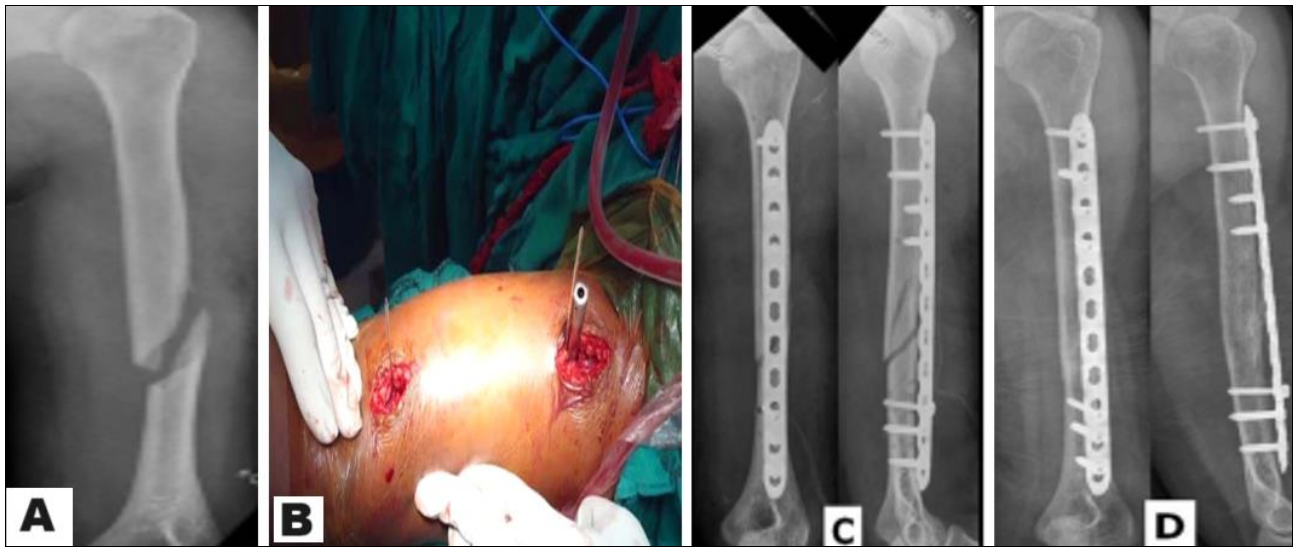
The Traction Restores The Length, Alignment And Rotation Of The Fracture Usually Through The Proximal And Distal Incisions, Two Screw Holes Are Exposed And These Screw Holes Are Drilled And Screws Are Placed After Confirming The Position Of The Plate On The Bone. These Screws Are Not Tightened, The Position Of The Plate After The Pre-Emptive Placement Of The Screws Is Confirmed In The Image Intensifier. Then Through Stab Incision Additional Screws Are Inserted Proximally And Distally So That At Least 3 Screws Are Placed Proximally And Distally. The Antibiotics Are Given According The Routine Guidelines.

Post Op Protocol

Check Neurovascular Status Post Procedure. Support The Operated Limb in a Broad Arm Sling. Wound Inspection on the Second Day. Passive Motion Exercises 2 Days Post Op Up To 45 Degrees.

One Week Post Op Passive Flexion Up To 60 Degrees. Suture Removal Done On Post-Operative Day 12. One Month Post Op Passive Flexion Up To 90 Degrees. 6 Weeks Post Op Active Mobilization Begun. Weight Lifting Allowed As Tolerated. Check X-Rays Are Taken On Monthly Interval To Check For Union.

Case No.1



Preop

Intra Op

Immediate Post Op

Follow Up 1 Year

Fig 1: Sequential stages of treatment for a humerus diaphyseal fracture using the MIPPO technique: Preoperative X-ray (A), intraoperative view (B), immediate postoperative X-ray (C), and one-year follow-up X-ray (D).



Fig 2: Clinical range of movement of shoulder

Case 2



Pre Op Xray

Intra Op

Fig 3: Stages of humerus diaphyseal fracture treatment with MIPPO technique: Preoperative X-ray showing the fracture (left), and intraoperative views showing minimally invasive incisions (right).

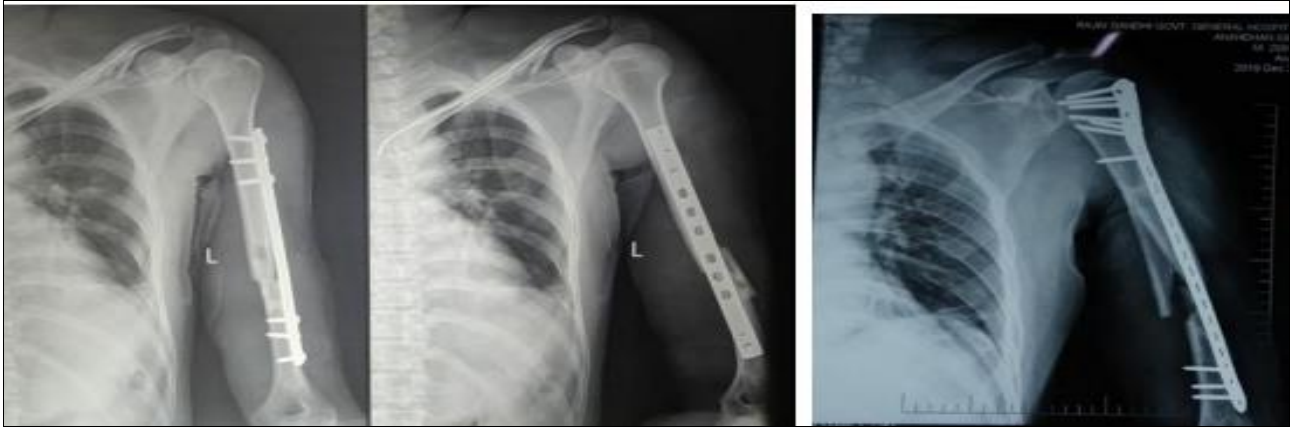


Fig 4: Immediate Post Op Xray



6 Months Post Op Xray

1 Year Post Op Xray

Fig 5: 6 months post-operative and one-year post-operative X-rays

Case 3



Pre-Op X-ray

Immediate Post Op Xray

1 Year Post Op Xray

Fig 6: Pre-operative, immediate post-operative and one-year post-operative X-rays



Fig 7: Clinical outcome 1-year Follow-up

Results

It was found that Fracture Humerus is more common in adult population.

More than 50% patients are in the age group of 30 to 50 years and 17% were in age group of more than 50 years of age. Mean age is 41.26 years.

In our study this fracture is more common among the males 29 (96%) than females.

Table 1: Distribution of patients by gender.

Gender	Frequency	Percentage
Female	01	04
Male	29	96
Total	30	100

Based on AO classification of Diaphyseal Humerus Fracture (10, 14).

Table 2: Classification of diaphyseal humerus fractures based on the AO classification.

Type	Subtype	Frequency	Percentage
A	A1	5	6.7
	A2	10	33.3
	A3	7	23.3
B	B1	1	3.3
	B2	1	3.3
	B3	1	3.3
C	C1	2	6.7
	C2	1	3.3
	C3	2	6.7
Total		30	100

Among the 30 patients in our study, 66% of patients having RTA that is Road Traffic Accident as a mode of injury, 26% patients having history of fall down from surface level or fall from height, while only 3% of patient having history of sustained injury due to assault and railway injury.

Only 13% of patients had other associated injury in form of spinal injury and forearm injury of same side having humerus fracture. Out of 4 patient 2 patient having spine injury (D8 & D12 wedge #) and 2 having forearm bone fracture of same side. Remaining 80% had isolated fracture of Diaphyseal Humerus.

Total of 60% patients were having fracture on the right side, and 40% on left side.

Duration of Surgery: Vary with type of fractures and surgeons skill. Average time of surgery is 70.16 minutes.

Longest time taken was 90 minutes in patient having segmental humerus fracture with same side forearm bone fracture. Shortest time was 60 minutes in many cases.

Table 3: Duration of surgery.

Minutes	No of patients	Percentage
60-70	18	60
71-80	10	33
81-90	2	7

In our study we found that 86% of patient's post-operative period went event free in terms of union, While 2 patients were having post-operative radial nerve palsy, they were counseled for nerve site exploration after explaining the prognosis, patients refused for same and palsy recovered over period of time. Another 2 patients were having superficial infection of stich line; they were treated with daily dressing and appropriate injectable antibiotics. There was no hardware failure in any patients.

Table 4: Post-operative outcomes and complications.

Score	Percentage	Number
0-10	86	26
10-20	14	4

DASH questionnaire involve 30 item disability/symptom scale, question ask about the degree of difficulty in performing different physical activities because of the arm, shoulder or hand problem. Each item has five response options. The scores for all items are then used to calculate scale score ranging from 0(no disability) to 100 (most severe disability). From above data we can interpret that majority of patients are able to perform activities without much difficulty

Table 5: Functional assessment of shoulder joint (UCLA SCORE):

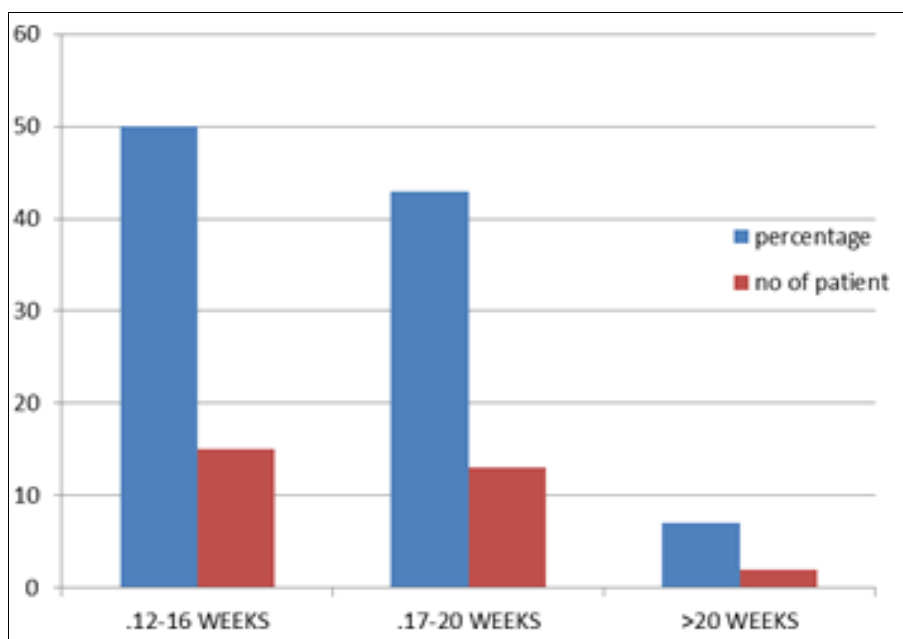
Score	No.	Percentage
34-35 (Excellent)	21	70
29-33 (Good)	7	26
21-28 (Fair)	2	4
0-20 (Poor)	0	0

The UCLA scoring system rated 21 patients (70%) as a excellent result; 07 patients (26%) as a good result and 02 patients (04%) as a fair result.

The MAYO Elbow performance scoring system rated 24 patients (80%) as a excellent result; 05 patients (17%) as a good result and 01 patients (3%) as a fair result.

Table 6: Functional assessment of elbow joint (Mayo Score)

Score	No.	Percentage
>90 (Excellent)	24	80
75-89 (Good)	5	17
60-74 (Fair)	1	3
<60 (Poor)	0	0

**Fig 8:** Fracture union time

We found that 50% of patients were having union within 12 to 16 weeks, and 43% patient having union within 17-20 weeks and 7% of patient having union at 22 weeks. Had excellent outcome, 26% (07patients) had good outcome and 04% (02) had fair outcome. According to MEPS score, 80% (24 patients) had excellent outcome, 17% (05 patients) had good outcome while 03% (01 patients) had fair outcome.

The mean time for fractures site consolidation in our study was 17 weeks, which was marginally longer than a similar study conducted by An Zhiqian *et al.* in 2007 [16.2 weeks union time] [11].

Discussion

While the majority of humerus shaft fractures are successfully treated by conservative methods, [3, 4] controversy regarding the ideal option of surgical fixation remains. The patient's clinical condition and activity level, fracture type and localization and the surgeon's experience are important determinants in deciding the most suitable alternative.

Minimal invasive methods gained popularity with bridging plate osteosynthesis in the last decade. However, few studies have reported on humerus fractures. In 2004, Livani and Belangero concluded that MIPPO is a feasible, safe and efficient method with no major complications in the treatment of humerus shaft fractures [15]. Better results have also been reported with MIPPO compared to the conventional surgical techniques in terms of providing a shorter recovery time by early stabilization with minimal soft tissue damage [13]. Aksu *et al.* reported early return of function in adjacent joints to the fracture site and reduced fracture healing time after MIPPO in humerus fractures [19]. However, further clinical studies are needed to state the proven benefits of MIPPO in the treatment of humerus shaft fractures.

In the present study, remarkable improvement in both objective and subjective measures was observed in the

affected limbs at the final follow-up, with the exception of one patient with floating elbow. Despite the lack of a control group, we believe that the good results were related to the deltoid sparing approach, particularly in terms of shoulder function. Although the MIPPO technique has many advantages, there is a general reluctance due to the concerns about neurovascular injury. Poor neurovascular monitorization, prolonged fluoroscopy time, difficulties in maintaining reduction and anatomic obstacles encountered during the advancement of the plate are factors complicating the procedure.

Some cadaveric and clinical studies have been published on the proximity of the nerve and plate. Apivatthakakul *et al.* described the application of a percutaneous plate on the anterior surface of the humerus without the need of radial nerve exploration [8]. Ji *et al.* emphasized that MIPPO through lateral approach is safe and feasible in the treatment of humeral shaft fractures [14]. Regarding the close relation between the musculocutaneous nerve and the anterior compartment of the arm, Gardner *et al.* [5] described the danger zones for musculocutaneous nerve in MIPPO of the humerus. They advised surgeons to make a longer skin incision and use an open approach to protect the musculocutaneous nerve during screw insertion. In our opinion, the radial nerve palsy observed in this study was due to over tightening of the nerve by a penetrating retractor (Hohmann retractor). Therefore, the use of this retractor was avoided and no other neurologic complication was seen. Anatomical obstacles, which may interfere with the clinical outcomes, must be considered as well as neurovascular structures.

It is well documented that disruption of the deltoid insertion is a serious problem, which often causes functional impairment [16]. Preserving or reattaching the deltoid insertion has been highlighted in various studies [12, 13]. Our previous research

experience in minimal invasive plating of the anterior humeral surface on 12 cadavers and the presented clinical study revealed that the anterior deltoid insertion is the main anatomical obstacles on the anterior humeral surface. It was also noted that the release of more than 20% of the anterior deltoid insertion may compromise deltoid muscle function^[18]. Considering our previous anatomical research and the literature, we recommend antegrade advancement with the deltoid sparing approach in order to protect deltoid function.

In addition to the high risk of neurovascular injury, the difficulty in providing an 'optimal working length can be considered a limitation of this technique^[16]. However, we did not observe any failure due to the use of a shorter plate than recommended. This was contributed to the adequate implantation technique and screw placement (at least 6 cortices on each side), immediate rehabilitation and patients' orientation. The relatively small number of patients and the absence of a comparison group is a possible limitation of this study. Therefore, further studies are necessary to compare minimal invasive osteosynthesis with alternative approaches to clarify the potential benefits of this technique.

Conclusion

Minimally invasive plate osteosynthesis can achieve comparable radiological and functional results to open plate osteosynthesis method for humeral shaft fracture, while reducing the operative time and perioperative complications. The MIPO has a better patient compliance with early rehabilitation and a better cosmetic outcome. Chances of nonunion, delayed union and deep infection are less.

Limitations

The major limitations of our study was that we did not have a control group for comparison or another group treated with some other technique of humeral diaphyseal fracture fixation. Also the follow-up of our patients was for 12 months. The MIPO is an intricate technique for treatment of humeral shaft fractures requiring a relatively long learning curve. However, the results are good and reproducible. The risk of radial nerve injury is real and should not be undervalued, even when all the technical precautions are followed especially in mid-lower 1/3 shaft fractures. Increased C arm exposure

Conflicts of Interest

No conflicts declared.

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