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Minimally invasive percutaneous plate osteosynthesis by anterior approach for fracture shaft of humerus

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Abstract
Background: Minimally invasive plate osteosynthesis (MIPO) technique is one of the many options for the fixation of diaphyseal fractures of the shaft of humerus using the anterior approach. We evaluated the clinical, radiographic, and functional outcome over a minimum follow-up of 18 months using the MIPO technique to fracture shaft of humerus.
Materials and Methods: Our study included 30 adult patients with diaphyseal fractures of the humerus treated with MIPPO technique between October 2013 and May 2015. Exclusion criteria included pregnancy, open fractures, pathological fractures, fractures older than 3 weeks.
Locking plate fixation was done using the MIPO technique in all cases after closed indirect reduction. Callus formation at the fracture site radiologically, and alleviation of pain on movement were the criteria for union. We assessed shoulder function using UCLA shoulder score and elbow function using Mayo elbow performance scores, respectively.
Results: The study consisted of 24 males and 6 females. The mean age was 44years(range: 18-60 years).Fourteen of the 30 patients (46.7%) had the right side fractures and 2 were 12A1,8 were12A2,6 were12A3,8 were12B2,2 were12B3 and 4 were12C2 fractures based on AO classification. The mean radiological fracture union time was 12.87 weeks (range: 12-18 weeks). Shoulder function was excellent in 26 cases (86.67%) and good in remaining 4 cases (13.33%) based on the UCLA score. Elbow function was excellent in 24 cases (80%), good in 6 cases (20%) as determined by MEPI score.
Conclusion: MIPPO of the humerus is a good management option in the treatment of diaphyseal fractures.

Keywords: Minimally invasive plate osteosynthesis, Locking compression plate, Diaphyseal fractures of humerus

1. Introduction
Open reduction and internal fixation (ORIF) is the gold standard for surgical treatment. The advantages include anatomical reduction of fractures and less interference to elbow and shoulder function [1, 2]. Disadvantages of this technique are extensive soft tissue stripping and disruption of periosteal blood supply, and hence the risk of non-union. Iatrogenic radial nerve palsy is another major disadvantage [3, 4]. We aimed at adequate healing and early functional rehabilitation of the limb though compromising precise reduction and absolute stable fixation. Stable mechanical fixation requires precise reduction and opening of the fracture site. It heals by primary intention which is biologically inferior to healing by secondary intention with the preservation of fracture haematoma causing minimal soft tissue injury [5, 6].
With progressive improvements over the years in surgical techniques, the conservative methods of reduction and stabilisation have given way to internal fixation with plate and screws despite their drawbacks [7, 8]. Merits and demerits apart, we have chosen minimally invasive percutaneous plate osteosynthesis (MIPPO) technique of fixation of fractures of shaft of humerus as the option in our study and achieved encouraging results.
Our study evaluates the clinical, radiographic, and functional outcomes of 30 patients with fracture of shaft of humerus over a period of 18 months adoped under the technique of MIPPO for the fixation of these fractures.
30 patients with diaphyseal fractures of humerus treated with MIPO technique, in a prospective clinical study were included in this study conducted between October 2013 and May 2015 at our hospitals.

Minimum period of our study was18 months. The fractures were classified according the AO method [9].We fixed the fractures with narrow long 4.5-mm locking compression plate (LCP-26cases) and on occasions with dynamic compression plates (DCP-4cases). We followed standard and defined protocol for the study after getting hospital ethical committee clearance. The inclusion criteria were fit and well patients who have agreed for the informed written consent and belonged to the age group between 18-60 years with closed diaphyseal fractures of humerus. We excluded patients with fractures during pregnancy, open fractures, pathological fractures, fractures of more than 3 weeks duration and fractures near the joints from our study. Patients were evaluated clinically noting the function of the radial nerve, the condition of the skin and soft tissues, preoperatively.

Anteroposterior and lateral radiographs were used to template the exact length of implant and the preoperative planning of the fixation of the fracture with screws.

Fig 1: Pre-operative X-ray of the arm showing fracture shaft of humerus, AO-12A2 and follow-up X-rays at monthly intervals, at 4weeks, 8 weeks and at 12 weeks

1 Post-operative radiograph and clinical photographs of the same patient showing: elbow flexion (b) elbow extension c) healed surgical scars (d) shoulder internal rotation (e) shoulder abduction and (f) elbow flexion

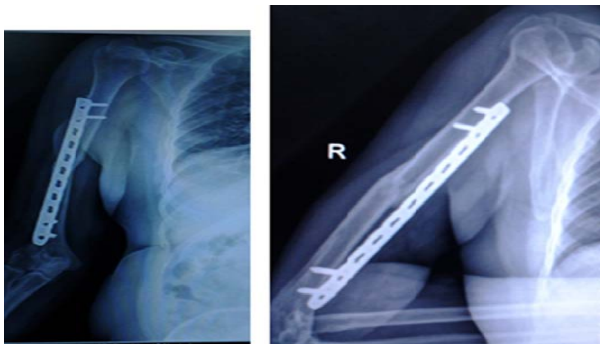

Fig 2: Post-operative radiograph

Fig 3: Clinical ROM photo

1.1 Procedure

Under general anaesthesia, the procedure was performed with 3cms incision - proximally below the acromion and distally 6 cms above the medial epicondyle with an anterior approach. Closed reduction and fixation was achieved under C-arm image with the machine on the same side as the arm being operated and avoiding manipulation of the arm during the procedure while maintaining elbow in 70 degree flexion and supination after achieving manual reduction of fracture. Submuscular tunnel was created by finger dissection and using the edge of the plate, under the brachialis muscle extraperiosteally. Temporary fixation of the appropriate plate was done with 2 mm K-wires and the position confirmed under image intensifier before definitive fixation. Long narrow LCP was fixed anterolaterally across the fracture with 2 or 3 screws on either side. Rotational deformity was avoided by noting the 'cortical step sign' and the 'diameter difference sign' as described by Krettek [10].

1.2 Post Operative care

Immobilisation was done with arm-pouch. Mobilisation is started as soon as the pain permitted the patient to do so. Simple pendulum exercises were adviced. The patients were followed up as per protocol. The union time based on callus formation at the fracture site as per radiological follow-up with antero-posterior and lateral views were noted. Union was considered achieved with the presence of bridging callus in three of the four cortices seen on the anteroposterior and lateral radiographs and clinically, by abscence of pain at the fracture site. Functional assessment of shoulder and elbow were done using UCLA Score and MEPI Score, respectively [11, 12] with due care to note any of the possible post-operative complications.

Fig a): Intraoperative images

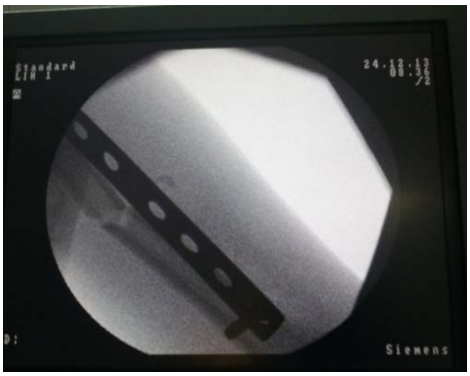

Fig b): fluoroscopic images

The patients were followed up and reviewed at monthly intervals for the initial few months till callus formation and fracture union, then once every 3 months till 18 months.

The shoulder and elbow function were assessed. The grading

of UCLA shoulder score was followed as per the standards as excellent (34-35 points), good (29-33 points), fair (21-28 points), and poor (0-20 points). Function of elbow was graded on the basis of MEPI Score into excellent (≥90 points), good (75-89 points), fair (60-74 points), or poor (<60 points).

2. Results

The mean age was 44 years (range 18-60years). Twenty four (80%) were males and six (20%) were females. 16 cases occured in the left arm and 14 in the right arm with 2 of A1, 8 of A2, 6 of A3,8 of B2, 2 of B3 and 4 of C2 type of fractures. Road traffic accident was the most common mode of injury involving 16 cases, 10 were due to slip and fall, 2 of them occurred after assault and 2 following fall from height. The duration of trauma to injury was less than 1 week in 22 of them and during the second week after injury in 8 of them.

One of the cases had an associated injury in the form of closed fracture of shaft of right tibia which was corrected by closed reduction and interlocking nail fixation in the same sitting which got united in about 12 weeks.

The mean follow-up of our cases was 16.73 months (range: upto 18months). Union was observed at a mean period of 12.87 weeks (range: 12-14weeks). Minimum angulation of less than 5° of varus or valgus angulation were accepted which remodeled to correct alignment over due course of time. Those fractures which failed to unite by 16 weeks were considered as 'delayed union' and those which did not unite by 32 weeks were categorised as 'non-union'

3. Discussion

Minimally invasive technique for fracture treatment has evolved based on the idea that with the preservation of fracture haematoma and the vascularity around the fracture site, new bone is layed down in the form of callus, a fact which was recognised by Albrecht Haller's (1708-1777) [13] and led to the success of the MIPPO technique for fracture fixation at other sites and lies in the fact that using long plates across zones of extensive fracture fragmentation with only few screws on either side of the fracture which withstands considerable deforming forces, though the tension side for shaft of humerus and the expected placement of the plate lies posteriorly where the plate should be placed, according to principles. The idea has evolved from the knowledge of the fact that with minimal stress per unit area, the bending stress gets distributed over a long segment of the plate with the resultant reduced risk of plate failure [13] allowing successful fixation as the construct becomes elastic [14, 15]. This disadvantage of extensive soft tissue dissection required for ORIF has promoted the development of a less invasive technique that allows indirect reduction and percutaneous plating of the anterior humerus[15] and has been resorted to, using the above knowledge. Earlier reports have shown excellent healing rates and alignment, and rare incidences of complications.

Humeral shaft fractures constitute around 3-5% of all fractures [16]. MIPPO is technically demanding and needs intraoperative imaging in order to obtain adequate fracture alignment. Scarring of brachialis muscle and inadequate postoperative rehabilitation, contribute to limited elbow range of motion. Krettek and Tscherne first reported MIPPO for supracondylar femoral fractures in 1996 [16]. Long plates used to bridge an extensive zone of fragmentation with only short fixation on either end of the bone can achieve union at the fracture site by callus formation provided the fracture haematoma is undisturbed. This process is augmented by micromotion at the fracture site.

The advantage of MIPPO over open reduction and plate fixation of fractures of shaft of humerus is less surgical trauma to the soft tissue and maintaining the periosteal circulation contrary to the method of application of the plate on the bone by an open technique which interferes with the local vascularization, leading to the possible osteonecrosis beneath the implant, ending up in delayed healing or non-union.

The disadvantage of primary bone healing without callus formation is the risk of refracture after removal of the implant following an open technique. The union time for fractures in our series was 12.87+/-1.06 weeks (range: 12-14weeks). The potential to remodel is much higher after secondary bone healing following MIPPO fixation and fracture union.

The brachialis muscle covers the humerus anteriorly and protects the radial nerve from injury when a plate is inserted submuscularly. Apivatthakakul *et al.* [5] have described the danger zone for the radial nerve with respect to percutaneous locking screw placement which lies 36.35%-59.2% of the humeral length predominantly in the middle third of the humeral shaft and that for the musculocutaneous nerve lies, on an average, 18.37%-42.67% of the humeral length from the lateral epicondyle [5]. With due care and note of these tips the complications which may be encountered from faulty technique could be minimized.

Open reduction and internal fixation (ORIF) is the gold standard for surgical treatment. The advantages include anatomical reduction of fractures and less interference to elbow and shoulder function. Disadvantages of this technique are extensive soft tissue stripping and disruption of periosteal blood supply, and hence the risk of non-union. Iatrogenic radial nerve palsy is another major disadvantage. The complex anatomy of the arm and the risks of injuring the vital structures have been the intriguing challenges ahead of surgical fixation of these fracture. Minimally invasive plate osteosynthesis (MIPPO) technique is one of the many options for the fixation of diaphyseal fractures of the shaft of humerus using the anterior approach with idea of achieving relative stability at the fracture site after indirect reduction. We evaluated the clinical, radiographic, and functional outcome of 30 cases over a minimum follow-up of 18 months using the MIPO technique to humeral shaft fracture

Callus formation at the fracture site radiologically, and alleviation of pain on movement with abscence of tenderness at the fracture site as criteria for union. MIPPO being biological method of fixation and the objective being achievement of relative stability at the fracture site allowing callus formation, patients with compromised soft tissue environment were excluded from the procedure like open fractures with soft tissue loss. Other factors in exclusion criteria were pregnancy, pathological fractures and patients in whom time lag between injury and surgical intervention exceeded three weeks. We included patients who are medically fit for surgery and in the age group of 18-60 years who have given written informed consent for the procedure and patients with closed diaphyseal fractures of humerus. We assessed shoulder function using UCLA shoulder score and elbow function using Mayo elbow performance scores. Based on these criteria we compared the results of the two groups of patients.

We aimed at adequate healing and early functional rehabilitation of the limb though compromising precise reduction and absolute stable fixation[13].Stable mechanical fixation requires precise reduction and opening of the fracture site, heals by primary intention and is biologically inferior to healing by secondary intention. With the preservation of

fracture haematoma causing minimal soft tissue injury [14] the goal of healing by secondary union is achieved by improving the techniques of biological fixation for fractures and also the development of stabilization systems [15, 16]. With progressive improvements, the conservative methods of reduction and stabilisation [17, 18] have given way to internal fixation with plate and screws despite their drawbacks [19-22]. Merits and demerits apart we have chosen minimally invasive percutaneous plate osteosynthesis (MIPPO) technique of fixation of fractures of shaft of humerus as the option in our study and achieved encouraging results. This is a short term study with follow-up period extending from the duration of fracture union to 18 months and the discussion is essentially one of preliminary assessment.

Radial nerve paralysis occurred on one occation in our study who recovered without any sort of remedial procedure during the following 18 weeks. According to Hadhoud MM. *et al.* [23]. there was one case of postoperative radial nerve palsy in the MIPO group from retraction to achieve distal exposure and recovered without interference on follow-up of the patients. Pospula and Abu Noor [24] reported one case of iatrogenic radial nerve palsy when the MIPO technique was used to treat 12 cases of humeral shaft fractures.

The radial nerve follows a fixed course, anatomically [5] According to Apivatthakakul *et al.* [5] "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. and on pronation of the forearm, 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 entire procedure. The study of postoperative ultrasonographic measurement of the distance between the radial nerve and the implant used in the MIPPO technique by Livani *et al.* substantiates this fact [8].

There was no case of superficial or deep infection in our study. Concha *et al.* [25] studied a series of 35 patients who underwent MIPO for humerus shaft fractures and reported the occurrence of only one deep and one superficial infection, which represents a 6% infection rate. According to Hadhoud MM. *et al.* [23] there was no infection in the MIPO group.

Union was observed at a mean period of 12.87weeks (range: 12-14weeks). Two incidences of delayed union (13.33%) which happened to unite between about 16 and 18 weeks after fixation without any intervention. There was only one case of delayed union, which united after 40 weeks according to the study by Hadhoud MM. *et al.* [23] and the average union time was 15.3 weeks. The incidence of non-union was 0% in our study. An *et al.* [26] documented the results of MIPO in the treatment of mid-distal humeral shaft fractures and the mean fracture union time was 15.29 weeks.

The functional outcomes were assessed by UCLA shoulder score and MEPI score for the affected elbows, respectively. Excellent shoulder scores in 26 (86.7%) of the cases and good outcome in four cases. The elbow function assessed by the MEPI score showed excellent outcome in 24 cases (80%), good outcome in six cases (20%).According to a study by M. Shetty *et al.* [27]. the functional outcomes assessed by UCLA shoulder score and MEPI score systems in the affected shoulders and elbows in the two groups were also consistent with the literature. Excellent shoulder scores in 27 (84.3%) of the cases in this series could be because of the level of fracture (the shaft and lower one-third fractures). The remaining cases had good outcome. The elbow function gauged by the MEPI score showed excellent outcome in 26 cases (81.2%), good outcome in five cases (15.6%), and a fair result in one case (3.1%) (Who had an associated fracture in the olecranon), according to their study.

4. Conclusion

MIPPO after anterior approach is safe and reproducible option, respects the principles of biological fixation with minimal soft tissue dissection, preserves fracture haematoma and periosteal blood supply, and is more forgiving in comminuted fractures of the diaphysis.

5. References

1. Niall DM, O′Mahony J, McElwain JP. Plating of humeral shaft fractures - has the pendulum swung back? Injury. 2004; 35:580-586.
2. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures a meta-analysis Acta Orthop. 2006; 77:279-284.
3. Lim KE, Yap CK, Ong SC, Aminuddin M. Plate osteosynthesis of the humerus shaft fracture and its association with radial nerve injury a retrospective study in Melaka General Hospital. Med J Malaysia. 2001; 56:8-12.
4. Paris H, Tropiano P, Clouet D′orval B, Chaudet H, Poitout DG. 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; 86:346-359.
5. 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; 36:530-8.
6. Zhiquan A, Bingfang Z, Yeming W, Chi Z, Peiyan H. Minimally invasive plating osteosynthesis (MIPO) of middle and distal third humeral shaft fractures, J Orthop Trauma. 2007; 21:628-33.
7. Ziran BH, Belangero W, Livani B, Pesantez R. Percutaneous plating of the humerus with locked plating: Technique and case report. J Trauma Inj Infect Crit Care. 2007; 63:205-10.
8. Livani B, Belangero W, Andrade K, Zuiani G, Pratali R. Is MIPO in humeral shaft fractures really safe? Postoperative ultrasonographic evaluation Int Orthop. 2009; 33:1719-23.
9. Muller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures of the long bones New York: Springer, 1990.
10. Krettek C, Schandelmaier P, Tscherne H. Distal femoral fractures: Transarticular reconstruction, percutaneous plate osteosynthesis and retrograde nailing [in German]. Unfallchirug. 1996; 99:2-1038.
11. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. Clin Orthop Relat Res. 1981; 155:7-20.
12. Morrey BF, An KN, Chao EY. Functional evaluation of the elbow. In: Morrey BF, editor. The elbow and its disorders 2 nd ed Philadelphia: WB Saunders, 1993, 86-97.
13. Wagner M, Frigg R. AO Manual of fracture management: Internal fixators. Chapters 1.2: Concepts of fracture fixation, 2006.
14. Baumgaertel F, Buhl M, Rahn BA. Fracture healing in biological plate osteosynthesis Injury. 1998; 29(3):C3-6.
15. Dickson KF, Munz JW. Locked plating: Biomechanics and biology Tech Orthop. 2007; 22:4

16. Wagner M, Frenk A, Frigg R. Locked plating: Biomechanics and biology and locked plating: Clinical indications Tech Orthop. 2007; 22:4.
17. Camden P, Nade S. Fracture bracing the humerus Injury. 1992; 23(4):245-248.
18. Hunter SG. The closed treatment of fractures of the humeral shaft Clin Orthop Relat Res. 1982; 164:192-8.
19. Chao TC, Chou WY, Chung JC, Hsu CJ. Humeral shaft fractures treated by dynamic compression plates, Ender nails and interlocking nails Int Orthop. 2005; 29:88-91.
20. Ajmal M, O'Sullivan M, McCabe J, Curtin W. Antegrade locked intramedullary nailing in humeral shaft fractures Injury. 2001; 32:692-4.
21. Petsatodes G, Karataglis D, Papadopoulos P, Christoforides J, Gigis J, Pournaras J. Antegrade interlocking nailing of humeral shaft fractures J Orthop Sci. 2004; 9:247-52.
22. Santori FS, Santori N. The Exp Nail for the treatment of diaphyseal humeral fractures J Bone Joint Surg Br. 2002; 84(3):280.
23. Hadhoud MM, Darwish AE, Mesriga MM. Minimally invasive plate osteosynthesis versus open reduction and plate fixation of humeral shaft fractures. Menoufia Med J. [serial online] 2015; 28:154-61.
24. Pospula W, Abu Noor T. Percutaneous fixation of comminuted fractures of the humerus: initial experience at Al Razi hospital, Kuwait Med Princ Pract. 2006; 1:423-426.
25. Concha JM, Sandoval A, Streubel PN. Minimally invasive plate osteosynthesis for humeral shaft fractures: are results reproducible? Int Orthop. 2010; 34:1297-1305.
26. An Z, Zeng B, He X, Chen Q, Hu S. Plating osteosynthesis of mid-distal humeral shaft fractures: minimally invasive versus conventional open reduction technique Int Orthop. 2010; 34:131-135.
27. Shantharam M, Shetty M, Ajith Kumar KT, Sujay Abhishek R. Kini, Kiran GK. Dept. of Orthopaedics and Traumatology, Tejaswini Hospital and SSIOT, Kadri, Mangalore, India, Minimally invasive plate osteosynthesis for humerus diaphyseal fractures, Indian. J. Orthop [serial online] 2011 [cited 2015 Jul 3] 45:520-6. 2011; 45(6):520-526.