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MIPO in the Management of Type IIIA Compound Femoral Shaft Fractures Caused by High Velocity Missiles

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Abstract

Background: Compound femoral shaft fractures that caused by high-velocity missiles HVMs (bullets and shells) are very extensive injuries, and still remain one of the greatest challenges to orthopedic trauma surgeons, closed intramedullary locked nail is considered the gold standard treatment modality, but it is not always available or applicable, and conventional plating method of these fractures had increasing rates of infection, delayed union, nonunion and implant failure.

Aim of the study: To evaluate MIPO (The Minimally Invasive Plate Osteosynthesis technique) technique as an alternative procedure to closed intramedullary locked nail in treatment of type IIIA femoral shaft fractures due to HVMs.

Patients and methods: This prospective study, from October 2014 to March 2016, included 16 male patient, aged between 22-47 y, 4 patients were civilians and 12 were militaries, with 16 compound femoral shaft fracture of type IIIA (Gustilo-Anderson Classification) that caused by HVMs, 13 fracture were caused by bullets and 3 by shells. All fractures had been treated by early wound debridement and external fixation and one-stage conversion to internal fixation by MIPO technique using long DCP within 2 weeks, when there are no signs of active infection.

Results: For all fractures, 4 of 16 fracture (25%) had bony union in 18 week, 10 of 16 fracture (62.5%) had bony union in 24 week, and only 2 of 16 fracture (12.5%) did not have complete bony union at 24 week (delayed union), which had complete healing of the fractures in the next 6 weeks (in 30 week) without secondary surgical intervention. For all fractures, there were no wound healing complications, infections, nonunion or implant failure.

Conclusion: MIPO treating HVMs femoral shaft fractures can be used as an alternative procedure to closed intramedullary locked nail.

Keywords: Type IIIA compound femoral shaft fracture; HVMs; MIPO; Complications

Introduction

Compound femoral shaft fractures due to high-velocity missiles HVMs (bullets and shells) are very extensive injuries, victims are militaries and civilians, and it has been considered as surgical emergencies and associated with complications such as infection, non-union and mal-union; and carries social and economic burdens.

The challenge of such injuries is identifying the therapy that will result in the most predictable and acceptable fracture union with minimal complications [1].

Medium and high-velocity missiles from pistol, rifle bullets or fragments of shells produce almost the same pattern of injury; damage to the body by laceration, crushing, shock waves and cavitation's, in addition to the pathophysiologic effects, psychological trauma must be considered [2]. The success of management depends, to a large extent, on a minimal interference with the blood supply to the bone [3].

There are many classification systems for open fractures, such as Gustilo-Anderson classification which is widely used [4,5], and it is prognostically valuable for predicting infections [6-8].

High-velocity bullets are defined as those traveling at a speed >2000 ft/s (M16 military rifles and most hunting rifles) [9]. With higher velocities, the temporary cavity is larger and fills with water vapor at a low atmospheric pressure, causing a momentary vacuum, which may attract contaminating foreign material [10,11].

All open fractures must be assumed to be contaminated; step by step antibiotic prophylaxis, urgent wound and fracture debridement, stabilization of the fracture and early definitive wound cover can prevent more harmful effects [12], taking in consideration 6 h is the benchmark time from injury to debridement of open fractures in most of the trauma centers [13,14].

An effort should be made to convert an external fixator to a nail within 2-4 weeks after injury, in order to minimize the risk of infection [15,16].

Minimally invasive plate osteosynthesis (MIPO) is a method of biological internal fixation performed by introducing a plate *via* small insertion incisions, without interfering with fracture environment [17,18], MIPO can be a good alternative to the gold standard nail in treatment of femoral fractures due to HVMIs.

It has been rightly said by well-known anatomist Schenk, "If the fracture surgeon does something 'LOGICAL' then 'BIO' will do the rest" [19].

Patients and Methods

This prospective case series study was carried out in Baghdad Medical City. Approval for the work was obtained from The Iraqi Board for Medical Specializations (the scientific council of fracture and orthopedics). Written informed consent had been taken from all patients after careful explanation about method of management and other available options. Fractures were identified according to the Gustilo-Anderson Classification [4,5,20].

Inclusion criteria for this study were Patients with compound femoral shaft fractures that caused by high velocity missiles (bullets or shells) of type IIIA (Gustilo-Anderson Classification).

Exclusion criteria were Patients with compound femoral shaft fractures that caused by high velocity missiles (bullets or shells) other than type IIIA (like IIIB, IIIC), poly-trauma patients with major systemic injuries like head and chest injuries, patients with extensive limb injuries that required amputation, pediatric patients and elderly patients with medical comorbidities.

From October 2014 to March 2016, 16 male patients included in the study average age 31 years (range, 22 to 47 years). 6 left sided femoral fractures and 10 right sided femoral fractures. 13 fractures were caused by bullets and 3 fractures were caused by shells (blast injuries). 4 patients were civilians and 12 patients were militaries. 2 patients were hypertensive controlled with medication and 9 patients were smokers.

All patients were received at the Medical City Emergency Department. The injured limb was evaluated regarding the viability of the limb, the neurological status, the site and size of the entry and exit wounds. All patients received prophylactic antibiotics and anti-tetanus.

The patients then transferred to the operating room for wound debridement and skeletal fixation, we used external fixators (AO and Hoffman types) with two or three 6 mm half-pins inserted into the distal and proximal femoral fragments and connected to a unilateral frame after closed reduction of the fracture.

Removal of the external fixators and one-stage conversion procedure to internal fixation by MIPO technique with DCP was performed for all patients within 2 weeks; averaged 10.93 days (range, 7 to 14 days) (Table 1 and Figures 1 and 2).

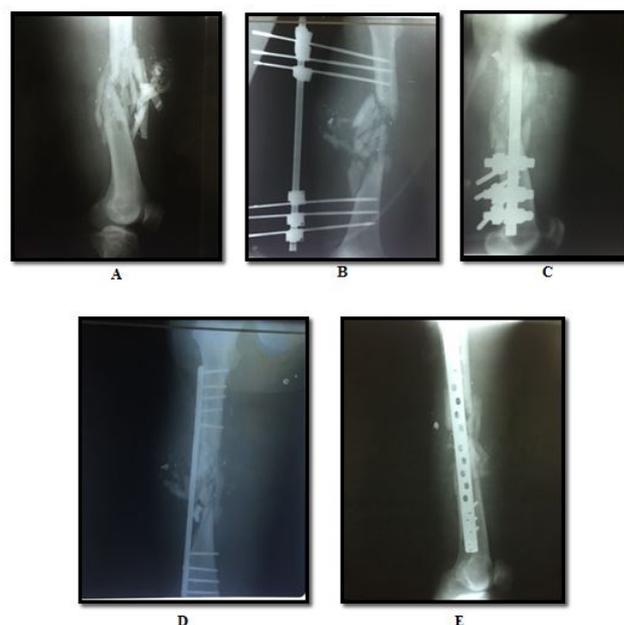


Figure 1: Patient number seven. (A) Type IIIA right side femoral shaft fracture caused by high velocity bullet. (B) AP plain radiograph of the fractured femur 24 h post injury. (C) Lateral radiograph 24 h post injury. (D) AP plain radiograph after 14 days. (E) Lateral radiograph after 14 days.

Post-operatively, patients started early active hip and knee movements and static quadriceps exercises as tolerated.

Table 1: Patients characteristics.

Case	Age /y	Sid e	Missi le	Note s	Smok er	Comorbidit y	Period/ d
1	47	Lt	Bullet	Civili an	Yes	Hypertensiv e	10
2	22	Rt	Bullet	Milit ary	No	No	7
3	40	Rt	Bullet	Milit ary	Yes	No	12
4	26	Rt	Bullet	Civili an	Yes	No	12
5	30	Lt	Bullet	Milit ary	No	No	9
6	36	Lt	Shell	Milit ary	Yes	No	10
7	25	Rt	Bullet	Milit ary	Yes	No	14
8	35	Rt	Bullet	Milit ary	Yes	No	12
9	28	Rt	Bullet	Milit ary	No	No	13
10	24	Rt	Shell	Milit ary	No	No	12
11	25	Rt	Shell	Civili an	Yes	No	11

12	23	Lt	Bullet	Military	Yes	No	11
13	33	Lt	Bullet	Military	No	No	12
14	42	Rt	Bullet	Military	Yes	Hypertensive	12
15	34	Lt	Bullet	Military	No	No	10
16	26	Rt	Bullet	Civilian	No	No	8

Two weeks postoperatively, all patients had been followed for wound care and removal of stitches. Patients were allowed to walk with crutches, without weight-bearing on the affected limb.

Clinical and radiological assessments were performed at 6 weeks and every 6 weeks until complete healing of the fractures (12 week, 18 week, 24 week, 30 week, and 36 week).



Figure 2: (A) Surgical incisions. (B) Tunnelling instrument. (C) Screws insertion. (D) Post-operative wounds.

Patients were allowed to walk with crutches with partial weight-bearing in the sixth post-operative week (all patients had radiological sign of callus formation in the sixth post-operative week). The progressive weight-bearing with crutches was gradually increased as fracture union progresses but full weight bearing was not allowed until complete healing of the fracture. Complications, if present such as infection, fixation failure and delayed union or non-union were documented. Post-operative wound infection was classified as superficial or deep infection according to the criteria of the US Centers for Disease Control and Prevention for defining a surgical site infection [21].

Results

All patients were males, with a mean age and standard deviation of 31.0 ± 7.5 years (range 22-47 years). Average follow-

up was 8.68 months (range, 6–14 months). Type of missiles was high velocity bullets in 13 case (81.3%), and shells in 3 cases (18.8%).

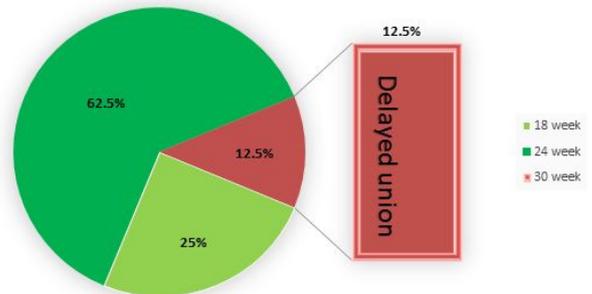


Figure 3: Fracture union/weeks.

4 of 16 fractures (25%) had bony union in 18 week, 10 of 16 fractures (62.5%) had bony union in 24 week and only 2 of 16 fractures (12.5%) did not have complete bony union at 24 week which considered as a delayed union. Of the 2 delayed union fractures, complete healing of the fractures occurred in the next 6 weeks (in 30 week) without secondary surgical intervention.

The union and delayed union rates/weeks are shown in **Figure 3** and the follow up results are shown in **Table 2**. For all the 16 fracture, the union rate was 87.5% (14 of 16 fracture), the delayed union rate was 12.5% (2 of 16 fracture), and there was no wound healing complications, infections, non-union or implant failure (**Figure 4**).

Discussion

Compound femoral shaft fractures that caused by high-velocity missiles HVMs (bullets and shells) are increasing in our country (Iraq) because of the war against terrorism.

Treatment by wound debridement and external fixation or primary interlocking nail is the main stay of treatment, but there is limited data regarding the ideal time to conversion from external to internal fixation; however, the general window of 2 to 4 weeks yields high rates of union and low infection [22]. However, an effort should be made to convert an external to internal fixation within 2 weeks after injury.

Wenda [23] and Krettek [24] introduced a percutaneous plating technique called “minimally invasive plate osteosynthesis (MIPO)”. MIPO has gained popularity and has continued to evolve in the last decade, but there are limited reports about management of the compound femoral shaft fractures that caused by high velocity missiles with MIPO.



Figure 4: (A-G) patient with right side compound femoral shaft fracture of type IIIA caused by high velocity bullet, treated by early wound debridement and external fixation of the fracture, then within 14 days, one stage conversion from external to internal fixation done with MIPO using long DCP. (A-B) AP and lateral post-operative x-ray, (C) 3 months post-operatively, (D) 6 months post-operatively, (E) 1 year post-operatively, (F) Same patient at 6 months post-operatively, (G) Same patient at 1 year post-operatively.

Closed intramedullary locked nail is considered the gold standard treatment for femoral shaft fracture [25], but it is not always available or applicable.

Wiss et al. treated 56 femoral fractures due to low velocity gunshot injuries with interlocking nailing and concluded that the result of closed interlocking nailing were excellent, all fractures united and there were no infections, two delayed unions and seven mal-unions [26].

Table 2: Follow-up results.

Cas e	PWB/w	FWB/w	Fracture union/w	Follow-up /m	Complication
1	6	24	24	8	No
2	6	22	18	6	No
3	6	24	24	7	No
4	6	24	24	10	No
5	6	24	24	8	No
6	6	24	24	9	No
7	6	20	18	6	No
8	6	24	24	10	No
9	6	24	24	9	No
10	6	24	24	8	No
11	6	30	30	12	Delayed union
12	6	24	24	9	No
13	6	22	18	8	No
14	6	30	30	14	Delayed union
15	6	24	24	8	No
16	6	22	18	7	No

PWB: Partial Weight Bearing; FWB: Full Weight Bearing; W: Weeks; M: Months

A retrospective review of 39 fractures of the femur in 37 patients caused by low and mid-velocity missiles treated with immediate nailing, they recommend immediate nailing of gunshot fractures of the femur [27], the cases in this study were due to low and mid-velocity missiles, HVMIs causing different pathology and more extensive injuries with more complications.

Singla et al. [28] in their prospective study of 55 compound femoral shaft fracture, concluded that, "the intramedullary interlocked nailing technique is ideally suited for compound femoral shaft fractures, because it gives more stability than plates due to its load sharing nature and its closeness to the weight bearing axis of body, also it allows early mobilization and weight bearing with axial compression on fracture site.

Apivatthakakul and Chiewcharntanakit [29] in their retrospective study of 36 closed femoral shaft fractures which underwent MIPO, there were no wound healing complications or infections and the union rate was (91.8%) and there was no plate failure.

Abulkalam et al. [30] in their prospective study of 40 comminuted femoral shaft fractures (open and closed), concluded that, the management of comminuted femoral shaft fracture with bridge plating is a very good procedure.

Oh et al. [31] in their study investigated the surgical outcomes of patients with femoral mid-diaphyseal fractures treated with MIPO, which were difficult for intramedullary nailing, they concluded that "in cases of difficult intramedullary nailing, MIPO could be an alternative surgical option, but concurrent soft tissue injuries and multiple trauma may increase the risk of non-union in spite of biological fixation".

Increasing rates of infection, delayed union, non-union and failure of implant in conventional plating method of open fractures had been widely reported [32-36].

Although, patients' number in our study was less than that of other studies and the follow up time was shorter, all these variables were not causing major influence on our results that are consistent with other studies.

Conclusion

MIPO treating of HVMs femoral shaft fractures can be used as an alternative procedure to intramedullary nail in fractures of type IIIA (Gustillo-Anderson Classification).

One-stage conversion from external to internal fixation, within 14 days, is the ideal time to decrease the complications in the management of HVMs femoral shaft fractures.

Recommendation

Prospective comparative studies with the gold standard are needed in the future to better demonstrate the effectiveness of MIPO technique in the treatment of HVMs femoral shaft fractures.

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The study is self-funded.

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