Acta Orthop. Belg., 2018, **84**, 491-496

ORIGINAL STUDY

Minimal Invasive Percutaneous Plate Osteosynthesis (MIPPO) vs. Open Plating in Superior Plating of Midshaft Clavicle Fractures

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INTRODUCTION

Minimally invasive percutaneous plate osteosynthesis (MIPPO or MIPO) technique was developed to preserve fracture biology during plate osteosynthesis of long bone fractures. This technique involves indirect reduction of fracture fragments without exposing fracture site with bridge plating through separate incisions apart from fracture area. Inıtially this technique was developed for distal femur and distal tibia, with favorable results with higher union rates and less complications *(4, 6)*. Later, this technique gained popularity and used for most of the long bone fractures, as well as periarticular fractures.

Clavicle fractures are commonly seen fractures in emergency care with an estimated incidence of 24.4 fractures per 100.000 population/yr. and account for 10.4% to 17.0% of adult fractures *(1)*. Although most of the clavicle fractures have been treated with non-operative treatment *(16)*, due to increased patient's expectations and reported evidence showing that a displaced clavicle may predispose to malunion and non-union *(7,11)*, increasing number of patients are receiving surgical treatment for displaced mid-shaft fractures.

Despite numerous techniques (including plating or nailing), plate osteosynthesis remains as the main choice of surgical treatment *(14,8,9)*. Despite favorable results, patients are subject to reported complications such as cutaneous hypoesthesia, delayed union or implant failure with non-union *(10,17)*. Fixation by minimal invasive percutaneous plate osteosynthesis technique may help to reduce such complications by preserving soft tissue envelope of fracture site. In this study, we aimed to compare these two plate fixation techniques (Open vs. MIPPO) to determine benefits and drawbacks of both techniques.

MATERIAL AND METHOD

In this retrospective-multicenter comparative study, the hospital records were evaluated in three

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No benefits or funds were received in support of this study.
The authors report no conflict of interests.

trauma centers (Two Training and Education Hospitals and one University Hospital). After local ethical board approval, data regarding mid-shaft clavicle fracture patients treated surgically between April 2011 and January 2015 were extracted from the hospital records database of each hospital. Inclusion criteria were defined as ; AO/ASIF type 15-B2.1-3 and 15-B3.1-3 fractures with more than 20 mm. shortening, adult patients (18 and 55 years), early admission (2 weeks after injury). Exclusion criteria included ; open fractures, ipsilateral additional fractures, fractures with neurovascular impairment. Sixty-five patients were analyzed in two groups to receive either MIPPO (n=32) or conventional plating (n=33). Thirteen patients (10 from MIPPO group and 3 from conventional plating group) did not attend to one year follow up visit, therefore lost from follow-up, consequently excluded from analysis. The study was completed with fifty-two patients, 22 from MIPPO group (Group M) and 30 from conventional plating group (Group C). Baseline characteristics including demographics (age, gender), side of involvement, mechanism of injury, AO fracture type, interval between injury and operation, duration of surgery (incision to wound closure) and amount of fluoroscopy use were collected.

Surgery

All of the operations were performed under general anesthesia, with patient positioned in beach-chair position.

In MIPPO group (Group M), three 2-3 cm long skin incisions were made over clavicle. One is lateral and the other one is medial along the superior border of clavicle. The third incision is centered over the fracture site for ıdentifying and protecting branches of the supraclavicular nerves and for reducing the fracture and fixing with lag screws if possible *(5)*. Appropriate length plate was chosen and pre-contoured, if necessary to fit the shape of the clavicle. Plate was inserted and passed subcutaneously via the lateral incision and advanced medially. Care was taken to keep periosteum and muscular insertions intact. Intra-operative fluoroscopy was utilized during positioning of the plate and reduction of fragments. The plate was fixed with three locking and non-locking screws (six cortices) on each fragment through each of the medial and lateral incisions. (Figure 1)

Fig. 1. — Conventional plating of AO 15-B2.3 type clavicle fracture. Small fragments not amenable for screw fixation were fixed using 2-0 Ethibond loops.

Fig. 2. — MIPPO application of AO 15-B2.3 type clavicle fracture.

In conventional plating group (Group C), an 8-10 cm oblique incision was made over the fracture site. Identifiable branches of the supraclavicular nerves were protected. The fracture was exposed with sharp dissection. Care was taken to keep periosteal stripping minimal. The fracture is reduced. Plate was contoured to fit the shape of the clavicle and then fixed as described for cases at Group M previously. (Figure 2)

Postoperative care and follow-up

Injured extremity was placed in arm sling for two weeks after the operation. Active shoulder

range of motion exercises were encouraged on the day after the operation. Patients were allowed to resume activity of daily living and liberal extremity use 4 weeks after the operation. Fracture union was assessed radiologically by appearance of bony bridging between fracture fragments on A-P x-ray, and also clinically by painless active shoulder function. Patients were invited for clinical and radiological evaluation at post-op 6 weeks, 3 months and following three month intervals until union had achieved. At the final follow-up, functional evaluation was made using Quick Disability of the Arm, Shoulder and Hand (DASH) instrument. Additionally cosmetic satisfaction, pain during lying on the affected site and presence of hardware irritation as skin irritation and dysesthesia were also investigated *(2)*.

Statistical analyses were performed with SPSS version 16.0 (SPSS Inc. IL. USA) software. Visual and analytical methods (Shapiro-Wilk's test) were used to test for normal distribution. Continuous variables were defined as mean ± standard deviations. Parameters with normal distribution were compared using t-test whereas those with non-normal distribution were compared using Mann Whitney test. Categorical data were compared using chi-square test or Fisher's exact test. P value < 0.05 was considered to be statistically significant.

RESULTS

Baseline characteristics of groups were given at table 1. Two groups were similar in regard to baseline characteristics. Majority of fractures were AO type 15-B2, also most fractures resulted from fall. Time from injury to operation was 2.4 days in Group M and 2.7 days in Group C (p=0.19), respectively (Table 1).

Study outcomes were given in Table 2. Mean time of operation was significantly longer in group M (53.59±7.78 min) compared to group C (46.90±4.72 min) (p<0.001). Mean fluoroscopy time was also significantly longer in group M compared to group C (13.77±2.65 sec vs. 1.80±0.61 respectively, p<0.001). Although mean hospital stay was shorter in group M (4.95±1.04 days) than group C (5.43±0.89), this difference did not reach statistical significance (p=0.09). Superficial wound infection occurred in one patient (4.5%) from group M and in 2 patients (6.7%) from group C. None of these patients required implant revision and all recovered with wound care and antibiotic treatment.

Table 1. — Baseline characteristics

	Group M (n=22)	Group C (n=30)	P value
Mean age (years)	32.32±8.22	34.70±9.37	0.37
Male gender	12 (54.5%)	18 (60.0%)	0.70
Right sided involvement	10 (45.5%)	13 (43.3%)	0.87
Mechanism of injury			
Fall	15 (68.2%)	19 (63.3%)	0.71
Motor vehicle accident	3 (13.6%)	7 (23.3%)	0.48
Sports injury	3 (13.6%)	4 (13.3%)	0.97
Assault	1 (4.5%)	0 (0.0%)	0.42
AO Fracture type			
15-B2	16 (72.7%)	22 (73.3%)	0.96
15-B3	6 (27.3%)	8 (26.7%)	0.96
Time from injury to operation (day)	2.4	2.7	0.98

Mean follow-up period was similar at both groups as ; 14.57±6.39 months (9.70 - 38.60 mo.s) in group M and 14.79±3.14 months (9.90 - 19.33 mo.s) in group C. Fracture healing time was significantly shorter in group M (13.64±2.98 weeks), compared to group C (16.50±4.52 weeks), (p=0.01). During follow-up, implant failure occurred in one patient from MIPPO group and in two patients from conventional plating group. These three patients were revised with open plating with a longer plate and bone grafting. Also delayed union (union after 6 months) was observed in two patients (% 6, 7) in conventional plating group.

At final follow-up examination quick DASH scores were not significantly different between two groups. None of the cases had implant removal at the time of final follow up examination. Although cosmetic dissatisfaction and dysesthesia over incision were reported more common in conventional plating group compared to MIPPO group, differences between groups did not reach statistical significance (p=0.17 and p=0.16 respectively). Other outcome variables were also similar between two groups. (Table 2)

Table 2. — Study outcomes

	Group M (n=22)	Group C (n=30)	P value
Operation data			
Operative time (min)	53.59±7.78	46.90±4.72	**<0.001**
Fluoroscopy time (sec)	13.77±2.65	1.80±0.61	**<0.001**
Hospital stay (days)	4.95±1.04	5.43±0.89	0.09
Wound infection	1 (4.5%)	2 (6.7%)	0.74
Follow-up data			
Follow-up time (months)	14.57±6.39	14.79±3.14	0.31
Fracture healing time (weeks)	13.64±2.98	16.50±4.52	**0.01**
Delayed union	0 (0.0%)	2 (6.7%)	0.50
Cosmetic dissatisfaction	9 (40.9%)	18 (60.0%)	0.17
Quick DASH score	8.15±1.92	8.35±2.18	0.73
Skin irritation	3 (13.6%)	4 (13.3%)	0.97
Dysesthesia	2 (9.1%)	8 (26.7%)	0.16
Pain	4 (18.2%)	7 (23.3%)	0.74
Implant failure	1 (4.5%)	2 (6.7%)	0.74

DISCUSSION

As of December 2015, more than 210 publications are available about MIPPO or MIPO at PubMed. Despite this abundance of data and evidence, few studies are available about use of MIPPO technique for treatment of mid-shaft clavicle fractures. Tieyi et al. reported 100 % union rate in an average union time of 14.6 weeks, from their retrospective review of 269 midshaft clavicle fractures treated with MIPPO method. They also reported an average DASH score of 4.6 points with 96% overall satisfaction *(15)*. Sohn et al. reported the outcomes of 15 midshaft clavicle fracture cases treated with anterior-inferior MIPPO plating. They reported 100% union, in an average duration of 15.1 weeks, with 86.7% excellent result according to UCLA scores functionally *(13)*. Zhang *et. al.* reported results of 15 midshaft clavicular fractures treated by MIPO by superior plating method. In this study they reported average operative time as 60.2 minutes and average duration of bony union as 10.1 weeks. Skin numbness was observed in 13.3% of patients with a mean DASH score of 3.8±2.9 *(18)*. A recent study by Sohn et. al. compared open plating with MIPO plating for midshaft clavicle fractures. They state that both technique revealed similar results, except less skin irritation was observed in patients treated with MIPO compared to open plating (0% vs 28% respectively). Same study also reported that operative time was shorter in MIPO plating compared to open plating (77.2 vs 87.5 min. respectively), but the difference was not statistically significant (*12*). In another study reported by Sohn et al. MIPO plating with superior or anteroinferior plating revealed similar results, with anteroinferior plating demonstrated less hardware related complications, without statistical significance *(14)*.

In present study mean operative time was 53.59±7.78 minutes for MIPPO cases and 46.90±4.72 minutes for conventional open plating cases, which are shorter than previously reported studies. Mean operation times of reported studies ranged between 60 to 87.5 minutes *(12,18)*. In present study, contrary to results of Sohn et al. we observed a time loss of approximately 6.7 minutes at MIPPO treated cases. This difference could be caused by repetitive fluoroscopy use for reduction of fracture ends and placement of plate. Additionally ; since conventional plating is a straightforward procedure, without a need for intraoperative imaging, shorter operation time was expected.

Union time is an important factor of time-to-return to labor. Another significant finding of our study was shorter union time observed at MIPPO group. Radiological fracture healing time was 13.64±2.98 weeks in MIPPO group, whereas 16.50±4.52 weeks in open plating group. Union time of MIPPO cases of our study was concordant with previous studies (between 10.1 and 15.1 weeks) *(13,18)* . Although Sohn *et al. (12)* could not demonstrate a significant difference between open plating and MIPPO in terms of union time ; we observed a more rapid union in MIPPO treated cases. This can be contributed to preservation of soft tissue during MIPPO application and relatively more periosteal stripping done during conventional open plating *(3)*.

Radiation exposure is an important factor of fracture treatment for operation theatre staff. In our study we observed significantly higher fluoroscopy utilization in MIPPO group. This increased use of imaging also translated to increased operative time.

This factor should be taken into consideration, counterweighting the benefits of MIPPO.

Similar to previously published studies, we did not observe overall functional and radiological difference between MIPPO and conventional plating groups. Both technique offers favorable radiological and functional outcome. Although not statistically significant, another finding in our study was three-fold increased prevalence of dysesthesia over incision, observed in open plating cases (26.7%). This finding was also reported by Sohn et al, reporting a dysesthesia prevalence of 28% *(12)*. Similarly in current study, two-fold higher rates of cosmetic dissatisfaction, pain, wound infection, delayed union and implant failure were observed in conventional plating group (table-2). With larger scale studies with increased power, these differences can reach statistical importance. Other study parameters including hospital stay, Quick DASH scores and skin irritation rates were roughly similar.

Our study has some limitations. Multicenter retrospective nature of our study with different surgeons makes the results of current study questionable. Another limitation of our study is we have not made discrimination between AO type 15-B2 fractures and AO type 15-B3 type fractures. Since fracture biology and healing between these two group of fractures are different, this also can be accepted as a confounder on results of this study.

CONCLUSION

Despite increased intraoperative imaging use and prolonged surgery time, MIPPO technique results with shorter fracture healing (bone union) time with less wound site related morbidities. Comparative studies with larger sample size are necessary to demonstrate further benefits of MIPPO method.

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