Minimal invasive plate osteosynthesis (MIPO) in fracture femur

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Background
The advantage of bridge plating in keeping the vascularity and the fracture healing promotes it to be widely used in comminuted fracture femur; the fracture site is not touched, the plate is inserted beneath the vastus lateralis from proximal and distal incisions away from the fracture itself, screws keep the alignment, and screws are limited only to the proximal and distal fragments. Longitudinal femoral fractures extending right to the trochanteric and or condylar areas are the main indication for minimally invasive plate fixations.
Patient and methods
This is a prospective study for minimal invasive plate osteosynthesis (MIPO) techniques in the treatment of the fractured femur. The study was carried out in Cairo University Hospitals from May 2009 to December 2014, on 60 patients, for an average follow-up of 3 years including 64% men (48 cases) and 36% women (22 cases), using both fixed angled plates (locked plates) in 34 cases (56%) and conventional dynamic compression plate (DCP) plates (nonlocked plates) in 26 cases (44%).
Results
Time taken for the union as shown by evidence of radiographic healing of the fracture was defined as the presence of callus around most of the fracture's circumference. The fracture-healing process ranged from 9 to 40 weeks (median: 16 weeks).
One (1.6%) patient suffered from malalignment in the form of varus deformity and two patients (3.3%) from malrotation within acceptable measures. None was the candidate for revision, two (3.3%) patients suffered from the shortening of insignificant value, eight cases (13.3%) suffered from the delayed union, four (6.7%) cases suffered from wound infection, and five (8.3%) cases suffered from decreased range of motion. Implant failure occurred in two cases and periprothetic fracture occurred in one case. Scoring of results according to Tegner and Lysholm was as follows: 27 cases (45%) with excellent outcome, 23 (38.3%) case with good results, 6 (10%) with fair outcome, and 4 (6.7%) with poor outcome.
Conclusion
The use of MIPO technique in fracture femur provides an easy, safe, and effective method of treatment especially in comminuted diaphyseal fracture with extension to the supracondylar or the subtrochanteric areas.

Keywords:
fracture femur, MIPO, osteosynthesis

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Introduction

The healing of a fracture is a remarkable process that results in the reconstruction of tissue very similar to the original ones, so this process should be studied to be possible to be reproduced. Indeed the healing process involves problems of cellular homeostasis that are among the most fundamental bases in biology [1].

The advantage of bridge plating in keeping the vascularity and the fracture healing promotes it to be widely used in comminuted fracture femur; the fracture site is not touched, the plate is inserted beneath the vastus lateralis from proximal and distal incisions away from the fracture itself, screws keep the alignment, and screws are limited only to the proximal and distal fragments. Longitudinal femoral fractures extending right to the trochanteric and or condylar areas are the main indication for minimally invasive plate fixations with angled blade plates or condylar screws because fractures that are restricted to the diaphyseal area are mostly treated by nailing [2].

Insertion of the plate from just the proximal and distal incision not only decreases the operative time but also the surgical trauma to the soft tissue. Reduction and alignment is obtained through indirect techniques, and

adjustment of rotation is an important issue to take care of especially in comminuted fracture [2].

This technique produced excellent bone healing. Later on, it seemed reasonable to restrict the incision to the length necessary to insert [3].

Although bridge platting does not negate the need for bone grafting, it decreases a lot of its need compared with the conventional technique. The need for bone grafting with bridge plating arises when there is no attempt of callus formation after 3 months for the fear of implant failure, especially when there is severe traumatic affection of vasculature [2].

The plate positioning together with the required approach is dependent on the local anatomy. Accordingly, this could be altered depending on the mechanical need, type of plate (conventional or locked), length of the plate, number of screws, position of screws, and type of screw (mono- or bicortical, self-drill, self-tap). Depending on the surgeon decision after perioperative planning, it is obvious that plating needs more thinking and technical needs than nailing [4].

Patient and methods

This is a prospective study for minimal invasive plate osteosynthesis (MIPO) techniques in the treatment of the fractured femur. The study was carried out in Cairo University Hospitals from May 2009 to December 2014, on 60 patients, with a mean age of 31 years, for an average follow-up of 3 years.

All patients were evaluated preoperatively regarding:

(1) History and examination.
(2) Primary trauma survey radiography.
(3) Whole femur radiography [anteroposterior view (AP) and lateral showing both hip and knee].
(4) Routine preoperative laboratories [complete blood count (CBC), random blood suger (RBS), kidney and liver functions, prothrombin time (PT), and prothrombin concentration (PC)].

The fractures were classified into:

(1) Open and closed.
(2) Isolated and associated with other fractures.
(3) According to the pattern of fracture.
(4) According to Association for Osteosynthesis (AO) classification of fracture femur.

Radiographic healing of the fracture was defined as the presence of callus around most of the fracture's circumference. The fracture-healing process ranged from 9 to 40 weeks (median: 16 weeks).

(1) The age ranged between 16 and 71 years and the mean age was 31 years.
(2) There were 64% men (48 cases) and 36% women (22 cases).
(3) MIPO was used in 60 cases using both fixed angled plates (locked plates) in 34 cases (56%) and conventional dynamic compression plate (DCP) plates (nonlocked plates) in 26 cases (44%).

Mechanism of injury

Road traffic accident: 20 cases (34%)

Motor car accident: 14 cases (24%)

Fall from height: 14 cases (24%)

Fall to the ground: 2 cases (2%)

Motorbike accident: 7 cases (12%)

Fall downstairs: 3 cases (4%)

There were 50 cases (84%) with closed fractures and 10 cases (16%) with open fractures.

Associated injuries

There were 32 cases (54%) with isolated injuries and 28 cases (46%) with associated injuries as follows:

(1) One patient with an associated head injury.
(2) Three patients with associated chest injuries.
(3) Seven patients with ipsilateral upper limb injuries.
(4) Sixteen patients with lower limb injuries (13 cases with ipsilateral injuries and 3 with contralateral ones).
(5) One patient with a spine injury.

Operative data

Techniques

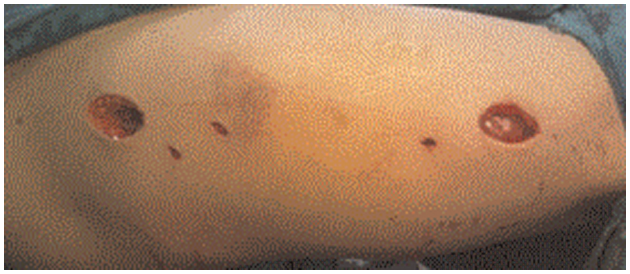
The patient was placed in the supine position with a wedge under the ipsilateral buttock, to allow the image intensifier to take an image. The sterile drapes were arranged so that the length and position of the patella could be examined intraoperatively.

The whole limb was draped free so it is possible for the image intensifier to assess the limb length and rotation in addition traction could be applied manually with the help of the assistant or by using a femoral distractor.

A distal lateral incision is to be made over the distal fragment. After assessing the proper length of the plate, another proximal lateral incision is fashioned. A chisel is passed underneath the vastus lateralis then the plate itself. Insertion of the first screw once more length and rotation were checked, and the second screw could be used to adjust the varus\valgus together with approximating the plate to the fragments, then the rest of the screws were inserted (Fig. 1).

After screws were inserted from the same proximal and distal incisions or different stab incisions for each, wounds were closed in separate layers (Fig. 2).

Figure 1



A proximal and distal incision is fashioned for the insertion of the plate.

Fractures in the condylar area combined with long shaft fractures could be stabilized in the same way. The knee joint can be reconstructed then the plate inserted in the same manner.

Postoperative management

The immediate postoperative patient is examined for the integrity of the neurovascular status, vital signs, alignment, limb length, and soaking of the dressing.

Then patient starts antibiotics (third-generation cephalosporin) half an hour before the operation and continues for the next 5 days with anticoagulation (clexane) (low molecular weight heparin) 40 mg once daily subcutaneous injection that is prescribed from the time of trauma till a day before the date of operation, then administrated once more a day postoperative for an average 2 weeks. In addition to the program of early mobilization, an immediate radiograph is taken to assess the reduction, alignment, and a reference for later follow-up.

Weight-bearing could be started with partial weight-bearing using crutches and just tiptoeing, on the appearance of callus formation (at 3rd–4th weeks postoperatively), then gradual increasing in

Figure 2

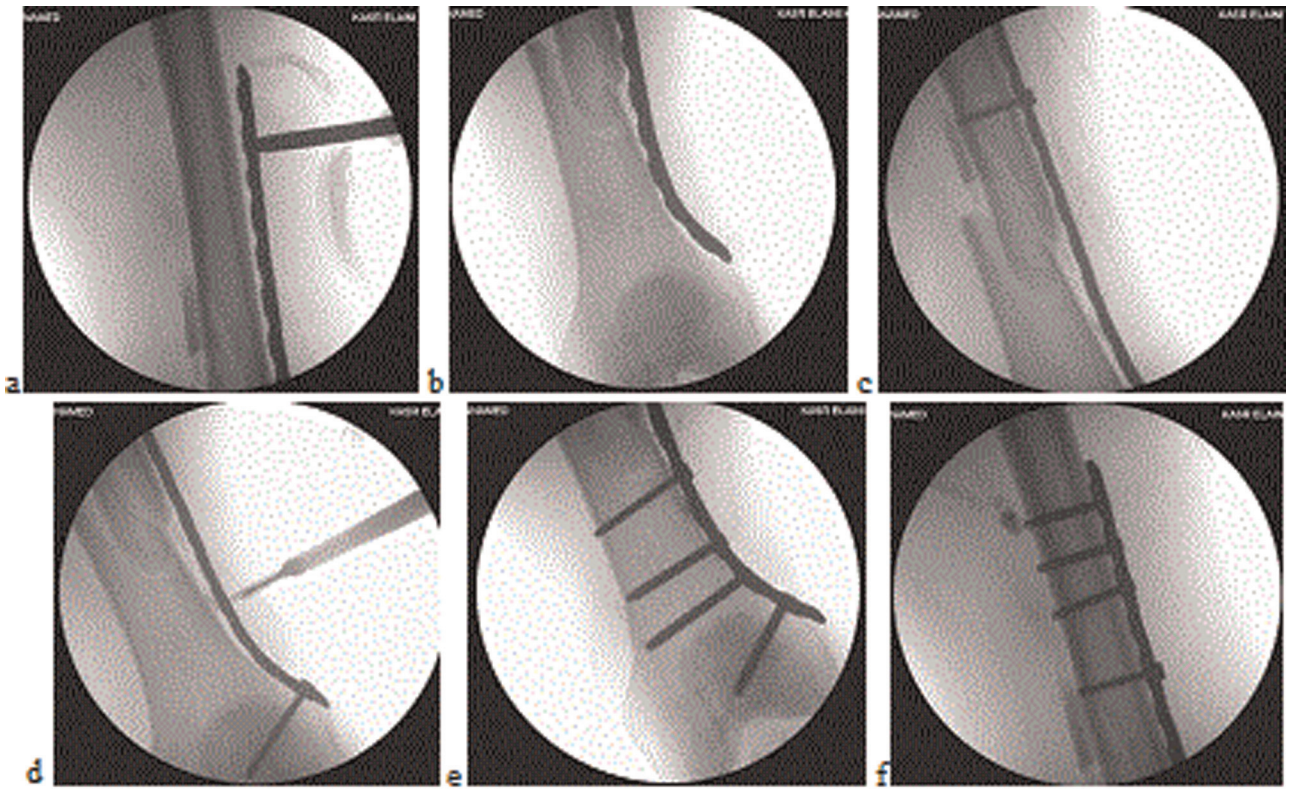


Plate and screw insertion in both the distal and proximal fragments. (a) Insertion of the plate from the proximal incision, (b) retrieval of the plate from the distal one, (c) insertion of the proximal screw, (d) distal one after checking rotation and alignment, (e) sequential insertion of the rest of the screw in the proximal, and (f) distal fragments.

weight-bearing from tiptoeing to whole feet on the ground with both crutches within 2–3 weeks more, and lastly walking independent of any aiding tool when the radiological finding shows callus surrounding most of the circumference of the fracture site. Protected weight-bearing usually takes on average 11–16 weeks.

Follow-up visits were required every 2–3 weeks till union then at 6, 12, and 24 months.

Results

During the period from May 2009 to December 2014, a study including 60 patients was prospectively managed using the MIPO technique in fracture femur management. This study was held in Cairo University Hospital.

Fixed angled plates (locked plates) were used in 34 cases (56%) and conventional DCP plates (nonlocked plates) in 26 cases (44%).

Time taken for the union as shown by evidence of radiographic healing of the fracture was defined as the presence of callus around most of the fracture's circumference. The fracture-healing process took from 9 to 40 weeks (median: 16 weeks) (Fig. 3).

One (1.6%) patient suffered from malalignment in the form of varus deformity and two patients (3.3%) with malrotation within acceptable measures. None was the candidate for revision, two (3.3%) patients suffered from the shortening of insignificant value, eight cases (13.3%) suffered from the delayed union (after the 12th week without signs of a complete union), treated by autologous red bone marrow injection on the 12th week. The average time of union was 3 months from bone marrow injection, and it was repeated three times at a 3-week interval. The amount of bone marrow was 10 ml, four (6.7%) cases suffered from wound infection, three cases were open fracture, and one was closed (culture and sensitivity was done and antibiotic therapy initiated) two were superficial infection, improved on antibiotics and repeated dressing, two cases needed three sessions of debridement, one case had resolved after debridement, an in the other one, infection resolved after plate removal as a complete union had been achieved. Five (8.3%) cases suffered from decreased range of motion ranging from few degrees of flexion or extension deficit to knee stiffness, three cases with decreased flexion range (from 20° to 50° flexion deficit, knee stiffness in extension), two cases with extension deficit, (10°–30° extension deficit) (all cases managed with physiotherapy), and two cases (one case with knee stiffness in extension and the other with extension deficit of 30°) needed manipulation under general anesthesia then continuing on physiotherapy.

Figure 3

A 23-year-old male patient had a road traffic accident; with open fracture shaft femur, he was operated after two sessions of debridement. (a) Pre- and (b) postoperative radiographs after minimal invasive plate osteosynthesis technique of open fracture femur.

Implant failure occurred in two cases. In the first one, wedge fracture midshaft (32-B2) femur, the patient started premature weight-bearing immediately postoperatively. Bending of the plate occurred in varus (nonlocked plate) without its fracture. Closed correction of the deformity under general anesthesia with the application of cast bracing for a 4-week union occurred and the patient started partial weight-bearing (Fig. 4).

The second one had a comminuted fracture distal 2\5 of the femur (33-C3) with intercondylar extension (with distal femoral locked plate). Four-week postoperatively, the intercondylar component united together with the distal comminution, but the proximal part remained without evidence of healing. The patient started weight-bearing in spite of instructions, suffered

Figure 4

A 19-year-old male patient had a road traffic accident; with closed wedged fracture shaft femur, operation was done 4 days later. (a) Pre- and (b) postoperative radiographs of minimal invasive plate osteosynthesis femur. (c) Plate bending after premature weight-bearing (noncompliant patient). (d) Radiograph after correction of varus deformity with cast brace, (e) after removal of cast brace, and (f) 6 months afterward, respectively.

from implant failure, cast bracing was done, union occurred within 5 weeks afterwards, and partial weight-bearing was permitted.

The periprothetic fracture occurred in one case with the MIPO technique. A transverse midshaft fractured femur (32-A3) in the polytraumatized patient was

treated with the MIPO technique (a conventional broad DCP plate was used). Six months afterwards patient came to the causality department suffering from a stress fracture at the proximal tip of the implant, whereas the main fracture was completely united. The patient was admitted, and a week later a revision surgery was done. The plate was removed but she was not a candidate for plate fixation because of the poor quality of bone. Insertion of the interlocking nail was done, and there were some difficulties with interlocking nail insertion due to difficulties in the plate and screw removal especially with a broken screw. Also with reaming as there was medullary sclerosis, in addition to interlocking nail insertion, bone grafting was done.

Classification and evaluation of our radiographic results is as follows:

(1) 100% cortical contact in both AP and lateral views, perfect reduction.
(2) 75%–100% cortical contact, excellent reduction.
(3) 50%–75%cortical contact, good reduction.
(4) 25%–50%cortical contact, fair reduction.
(5) Less than 25% cortical contact, poor reduction

In the study, 35 cases (58.33%) were with excellent reduction, 22 (36.67%) with good reduction, and 3 (5%) with fair reduction.

Scoring of results according to Tegner and Lysholm was as follows: 27 cases (45%) were with excellent outcome, 23 (38.3%) case with good results, 6 (10%) with fair outcome, and 4 (6.7%) with poor outcome (Table 1).

Factors affecting the outcome

Age

Patients with age younger than 16 years and skeletally immature and have got good bone quality in addition to good muscle power showed much better healing potentials and early weight-bearing.

Patient compliance

In comminuted fracture, premature weight-bearing can lead to fixation failure regardless of the modality of fixation or the principle adopted. (One patient got plate bending and another one got implant failure after premature weight-bearing.)

Table 1 Clinical results in relation to reduction achieved

Results reduction	Excellent	Very good	Good	Fair
Anatomical	8	6	1	
satisfactory	15	11	5	2
Nonsatisfactory				2

Open fracture

Four (6.7%) cases suffered from wound infection, three (75%) cases were open fracture, and one (25%) was closed.

A higher risk of infection is still there with open fractures related to the initial trauma.

Pattern of fracture

Eight cases suffered from the delayed union (after the 12th week without signs of a complete union), six of them of the simple transverse pattern (32-A3), and two were comminuted (32-C3) treated by autologous red bone marrow injection on the 12th week; average time of union was 3 months.

Site of fracture

Metaphyseal fractures are more favorable for MIPO, as when adopting the MIPO technique, a combination of limited open perfect anatomical reduction of the articular component of a fracture together with an indirect biological reduction of the rest of it is used, especially when there is no room for interlocking nail and no space to secure its locking screws.

Associated injuries

Early stabilization of fractures of the femoral shaft is the preferred treatment at most major trauma centers, and this practice appears to have contributed to decreased rates of morbidity and mortality for multiply injured patients. A significant increase in the occurrence of adult respiratory distress syndrome in association with a delay in the operative stabilization of femoral fractures in patients who had multiple injuries is found.

Associated musculoskeletal injuries

Associated musculoskeletal injuries affect rehabilitation and time for weight-bearing, sustaining injuries that prevented early full weight bearing, including quadriplegia, severe closed intracranial injury, and ipsilateral musculoskeletal injury.

Distraction at the fracture site

Even when adopting biological concepts, distraction at the fracture site (when using traction as an indirect method of reduction) can delay bone healing. This was the situation in two cases with the delayed union in the simple transverse fractures, when union occurred after autologous red bone marrow injection.

Discussion

After surgery, the achieved reduction was assessed by measurements made on the anteroposterior and the lateral views. In this case, it was aimed to get the most acceptable reduction.

The cases in which satisfactory reduction has been achieved, it did not affect the clinical outcome substantially.

In this study, three cases had malalignment, one patient (2%) suffered from malalignment in the form of varus deformity and two patients (4%) with malrotation within acceptable measures, and none was the candidate for revision.

In the series done by Mize *et al.* [5], 2 out of 29 cases (7%) had valgus deformity (5° and 10° with no secondary operation).

In the series done by Zehntner *et al.* [6], 20 cases (35%) suffered from malalignment in varus or valgus, and 17 cases (30%) suffered from rotational malalignment (57 cases).

In the study done by Krettek *et al.* [7], one case (14%) had varus deformity of 10° and two cases (28%) with rotational deformities, one of 2° and the other with 15° and had to perform a second corrective osteotomy operation (7 cases).

In the study done by Schandelmaier *et al.* [8], two cases (5%) were with rotational deformities, 5 cases (12.5%) with varus or valgus deformities, and 3 cases had corrective osteotomies (40 cases).

In this study, clinical results were evaluated according to Tegner and Lysholm knee score. The mean score was 89 (between 51 and 95) [9].

Good results usually were associated with isolated injuries, to whom an early fixation was done, and a compliant patient with physiotherapy.

Poor results usually were associated with polytrauma patient with multiple sessions of debridement, to which the operation had been postponed for a local or general condition; also in compliance to physiotherapy had a rule.

The study held by Krettek *et al.* [7], had a Lysholm score of a mean 87 (between 57 and 93), hip flexion of average 100° (range between 80° and 120°), hip extension of average 0° (range between 0° and 10°), knee flexion 115° (range between 75° and 145°), and knee extension 0° (range between 0° and 5°).Frankhauser *et al.* [10] is a prospective study of 30 fractures with a follow-up of 20 months and a Lysholm score of a mean of 71.

Markmiller *et al.* [11] documented 16 patients prospectively. A conversion procedure was done in two patients in the plate group. At the 1-year follow-up, mobility of the knee was on average 110° in the plate group. Lysholm score was of a mean of 78.5.

Theoretically, the plate can equal the whole length of the broken bone. However, at least the minimal length of the internal plate can be determined using the two factors: the plate span width and the plate screw density. Plate span width is defined as the ratio of the plate length and overall fracture length. Empirically, it was found that the plate length should be two to three times higher than the overall fracture length in comminuted fractures and eight to ten times higher in simple fractures [4]. The second factor is the Emanuel Gautier plate screw density, which is the ratio formed by the number of screws inserted and the total number of plate holes. Empirically, it is recommended to be below 0.5, indicating that less than half of the plate holes are occupied by screws [4].

In this series, the plate length was two to three times the fracture length but it never happened to occupy the whole length of the plate.

Conclusion

The use of the MIPO technique in fracture femur provides an easy, safe, and effective method of treatment, taking into consideration the following points:

(1) There is no age limitation for application.
(2) Easiness of the usage of MIPO technique in comminuted diaphyseal fracture with extension to the supracondylar or the subtrochanteric areas.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Mckibbin B. The biology of fracture healing in long bones. J Bone Joint Surg 1990; 93:49–55.

2 Wenda K, Runkel M, Degreif J, Rudig L. Minimally invasive plate fixation in femoral shaft fractures. Injury 1997; 28(Suppl 1):S–A13e 9.

3 Wenda K, Degreif J, Runkel M, Ritter G. Technique of plate osteosynthesis of the femur. Unfallchirurg 1994; 97:13–18.

4 Gautier E, Sommer C. Guidelines for the clinical application of the LCP. Injury 2009; 34(Suppl 2: B) 63–76.

5 Mize RD, Bucholz RW, Grogan DP. Surgical treatment of displaced, comminuted fractures of the distal end of the femur. J Bone Joint Surg Am 1982; 64:871–879.

6 Zehntner MK, Marchesi DG, Burch H, Ganz R. Alignment of supracondylar/intercondylar fractures of the femur after internal fixation by AO/ASIF technique. J Orthop Trauma 1992; 6:318–326.

7 Krettek C, Schandelmaier I', Miclau T, Tscheme H. Minimally invasive percutaneous plate osteosynthesis (MIPPO) using the DCS in proximal and distal femoral fractures. Injury 1997; 28:20–30.

8 Schandelmaier I', Farouk O, Krettek C, Miclau T, Tscheme H. The minimal invasive plate osteosynthesis: is percutaneous plating biologically superior to the traditional technique. J Orthop Trauma 1999; 13:401–406.

9 Mitsou A, Vallianatos P, Piskopakis N, Maheras S. Anterior cruciate ligament reconstruction by over-the-top repair combined with popliteus tendon plasty. J Bone Joint Surg Br 1990; 72:398–404.

10 Frankhauser F, Gruber G, Schippinger G, Boldin C, Hofer H, Grechang W, Szyszhowtiz R. Minimal invasive treatment of the distal femoral fracture with the LISS. Acta Orthop Scand 2004; 75:56–60.

11 Markmiller M, Konrad G, Südkamp N. Femur-LISS and distal femoral nail for fixation of distal femoral fractures: are there differences in outcome and complications?. Clin Orthop Relat Res 2004; 426:252–257.