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A prospective study of functional, clinical, and radiological outcome of fracture shaft of humerus middle & distal one third treated by mippo technique

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Abstract
The goal of operative treatment of shaft of humerus fractures is to reestablish length, alignment, and rotation with stable fixation that allows early motion and ideally early weight bearing on the fractured extremity. Various methods of treating middle and distal humeral shaft fractures have continued to evolve from closed methods, external fixation, antegrade and retrograde intramedullary nailing, and conventional plating to minimally invasive osteosynthesis. Plate osteosynthesis remains the gold standard of fixation for humeral shaft fractures. biological plate osteosynthesis is important to preserve bone vascularity, also to improve consolidation, to reduce the infection rate, to avoid bone grafting. MIPO techniques avoid direct exposure of the fracture site and transform the implants in an internal extramedullary splint. More flexible fixation should encourage the formation of callus while less precise indirect reduction will reduce operative trauma. This study determines the safety of MIPPO technique and also to evaluate the clinical, radiological, and functional outcomes in the treatment of humeral shaft fractures (middle & distal one third).

Keywords: Functional, clinical, radiological outcome, fracture shaft of humerus middle, distal one third treated mippo technique

Introduction
The internal fixation of 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). MIPPO has been widely used to treat long bone shaft fractures in recent years because of its technical advantages and satisfactory clinical outcomes. The plate is inserted through a percutaneous approach with separate proximal and distal incisions. This method causes less soft tissue disruption and preserves the fracture hematoma & blood supply to the bone fragments [2] In general; there are four conventional surgical approaches to the humeral shaft: posterior, anterolateral, anterior, and anteromedial. The anterior approach is a safe and feasible method to use minimally invasive percutaneous plate osteosynthesis (MIPPO) in the treatment of humeral shaft fractures proven by Dr. T. Apivatthakakul *et al*. However, the anterior approach might only be suitable for proximal and middle third fractures [2] we undertook a study to determine the safety of MIPPO technique and also to evaluate the clinical, radiological, and functional outcomes in the treatment of humeral shaft fractures (middle & distal third).

Aim of Study
The aim of the clinical study was to determine the safety of MIPPO technique and also to evaluate the clinical, radiological, and functional outcomes in the treatment of humeral shaft fractures (middle & distal one third).

Materials and Methods
We have done a prospective study of twenty cases of fracture shaft of humerus middle and distal one third treated with minimally invasive percutaneous plate osteosynthesis from January 2010 to June 2012. Clinical, radiological and functional outcomes were carried out in all cases.

Inclusion Criteria

- Age above 20 years
- Fracture shaft of humerus (middle & distal third)
- Closed displaced unstable fractures

Exclusion Criteria

- Open fractures
- Neurovascular injury
- Distal humerus fracture with intra articular extension
- Fracture of proximal third of humerus
- Pathological fractures
- Skeletally immature patients
- Patients in which time lag between injury and surgical intervention exceeded three weeks

All eligible patients undergone surgical fixation using MIPPO technique and post op follow up done till 3 years recording the clinical, functional and radiological outcome. The data collected from the patients - sex, injured side, rate of associated injuries, rate of postoperative complications and fracture characteristics were analyzed. Statistical analysis was performed using SPSS software, version 13.0. Independent sample t test was used to compare the results of patient's age, duration of injury, operation time, duration of follow-up, healing time, range of motion of the shoulder and elbow and score of UCLA and MEPS.

Age distribution

Table 1

Age	No. of patients
21-30	3
31-40	8
41-50	5
51-60	2
Above 60	2

Sex Distribution

Table 2

	Sex	Frequency	Percent
Valid	Female	5	25.0
	Male	15	75.0
	Total	20	100.0

Side of Injury

Table 3

Side	Frequency	Percent
Left	11	55.0
Right	9	45.0
Total	20	100.0

Mode of Injury

Table 4

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Fall	6	30.0
RTA	14	70.0
Total	20	100.0

AO/OTA Classification System

Table 5

AO Classification	Frequency	Percent
A-2.2	7	35.0
A-3.2	11	55.0
B-2.2	2	10.0
Total	20	100.0

Associated injuries

Table 6

Associated injuries	Frequency	Percentage
Distal radius fracture	1	5.0
Distal radius fracture right	1	5.0
Fracture both bone forearm	1	5.0
Fracture both bone right leg mid 1/3	1	5.0
None	15	75.0
Subtrochateric fracture right with both bone fracture left	1	5.0
Total	20	100.0

Time interval

1-5 days - 8
6-10 - 7
11-15 days-5

Results

Twenty patients were treated for the fracture shaft of humerus middle and distal one third by applying the MIPPO technique. All patients had intact radial nerve function before the procedure. All cases were operated on using double windows by the MIPPO technique under fluoroscopic control,. The plates were fixed with three to four screws in both proximal and distal fragments. The wound was closed without drains or external immobilization. The patients were encouraged to perform passive range of motion of the shoulder and elbow during the first postoperative week. Active motion was carried out from the second week onwards without a cast or brace. The mean age of the patients was 41.30 years (range 21 – 65 yrs). The average operating time was 100.50 minutes (range 70 – 140 min). The average time interval between the injury and surgery was 7.25 days (range 3 -15 days).The average duration of follow-up was 36.50 weeks (range 24 – 72 weeks). Two patients had radial nerve dysfunction after the operation. On re-exploring, we found that the radial nerve had been exposed carefully in the first patient, and then we confirmed that its damage was due to dragging and contusion. The patient's radial nerve function fully recovered 6 months after the exploration. Another patient's radial nerve function recovered after 12 weeks without any secondary procedure. Fracture union was achieved in all patients without bone grafting. One patient had delayed union for which we gave brace, and then it went on union after 32 weeks. All fractures united with a mean healing time of 17.84 weeks (range 12 - 32 weeks). The UCLA scoring system showed excellent results in nine cases (45 %) and good results in seven cases (35%) and fair in 4 cases (20%).Eighteen patients (90%) had excellent results; two patients (10%) had good results of their elbow function when assessed with the Mayo elbow performance scoring system. There were no superficial or deep infection and implant failures in our study.

At their final follow up, all the twenty patients had an anteroposterior and lateral radiographs of the humerus taken to measure the humeral axial alignment. Normal alignment was seen in nine (45%) cases, whereas varus angulation was

found in seven (35%) cases, and valgus deformity in four (20%) cases.

Discussion

In the 1980s, minimally invasive methods (MIMs) based mainly on bridging-plate osteosynthesis were introduced.[9, 10] since that time, MIMs for fracture treatment have been developed continuously and developed further. The MIPPO technique is an example of an MIM that has become more popular now days.

Dr. T. Apivatthakakul[4] and colleagues have verified that the MIPPO technique can be safely and efficiently applied in the treatment of shaft of humerus middle and distal one third fractures through the anterior approach. Apivatthakakul T *et al* [4] studied on ten arms from five fresh cadavers. There was no radial nerve compression or entrapment by the plate. The distance measured from the closest part of the plate to the radial nerve was 2.0-4.9 mm (average 3.2 mm) with forearm in full supination. When the forearm was pronated, the radial nerve moved closer to the plate by a distance of 0-3 mm. The results of this study showed that it is possible to treat humeral shaft fractures by MIPO technique using an anterior approach.

In our clinical study, 20 patients who sustained middle and distal one third humeral shaft fractures were treated with the MIPPO technique. All the fractures united with a mean healing of 17.84 weeks (range 12 - 32 weeks), which is almost comparable to that reported by Zhiquan A *et al* [1] - 16.2 weeks (range 12 to 32 weeks) and Sang-Jin shin *et al* [8] – 18.4 weeks.

The mean operating time in our study was 100.50 minutes (range 70 – 140 min), whereas in Zhiquan A *et al* [1], it was 113.8 minutes (70-160 min), and Fang Ji *et al* [2], it was only 48 minutes (35-90 min)

In our study, we encountered 2 cases of radial nerve dysfunction post-operatively, which recovered after 6-12 weeks in one case and 6 months in another case after exploration, whereas Zhiquan A *et al* [1] and Apivatthakakkul *et al* [4,5] reported no cases of radial nerve dysfunction after surgery. However, Fang Ji *et al* [2] in his study reported one patient with radial nerve dysfunction which recovered five months after second surgery, and Pospula *et al* reported one patient with transient radial nerve palsy. Livani *et al* [7] reported good results in 35 cases of middle and distal third humeral shaft fractures without any iatrogenic radial nerve lesions. In Sang-Jin shins *et al* [8] study one patient had radial nerve palsy.

In the reviewed literature, there were no reports of non-union after MIPPO technique. However in our series, one patient had delayed union for which we gave brace and then it went on union after 32 weeks.

In Zhiquan A *et al* [1] study, UCLA scoring system rated seven patients (63.8%) as excellent results and six (46.2%) as good results. In Sang-Jin shin *et al* study [8] (31 patients) - 9 were excellent and 3 were good for the proximal humeral fractures, excellent results in 15 cases and good in 4 cases for middle and distal third fractures. Where as in our study the UCLA scoring system showed excellent results in nine cases (45 %) and good results in seven cases (35%) and fair in 4 cases (20%).

In Zhiquan A *et al* [1] MEPS score was excellent in all cases where as in our series eighteen patients (90%) had excellent results; two patients (10%) had good results.

The plate is used as a splint on the outside of the bone as a bridge plate from the biomechanical point of view. Both ends of the plate are fixed to the main fragment by three to four screws. Long plates bridging an extensive zone of fragmentation with only short fixation on either end of the bone will undergo considerable deformation forces. As the bending stresses are distributed over a long segment of the plate, the stress per unit area is correspondingly low, which reduces the risk of plate failure. The entire construction becomes elastic and even simple fractures can be successfully bridged. Although technically difficult, the MIPPO technique is less invasive when compared to the conventional open reduction technique [3].

In comparison with open reduction and internal fixation using a plate, one of the major theoretical advantages of MIPO with an anteriorly placed plate to treat mid-distal humeral shaft fractures is less surgical trauma to the soft tissue around the fracture site. The periosteal circulation around the fracture fragments is minimally disrupted and thus bone union is promoted and complications such as nonunion are decreased.

Conclusion

The results obtained in this study have shown that the MIPPO technique is safe, convenient and effective, since there was no obvious damage, nor major complications. In addition, 20 fractures healed within a similar healing time to other methods with both good alignment and function of shoulder and elbow joints.

Advantages of applying the MIPPO technique are as follows:

1. It is suitable for humeral shaft fractures middle and distal one third.
2. There is no risk of axillary nerve injury.
3. The radial nerve is not at risk as long as the forearm is kept in supination during the procedure
4. No screws are inserted into that part of the humeral shaft where the radial nerve runs along the spiral groove.

Mid-distal third humeral shaft fractures could be effectively treated with the MIPO technique, with advantages of shorter fracture union time and lower incidence of iatrogenic radial nerve palsies but with similar functional outcomes to the conventional open plating technique.

The results obtained with this technique are encouraging. The technique was associated with no shoulder pain and an almost complete restitution of stregth and articular range of motion. Within 6 months, 96% of the patients returned to their normal activities.

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