Research Article

MIPO technique for compound diaphyseal tibial fractures treated earlier by external fixators

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Abstract

Background: MIPO technique is one of the best methods of treatment for comminuted diaphyseal tibial fractures which preserve the endosteal blood supply with minimal interference with muscle attachment and periosteal blood supply for the bone fragments.

Aim of the study: to compare between using MIPO technique in the treatment of compound comminuted tibial diaphyseal fractures after application of external fixators and using the external fixators for treatment alone.

Materials and Methods: 41 patients with 49 compound diaphyseal tibial fractures treated by external fixators, 28 (57.1 %) fractures of them were exchanged into internal fixation after 15-35 days (n=28) mean (29.4 days) by MIPO technique (group I), and the rest (21, 42.9 %) were left with their external fixators to the end of the study (group II). Thirty-six patients were male, and 5 were female. The 4 parameters of final comparison were infection (superficial, pin tract, and deep), nonunion, malunion and time to union.

Results: Seventeen (34.8%) fractures developed superficial and pin tract infection and only 8 (16.3%) fractures developed deep infection. Only 7 (14.3%) fractures developed non-union, 4 (8.1%) in group I, and 3 (6.2%) in group II. Thirteen (26.5%) fractures developed malunion, from them 10 (20.4%) in group II and only 3 (6.2%) in group I. In group I, 14 (50%) fractures were united after 3 months of follow-up, 21(75%) after 6 months, 23 (82%) after 1 year, and 24 (85.7%) fractures after 1.5 year (24/28). Mean union time was (20.6) weeks. In group II, 6 (28.5%) fractures were united after 3 months, 10 (47.6%) after 6 months, 13 (61.9%) after 1 year, and 18 (71.4%) after 1.5 year (18/21). Mean union time was 12.5 months (50 weeks). Group I with MIPO technique showed good and early union at 3, 6 months and 1 year follow-up (P-value < 0.05) in comparison to group II.

Conclusion: The MIPO technique is a reliable fixation approach to fractures of the diaphysis of tibia, preserving most of the osseous vascularity and fracture haematoma and thus providing for a more biological repair.

Key words: **MIPO technique, external fixator, compound fractures, diaphyseal tibial fractures**.

INTRODUCTION

Diaphyseal tibial fractures are special problem confronting the orthopedic surgeons, as the bone is subcutaneous and deprived of muscle attachment, and poor blood supply. Comminuted tibial shaft fractures are primarily caused by high-energy trauma, such as motor vehicle accidents, sports injuries, and falls from a height; they are the most common diaphyseal fractures in adults [1]. Many modalities of treatment are available for comminuted diaphyseal tibial fractures, like open reduction and internal fixation with plate and screws, intramedullary nails, external fixators, and biological bridging plate. Minimally invasive percutaneous plates provide an alternative to manage these lesions.

Minimally invasive percutaneous plating is inserted percutaneously through a small incision, thereby providing stability and minimizing any intra-operative iatrogenic soft tissue damage [2-3]. Biological plating techniques are those in which blood supply to the fractured fragments is maximally preserved. The objective of biological fixation is to aid the physiological process of bone healing wisely and optimally, with minimal amount of operative intervention [4]. Its advantages are that the MIPO technique does not interfere with the fracture site and thus provides improved biological healing [5]. The development of indirect reduction techniques dates from the late 1980s; the aim of these techniques is to achieve axial alignment and stable fixation while preserving the fracture biological environment. Bone heals by both endosteal union and callus formation. It has been reported that the use of these methods successfully decreases the incidence of fracture complications [6]. The minimally invasive techniques enable a longer plate to be used. It has several advantages as it distributes the stress over a longer length of bone, allows screws to be inserted at the most desirable intact bone away from the fracture site, and better aids the alignment of the distal to the proximal intact fragment [7]. Many classifications systems are used for open tibial fractures, but the most useful one is Gustilo's classification. The Gustilo-Anderson (GA) classification describes soft tissue injury [8].

Type I Open fracture with a skin wound <1 cm in length and clean.

Type II Open fracture with a laceration >1 cm in length without extensive soft tissue damage, flaps, or avulsions.

Type III Open segmental fracture with >10 cm wound with extensive soft tissue injury or a traumatic amputation (special categories in Type III include gunshot fractures and open fractures caused by farm injuries).

III_A Adequate soft tissue coverage.

III_B Significant soft tissue loss with exposed bone that requires soft tissue transfer to achieve coverage.

III_C Associated vascular injury that requires repair for limb preservation.

MATERIAL AND METHODS:

Forty-one patients with 49 compound tibial diaphyseal fractures that treated by early external fixators, between January 2010 and June 2014 at Al-Yarmouk teaching hospital. The mean age of the patients at the time of injury was 34.6 years (range, 15–65 years).

Thirty-six patients were male, and 5 patients were female, as shown in table 1 .

Table 1: Sex distribution.

Sex	**Number of patients**	**%**
Male	**36**	**87.8**
Female	**5**	**12.2**

thirty-two patients were injured in blast injury, 5 by road traffic accident, and 4 patients were injured by fall from height. Thirty-three patients are unilateral and 8 with bilateral fractures as shown in table 2. All the fractures were comminuted

Table 2: Types of injury.

Type of injury	**Number of patients**	**%**
Blast injury	**32**	**78**
RTA	**5**	**12.2**
FFH	**4**	**9.8**

The mean Injury Severity Score (ISS) of the 41 patients was 12.8 (range, 9–27).

The 49 open tibial fractures were classified according to the criteria of Gustilo [8]: type I, 11 fractures; type II, 21 fractures; type IIIA, 6 fractures; type IIIB, 10 fractures, and type IIIC, 1 fracture as shown in table 3.

Table 3: Gustilo classification.

Gustilo classification	n	%
Type I	11	22.4
Type II	21	42.9
Type IIIA	6	12.2
Type IIIB	10	20.4
Type IIIC	1	2.1

Severity of fractures was classified according to AO/ASIF classification [9]: type A, 5 fractures; type B, 20; type C, 24. One fracture was in the proximal third of the tibial shaft; 45 were in the middle third; 3 were in the distal third as shown in table 4.

Table 4: AO/ASIF classification.

AO/ASIF classification	n	%
Type A	5	10.2
Type B	20	40.8
Type C	24	49

Groups and treatment:

Patients were randomly divided into the following two groups according to the method of treatment: group I, external fixators were applied at the time of initial debridement followed by MIPO after 15-35 days (n=28) (mean 29.4 days); group II, immediate external fixators as definitive treatment (n=21). All fractures were initially stabilized by closed AO external fixators. Intravenous antibiotic treatment with a 3rd generation cephalosporin for Gustilo type I and II fractures with the addition of gentamycin (Garamycin) for type-III fractures was begun earlier in the emergency room, and continued for 3–5 days after the initial surgery. After the patient was resuscitated and all required emergency surgical procedures were completed, the open wound was irrigated and debrided. Debridement was repeated at 48-hour intervals until the wound was clean and all devitalized tissue had been excised.

For group I, the AO external fixators were exchanged to percutaneous bridge plate and screws, after healing of wounds and soft tissue, by passing the fracture and its comminution small 2 incisions proximal and distal to the fracture site in the anterior compartment of tibia, and by periosteum elevator we create a tunnel lateral to the tibia and the fracture, then a long ordinary plate routed in the tunnel either from proximal to distal or vice versa, sometime bending of plate done. About 3-6 screws fixed proximally and the same number of screws distally to the tibia. The screws fixed under direct vision, and no fluoroscopy used for reduction.

For group II, the external fixator left in place as definite treatment for the end of follow-up as shown in table 5.

Table 5: classification of patients into 2 groups according to treatment type.

	n	%
Group I	28	57.1
Group II	21	42.9

The soft-tissue managed as follows: primary suture (n = 3; 6.1%); delayed primary suture (n = 33; 67.3%); secondary split-thickness skin grafting (n = 2; 4.1%); local flap (n = 9; 18.4%); and free flap (n = 2; 4.1%). The primary sutures were performed in many cases of types I and II. The soft-tissue management in type IIIA consisted of primary sutures or delayed primary sutures, and that in type IIIB consisted of local or free flaps as shown in table 6 and figure 6. Bone graft was not used in any of our cases even for non-union or delayed union.

Table 6: Soft tissue management.

Soft tissue management	n	%
Primary suturing	3	6.1
Delayed primary suturing	33	67.3
Skin graft	2	4.1
Local flap	9	18.4
Free flap	2	4.1

Statistical analysis:

This is a comparative study compare between the 2 modalities of management of compound comminuted diaphyseal tibial fractures.

Follow-up evaluations lasted from 7 months to 1.5 year (mean, 1.1 year) after the original injury.

Superficial and deep infections were defined according to Dellinger *et al.* [10]. A superficial wound infection was located entirely above fascia with erythema and tenderness that required antibiotic therapy. A deep infection involving bone was defined as infection involving tissue below the deep fascia. Pin tract infection was defined as any persistent drainage from a pin site requiring intervention or positive bacterial cultures from the pin site.

Bony union was defined as follows: clinically, there was no pain or tenderness, and the patient walked without aids; radiographically, solid bridging callus had connected the fracture fragment on both anteroposterior view and lateral view [11]. Nonunion was defined as a lack of clinical or radiographic evidence of healing 9 months after the injury, requiring a secondary procedure. Malunion was defined as valgus or varus deformity of fracture site of about > 10 degrees, anterior or posterior angulation 10 degrees, and 5 degrees rotation. The 4 parameters of final outcome were infection, nonunion, malunion and healing time to union.

Follow-up of patients were arranged at time of admission, 2 weeks, 1 months, 3 months, 6 months, 1 year, and 1.5 years for both groups.

t – Test table used in our analysis. *The P* value of <0.05 was considered to be significant.

RESULTS

Infections:

Eight (16.3%) of the 49 open tibial fractures developed deep infections. Five of these infections were caused by methicillin-resistant Staphylococcus aureus (MRSA); and 3 were caused by Pseudomonas aeruginosa. The deep infections occurred 4 in Gustilo type II (8.2%, 4/49), 3 in type IIIB (6.1%, 3/49), and 1 in type IIIC (2.0%, 1/49).

Six (12.2%) of total infected fractures were in group II, and only 2 (4.1%) deep infections were in group I after the internal fixation. These infections are treated by wound debridement, thorough wash of the fracture site and triple antibiotics, 7 of them cleared form infection after 1-4 months (mean 2.3 months), and only one in group I in which the internal fixation was exchanged to external fixator.

Superficial and pin tract infection were developed in 17 (34.8%) of the total fractures in both groups, and treated by frequent dressing and antibiotics.

Fifteen (30.7%) of them are in group II, and only 2 (4.1%) in group I as shown in table 7.

Table 7: Infection.

	Deep infection		Superficial & pin tract infection	
Group I	2	4.1 %	2	4.1 %
Group II	6	12.2 %	15	30.7 %

Non-union:

Only 7 (14.3%) fractures developed non-union, 4 (8.1%) in group I, and 3 (6.2%) in group II as shown in table 8.

Table 8: Non-union.

Non-union	n	%
Group I	4	8.1
Group II	3	6.2

Malunion:

Thirteen (26.5%) fractures developed malunion, from them 10 (20.4%) in group II and only 3 (6.2%) in group I as shown in table 9. In group II, realignment of external fixators was done to correct the malunion under fluoroscopy before consolidation started. In group I, osteotomy and internal fixation was done after removal of original plate.

Table 9: Malunion.

Malunion	n	%
Group I	3	6.2
Group II	10	20.4

Time of fracture union and healing:

Patients were followed at time of admission, 2 weeks, 1 months, 3 months, 6 months, 1 year, and 1.5 years for both groups.

Forty-two (85.7%) of the total fractures showed good union at the end of our study (only 7 fractures were not united, 14.3%).

In group I, 14 (50%) fractures were united after 3 months of follow-up, 21(75%) after 6 months, 23 (82%) after 1 year, and 24 (85.7%) fractures after 1.5 year (24/28). Mean union time was 5.1 months (20.6 weeks), range 10 – 52 weeks.

In group II, 6 (28.5%) fractures were united after 3 months, 10 (47.6%) after 6 months, 13 (61.9%) after 1 year, and 18 (71.4%) after 1.5 year (18/21) as shown in table 10. Mean union time 12.5 months (50 weeks).

Table 10: fracture union time.

	1 month	3 months	6 months	1 year	1.5 year
Group I	0	14	21	23	24
Group II	0	6	10	13	18
***P*-value**		0.039	0.026	0.036	0.040

Group I with MIPO technique showed good and early union at 3, 6 months and 1 year follow-up (P-value < 0.05) than group II.

DISCUSSION

Compound diaphyseal tibial fractures are common problem in our emergency department because of high blast injuries due to frequent terrorist attacks in our country.

To maintain early function of the limb and stimulate the healing process, the so-called biological internal fixation was developed. It combines minimal surgical trauma, and acceptable rather than precise reduction [4].

Baumgaertel and Gotzen showed that in classic open fixation, 80% of the arteries were damaged, but in biological fixation, these vessels remain intact [7].

Regarding sex distribution, most of cases are male patients (n=36), because they were military victims, while the small percentage of females (n=5) was came from RTA.

In our study, the mean age of the patients at the time of injury was 34.6 years (range, 15–65 years); these result comparable to the studies by Siddhartha V et al [12], Bahari et al [13], and Redfern et al [14]. The age of the patient had no bearing on the time to union in our study.

Infection:

Eight (16.3%) fractures developed deep infections in our study which was higher than Siddhartha V et al [12] study in which 1 patient had a deep infection (2 %) which may attributed to the severity of injuries but it was comparable to the result of Lau et al [15] which was 16.7 % and less than Ronga et al [16] which was 42.3 % of cases, and this is may be related to the relative instability of external fixators in group II.

Superficial and pin tract infection were developed in 17 (34.8%) of the total fractures in both groups in our study, while in Siddhartha V et al [12] study only 5 patients (10.0%) had post-operative superficial wound infection and 14.6 % in Guo J J et al [17].

Malunion:

In our study, 13 (26.5%) fractures developed malunion, from them 10 (35.7%) in group II and only 3 (6.2%) in group I, while in the study by Collinge and Protzman [18], out of a total 38 fractures, they had one (2.6%) malalignment with >5° angulation and 1 cm shortening. Redfern et al [14] had 1 (5%) malunion in a series of 20 patients treated with MIPO with DCP. In their study on Minimally Invasive Plate Osteosynthesis in distal tibial fractures, Stefano Ghera et al. [19] reported one (5.56%) malunion out of 18 cases. These results may be attributed to the un-cooperation of our patients regarding walking and weight bearing. Our study is better than Helfet et al [20] in their series of 20 patients of distal tibial fractures treated by MIPO, reported 4 (20%) cases of malunion; 2 with >5 degrees of varus and 2 with >10 degrees of recurvatum, while our sturdy showed only 3 malunion in group II (MIPO group).

Time to union:

In our study, 21(75%) fractures united after 6 months, 23 (82%) after 1 year, and 24 (85.7%) fractures after 1.5 year. Mean union time was 5.1 months (20.6) weeks, range 10 – 52 weeks.

In Siddhartha V et al [12] study the mean time to union was (21.4) weeks with a range of 16–32 weeks and 96% fractures united within a period of 25 weeks. Lau et al [15] reported the average time to radiological bony union as (18.7) weeks, which ranged from the shortest 12 weeks to the longest 44 weeks. Oh CW et al [21] in their study of twenty-one patients reported the average time to union as (15.2) weeks. In the study of Bahari et al [13] mean fracture healing in distal tibial fractures was found at (22.4) weeks postoperatively. Redfern et al [14] in their study reported that the mean time to union for distal tibial fractures was (23) weeks (range: 18–29 weeks), without need for further surgery.

In our study, group I with MIPO technique showed good and early union at 3, 6 months and 1 year follow-up (P-value < 0.05) than group II (external fixators), because the MIPO technique preserve most of the osseous blood vessels and fracture haematoma and thus a more biological repair. It bridges the fracture comminution and hematoma, so it does not interfere with the natural healing of bone fracture.

Fernandes HJA et al [22], Jiang Z. [23], and Zhang QL et al [24] studies reported that the fracture healing time was significantly shorter in the minimally invasive percutaneous plates group compared to the interlocking intramedullary nailing group.

Conclusion:

The MIPO technique is a reliable fixation approach to comminuted fractures of the diaphysis of tibia, preserving most of the osseous vascularity and fracture haematoma and thus providing for a more biological Repair. The bone healing, though slightly delayed, was universal with this type of fixation. We advise to change form external fixators to MIPO technique in the treatment of compound fractures as soon as the wound healed and the fracture become closed one.

Due to preserved vascularity, there is lesser incidence of delayed union and non-union. There was reduced incidence of infection due to limited exposure. Infection can also be prevented by careful handling of soft tissues and by minimizing the operating time.

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