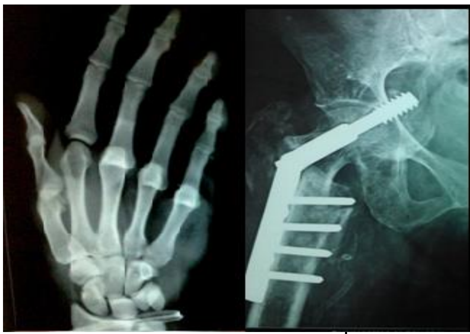

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A study of clinico-radiological outcomes of diaphyseal humerus fracture treated with minimal invasive plate osteosynthesis (MIPO)

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Abstract

Introduction: Humeral shaft fracture is one of the common injuries encountered in orthopedic surgery accounting for 1% - 5% of all fractures. Although nonoperative treatment of humeral shaft fracture is associated with satisfying clinical and functional outcomes in most cases, usually results in varus deformity and limitation of shoulder and elbow motion in some patients. Thus, orthopedic surgeons prefer operative management due to early return to function and low compliance of the patients.
Materials and Methods: 29 patients with diaphyseal fractures of the humerus treated with MIPO between January 2015 and June 2016 were included in the study. Patients with metabolic bone disease, polytrauma, and Gustilo and Anderson type 2 and 3 open fractures were excluded from the study. All patients having diaphyseal humerus fracture were treated with closed indirect reduction and plate fixation 4.5 dynamic compression plate using the MIPO technique. The surgery time, and time for union was noted. The shoulder and elbow function were assessed using the UCLA shoulder and Mayo elbow performance scores, respectively in follow up examination.
Results: Of the 32 patients in the study, 16 were males and 13 were females. The mean age was 34.5 years (Range: 18-58 years). Twenty of the twenty nine patients had the dominant side fractured. We had six cases of C1 and A2 type; three cases of A1, B2 and C3 type; four cases of B1 type; two cases of C3 type; and one case of A3 and C2 type of fracture. The mean surgical time was 93.1 minutes (range: 70–120 minutes). The mean radiological fracture union time was 13.1 weeks (range: 10–18 weeks). Shoulder function was excellent in 24 cases (82.7%) and good in remaining 5 cases (17.3%) on the UCLA score. Elbow function was excellent in 25 cases (86.2%) and good in 4 cases (13.8%) on mayo elbow performance score. 2 patients developed radial nerve palsy and translation was present in 4 patients.
Conclusion: In diaphyseal humerus fracture, MIPO gives good functional and cosmetic result and this should be considered as one of the good option in treatment of diaphyseal humerus fracture.

Keywords: Minimally invasive plate osteosynthesis, diaphyseal fracture, humerus

1. Introduction

The humeral shaft is defined as the expanse between the proximal insertion of the pectoralis major and the distal metaphyseal flare of the humerus. Cylindrical in shape, the shaft inherently provides strength and resistance to both torsional and bending forces. Distally the bone transitions into a triangular geometry with the base posterior; the supracondylar region maintains a narrow anterior-posterior dimension. Important osseous landmarks of the humeral shaft include the deltoid tuberosity at the mid-anterolateral aspect, which serves as the insertion for the deltoid muscle, and the spiral groove posteriorly, which houses the profunda brachii artery and radial nerve as they traverse proximally to distally in a posterolateral direction. The blood supply to the humeral shaft is provided predominantly by the nutrient artery, a branch off of the brachial artery that penetrates at the proximal third of the humerus on the medial side of the bone. The periosteum and the surrounding muscle bed also provide vascularity, to a lesser degree. Given the major role the nutrient artery plays in nourishing the humeral shaft, its disruption either through traumatic or iatrogenic means can be detrimental to fracture healing. It should be protected and preserved during surgical dissection [1, 2, 3, 7]. Regarding important neurologic structures, the median, ulnar, and radial nerves all lie in close proximity to the humeral shaft.

The median nerve travels adjacent to the coracobrachialis muscle belly, directly medial to the humerus and brachial artery, and provides no innervation to the muscles proximal to the elbow [1, 3, 6]. It is easily localized in the distal arm, where it lies on the anterior aspect of the brachialis muscle. In the proximal arm, the ulnar nerve runs in a similar fashion to the median nerve but lies posterior to the brachial artery. As the ulnar nerve travels distally, it pierces the medial intermuscular septum two thirds the distance down, thus moving from the anterior to the posterior compartment of the arm. It continues in the posterior compartment on its way toward the medial elbow. Like the median nerve, the ulnar nerve provides no innervation to muscles proximal to the elbow [1, 6]. Finally, the radial nerve, with its intimate and circuitous relationship to the humerus, is of special interest when treating humeral shaft fractures. The nerve begins its descent down the arm as a terminal branch off of the posterior cord of the brachial plexus and then enters the spiral groove just posterior to the deltoid tuberosity. It then courses pos-terolaterally adjacent to the bone, providing motor innervation to the triceps musculature. It finally exits the spiral groove on the lateral aspect of the humerus approximately 10 to 15 cm distal to the lateral acromion; it is there that the nerve is tightly bound by the lateral intermuscular septum and, therefore, highly susceptible to traction injury [1, 3, 4, 5].

Surgical treatment of humeral shaft fractures, when indicated, is controversial. Intramedullary nailing (IMN) [8, 9] and minimally invasive plating osteosynthesis [10], which are both types of biological fixation, are safe and effective options for treating mid-distal third humeral shaft fractures. A divergence of opinion exists in the literature between the values of IMN and minimally invasive plating osteosynthesis for the treatment of mid-distal third humeral shaft fractures. Modern surgery favours treatment modalities that are minimally invasive, have low morbidity, and provide rapid recovery and prompt return to work and activities of daily living [11]. Evidence shows the superiority of biological fixation over a stable mechanical fixation [12]. This leads to the development and improvement of biological fixation techniques for fractures and the development of stabilization systems that help achieve biological fixation [13]. Both procedures can provide excellent bone healing due to their biomechanical advantages [14].

Materials and Methods

29 diaphyseal fractures of humerus were treated with MIPO technique, in a prospective study between January 2015 and june 2016 at our centre. The cases were followed up for a minimum period of 1 year. The fractures were classified as per the AO trauma classification. All these fractures were fixed with 4.5-mm narrow dynamic compression plate (DCP) (Sharma India Pvt. Ltd.). All patients were operated by the same surgeon. The inclusion criterion was displaced diaphyseal fracture of humerus between 15 to 75 years and who were willing to participate in the study. The operative procedure was performed within 5 days of the injury. Exclusion criteria included coexisting medical disorders (such as a malignant tumor and hyperparathyroidism), vascular insufficiency of the upper limb, polytrauma patients, Gustilo and Anderson type 2 and type 3, patients with known alcohol or drug dependency. A routine preoperative clinical evaluation of the affected arm was carried out noting the swelling, abrasions, contusion, puckering of skin and distal neurovascular deficit, including the status of the radial nerve. Standardized anteroposterior (AP) and lateral (Lat) radiographs of the humerus, with the patient supine, arm abducted to 30° at the shoulder, elbow extended, and forearm supinated, were taken. These radiographs were also used to template the appropriate length of implant and planning the number and position of screws and their order of insertion.

Surgical Technique: The patients were positioned supine. Eight patients were given local brachial block, rest under general anesthesia. A 2-3 cm incision between the medial border of deltoid and proximal biceps, 5 cm caudal to the acromion process was made. Distally, a 2-3 cm incision at the lateral border of the biceps, nearly 5 cm proximal to the flexion crease. Retraction of biceps was done to expose the musculocutaneous nerve, overlying the brachialis muscle. The nerve is then retracted and brachialis muscle was split till bone. The lateral half of brachialis muscle then protects radial nerve. A sub-brachialis, extra-periosteal tunnel was created and a 4.5-mm dynamic compression plate is passed through the incision on the anterior surface of the humerus. Varus/ valgus angulation, length and rotation are restored by traction. Confirmation of the reduction done under image intensifier. Each side of the plate is fixed with three screws in anterior to posterior direction. Tunneling was done carefully in anterior fashion to prevent iatrogenic radial nerve injury. The amount of force required to be used for manual traction for achieving proper reduction was not easy at first, but becomes easy as technique is practiced. Rotational malalignment was checked under image intensifier. The operative time (skin incision to closure) was recorded. Postoperatively, shoulder immobilizer was applied.

Follow Up: The operative limb was kept in shoulder immoblizer till stitches were removed (12th day), there after the patients were advised to perform active gentle limb range of motion exercises as their pain control permits. The immoblizer was continued for another three weeks. However they were informed to take out the limb and perform informed exercise for ten minutes after every hour. To avoid stiffness, after four weeks they were trained by a physiotherapist to perform active range of motion exercises and were allowed to perform usual activities. After radiological signs of healing, a rehabilitation program was started. The aim was to gain full mobility, muscular strengthening and proprioception as soon as possible. The total rehabilitation period depends on the individual patient’s progression. The final aim is to restore ache free functional to full range of motion and strength. The union time and complications were noted. The patients were followed up by same surgeon, first after 2 weeks then monthly for the next 6 months, then once every 3 months till 18 months. The patient's shoulder and elbow function were analyzed using the UCLA [15] shoulder score and the Mayo elbow performance score (MEPS) [16]. The UCLA shoulder score was graded into excellent (34–35 points), good (29–33 points), fair (21–28 points), and poor (0–20 points) [17]. Function of elbow was graded on the basis of MEPS into excellent (≥90 points), good (75–89 points), fair (60–74 points), or poor (<60 points). Based on the anteroposterior and lateral radiographic view Union was accepted as the presence of bridging callus in three of the four cortices and absence of pain. Also any loss of fracture reduction was analyzed in similar radiographs.

Table 1: University of California at Los Angeles (UCLA)

Pain	Score
Present always and unbearable, strong medication frequently	1
Present always but bearable, strong medication occasionally	2
None or little at rest, present during light activities, salicylates frequently	4
Present during heavy or particular acvtivities only, salicylates frequently	6
Occasional and slight	8
None	10
Function	
Unable to use limb	1
Only light activities possible	2
Able to do house work or most activities of daily living	4
Most housework, shopping and driving possible, able to do hair, dress and undress, including fastening brassiere	6
Slight restriction only, able to work above shoulder level	8
Normal activities	10
Active forward flexion	
>150˚	5
120˚-150˚	4
90˚-120˚	3
45˚-90˚	2
30˚-45˚	1
<30˚	0
Strength of forward flexion(manual muscle testing)	
Grade 5 (Normal)	5
Grade 4 (Good)	4
Grade 3 (Fair)	3
Grade 2 (Poor)	2
Grade 1 (Poor muscle contraction)	1
Grade 0 (Nothing)	0
Satisfaction of patient	
Satisfied and better	5
Not satisfied	0

Maximum score = 35 points, Excellent = 34 - 35 points, Good = 29 - 33 points, Fair = 21- 28 points, Poor = 0 - 20 points

Mayo Elbow Performance Score (MEPS)

Function	Point Score
Pain (45 points)	
None	45
Mild	30
Moderate	15
Severe	0
Motion (20 points)	
Arc 100 degrees	20
Arc 50 to 100 degrees	15
Arc 2 degrees	5
Stability† (10 points)	
Stable	10
Moderate instability	
Gross instability	0
Daily function (25 points)	
Combing hair	5
Feeding oneself	5
Hygiene	5
Putting on shirt	5
Putting on shoes	5
Maximum possible total	100

Result

Of the 29 patients followed up to a minimum of 18 months in the study, 16 were males and 13 were females. The mean age was 34.5 years (range 18 to 58 years). Twenty out of twenty nine patients had the dominant side fractured. The mean surgical time was 93.1 minutes (range: 70 –120 minutes). Road traffic accident (RTA) was the most common mode of injury, found in 27 cases, two patients sustained injury following direct blow by 'lathi' hit on the arm. The mean follow-up of our cases was 29.72 weeks (18 - 40 weeks). Fracture union was observed at a mean period of 13.1 weeks (range: 10–18 weeks). In one case, where callus was not radio logically satisfactory at 12 weeks, we infiltrated bone marrow, and radiological union is seen at 18 weeks. There were two patients who developed radial nerve palsy postoperatively and recovered in 4 weeks. In 4 patients 2-3 mm translation was accepted but no complication occur in them. We had one case with postoperative sensory deficit over the lateral part of the forearm due to musculocutaneous nerve injury, which recovered within 8 months of surgery without any intervention. On determining the functional outcome, 24 cases (82.7%) had excellent outcome and 5 cases (17.3%) had good shoulder function on the UCLA score. With regard to elbow function, 25 cases (86.2%) had excellent outcome, 4 cases (13.8%) had good outcome.

Table 2: Master chart

Sr. no	age	Sex	AO type	Surgery time	Follow up	Union in weeks	Shoulder ROM (abd/flex)	Elbow ROM (flex/ext)	UC LA	ME PS	Translation	Complication
1	50	M	A1	90	24	12	120/170	140/0	35	95	2mm	-
2	28	F	C1	90	26	10	110/160	130/0	35	80	-	-
3	38	M	A2	120	26	10	100/170	135/5	34	100	-	-
4	30	F	B1	110	34	10	110/170	140/5	35	100	-	-
5	58	M	C1	120	40	18	90/150	100/0	34	95	-	Radial nerve palsy
6	28	M	B3	100	32	14	100/160	120/0	34	95	-	-
7	38	F	A2	90	32	12	120/170	130/0	35	100	-	-
8	40	F	B2	120	28	14	110/170	140/0	34	100	-	-
9	48	F	C1	100	20	16	110/160	130/0	33	90	-	-
10	18	M	A2	90	18	10	120/150	140/5	31	95	-	-
11	19	M	A1	100	20	12	110/170	130/5	33	95	3mm	-
12	42	F	C3	110	34	14	120/160	140/0	35	100	-	-
13	43	F	B3	80	36	14	120/170	130/0	34	100	-	-
14	28	M	B1	100	26	12	110/170	130/0	35	100	-	-
15	37	M	C3	90	28	10	110/160	120/0	31	80	-	-
16	19	F	B1	90	29	12	100/170	120/5	33	85	-	-
17	27	F	C1	100	27	14	110/170	110/0	31	90	-	-
18	42	M	B2	90	30	16	120/160	130/0	35	95	-	-
19	43	M	A1	80	34	12	100/160	135/0	34	90	2mm	-
20	31	F	C1	85	30	14	120/150	140/0	35	95	-	-
21	49	M	A2	75	35	14	120/170	130/0	31	95	-	-
22	39	M	B3	75	32	12	120/160	130/0	35	95	-	-
23	50	F	A2	80	38	16	110/160	120/0	34	100	-	Radian nerve palsy
24	37	M	A2	70	30	12	110/170	120/0	35	100	-	-
25	58	M	B1	90	40	18	110/170	90/0	31	85	-	-
26	56	F	C2	80	38	14	90/160	140/0	33	100	-	-
27	52	M	B2	75	31	16	120/150	140/5	35	95	-	-
28	22	F	A3	110	24	10	110/160	130/0	35	95	3mm	-
29	19	M	C1	90	20	12	120/170	120/0	34	90	-	-

UCLA - University of California at Los Angeles MEPS – Mayo Elbow Performance Score follow up in weeks, union in weeks, shoulder abduction/flexion in degree, elbow flexion/extension in degree, translation in mm

Fig 1: Clinical photo taken 3 months post operatively

Tscherne and Krettek first reported minimal invasive osteosynthesis for supracondylar femoral fractures in 1996 [18]. Then this technique is used in managing various other fractures also. Despite the requirement of high surgical expertise and time for this procedure, the MIPO technique seems to be reproducible and applicable in almost all types of shaft humeral fractures. Lower rates of iatrogenic nerve injury with minimal bone vascularity disruption, and soft tissue dissection are all the advantages over conventional plate technique. Though indirect reduction and plate placement is technically difficult and requires experience, Plates can be safely used anteriorly or anteromedially over the humeral shaft.

Excellent to good results have been achieved with sub brachialis plating with no major soft tissue problems and with functional results as per other methods [19]. Open technique of plating interferes with the local vascularity, leading to osteonecrosis underneath the plate, which may cause delayed healing to non-healing (published rate of nonunion being 5.8%) [20].

The course of the radial nerve is well described in literature [21]. According to Apivatthakakul *et al.* [10] when a plate is placed on the anterior side of the humeral shaft, the mean distance from the closest part of the plate to the radial nerve is 3.2 mm. Apivatthakakul *et al*. [10] also pointed out that when the forearm was pronated, the radial nerve was noted to move medially closer to the distal end of the plate and was at risk of iatrogenic injury. For this reason, the supination position of the forearm should be maintained during the operation. The brachialis muscle covers the humerus anteriorly and protects the radial nerve from injury when a plate is inserted submuscularly through two small incisions on the anterior side of the arm away from fracture site, supporting our findings of very less radial nerve palsies with the technique used in our study. Apivatthakakul *et al*. [10] have described the danger zone for the radial nerve with respect to percutaneous screw placement. It lies 36.35%–59.2% of the humeral length away from the lateral epicondyle, i.e., predominantly in the middle third of the humeral shaft.

The danger zone for the musculocutaneous nerve lies, on average, 18.37%–42.67% of the humeral length from the lateral epicondyle [22]. This gives us only the distal one-fifth of the humeral length, which is insufficient for application of the minimum of two locking screws. In our study we had one case of neuropraxia of the musculocutaneous nerve, just above the elbow where it pierces the deep fascia before continuing as the lateral antebrachial cutaneous nerve. This injury was attributed to the excessive traction applied at the small distal incision that we had made with the intention of avoiding opening the fracture site. This nerve is best protected by retracting it under vision after medially retracting the biceps, which is not always possible in the restricted working space available at the distal humerus.

Union of the humeral shaft fractures in this study presents good results with fixation through indirect reduction with maintenance of bone alignment through mini incision and replacing absolute stability by relative stability. This bridge-plate technique can be used even for the treatment of humeral shaft nonunion (both atrophic and hypertrophic nonunion) [23]. The present technique through its less tissue dissection and periosteal stripping makes a good modality of treatment. MIPO is also associated with less operative scars and better cosmesis. This contributes to the high patient satisfaction with this novel treatment.

Conclusion

In conclusion, this study demonstrates that the minimally invasive percutaneous osteosyntheses technique for treatment of humeral shaft fractures presents newer, effective, cosmetically advanced (minimal operative site scar) and acceptable modality of treatment for such fractures. Though the technique is complex, requiring a relatively long learning time the results are excellent and reproducible. To conclude, MIPO is definitely a better and promising modality of treatment.

The limitation of the 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. The evaluation of the standardized radiographs can be done by a different surgeons in an attempt to minimize bias. A larger multicenter study with control groups will help us to arrive at a definitive conclusion.

References

1. Browner BD, Levine AM, Jupiter JB, Trafton PG. Skeletal trauma. Philadelphia: Saunders 1998.
2. Carroll SE. A study of the nutrient foramina of the humeral diaphysis. J Bone Joint Surg Br 1963;45:176-81.
3. Epps CH Jr, Grant RE. Fractures of the shaft of the humerus. In: Rockwood CA Jr, Green DP, Bucholz RW, editors. Rockwood and Green’s fractures in adults. 3rd ed. Philadelphia: Lippincott Williams & Williams, 1991.
4. Guse TR, Ostrum RF. The surgical anatomy of the radial nerve around the humerus. Clin Orthop Relat Res 1995, 149-53.
5. Holstein A, Lewis GM. Fractures of the humerus with radial-nerve paralysis. J Bone Joint Surg Am 1963;45:1382-8.
6. Hoppenfeld S, deBoer P. Surgical exposures in orthopaedics: The anatomic approach. Philadelphia: Lippincott Williams and Wilkins 2003.
7. Meyer C, Alt V, Kraus R, Giebel G, Koebke J, Schnettler R. The arteries of the humerus and their relevance in fracture treatment [in German]. Zentralbl Chir 2005;130:562-7.
8. Petsatodes G, Karataglis D, Papadopoulos P *et al*. Antegrade interlocking nailing of humeral shaft fractures. J Orthop Sci 2004;9(3):247-252. doi:10.1007/s00776-004-0780-9
9. Fernandez F, Matschke S, Hülsenbeck A, Egenolf M, Wentzensen A. Five years’ clinical experience with the unreamed humeral nail in the treatment of humeral shaft fractures. Injury 2004;35(3):264-271. doi:10.1016/S0020-1383(03)00220-1
10. Apivatthakakul T, Arpornchayanon O, Bavornratanavech S. Minimally invasive plate osteosynthesis (MIPO) of the humeral shaft fracture: is it possible? A cadaveric study and preliminary report. Injury 2005;36(4):530-538. doi:10.1016/j.injury.2004.05.036
11. Garnavos C, Lasanianos N, Kanakaris NK, et al. A new modular nail for the diaphyseal fractures of the humerus. Injury 2009;40(6):604-610. doi:10.1016/j.injury.2009.01.130
12. Baumgaertel F, Buhl M, Rahn B. Fracture healing in biological plate osteosynthesis. Injury 1998;29(suppl 2):C3-C6. doi:10.1016/S0020-1383(98)95002-1
13. Wagner M, Frenk A, Frigg R. New concepts for bone fracture treatment and the locking compression plate. Surg Technol Int 2004;12:271-277.
14. Lin J, Hou SM. Locked nailing of severely comminuted or segmental humeral fractures. Clin Orthop Relat Res 2003;(406):195-204. doi:10.1097/00003086-20030100000029
15. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic

total shoulder arthroplasty. Clin Orthop Relat Res 1981;155:7-20.
16. Morrey BF, An KN, Chao EY. Functional evaluation of the elbow. In: Morrey BF, editor. The elbow and its disorders. 2nd ed. Philadelphia: W. B. Saunders 1993, 86-97.
17. Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. J Bone Joint Surg Am 1986;68:1136-44.
18. Krettek C, Schandelmaier P, Tscherne H. Distal femoral fractures: Transarticular reconstruction, percutaneous plate osteosynthesis and retrograde nailing [in German]. Unfall chirug 1996;99:2-10.
19. Shantharam Shetty M, Ajith Kumar M, Sujay KT, Abhishek Kini R, Kanthi Kiran G. minimally invasive plate osteosynthesis for humerus diaphyseal fractures, Indian Journal of Orthopaedics | November 2011;45:6.
20. Paris H, *et al*. Fractures of the shaft of the humerus: Systematic plate fixation: Anatomic and functional results in 156 cases and a review of the literature. Rev Chir Orthop Reparatrice Appar Mot 2000;86:346-59.
21. Gerwin M, Hotchkiss RN, Weiland AJ. Alternative operative exposures of the posterior aspect of the humeral diaphysis with reference to the radial nerve. J Bone Joint Surg Am 1996;78:1690-5.
22. Apivatthakul T, Patiyasikan S, Luevitoonvechkit S. Danger zone for locking screw placement in minimally invasive plate osteosynthesis (MIPO) of humeral shaft fractures: A cadaveric study. Int J Care Injured 2010;41:169-72.
23. Paulo Roberto Vilaca Jr, Marcelo Koh Uezumi. Anterior minimally invasive bridge-plate technique for treatment of humeral shaft non-union: J Orthopaed Traumatol 2012;13:211-216.