Complex femoral fractures: management by interlocking nails and percutaneous cancellous screws

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Background
Complex femoral fractures are fractures involving more than one anatomical region of the femur. Each of these fractures may be fixed with implants selected for each fracture, requiring large incisions. In this study, these fractures were fixed with antegrade interlocking nails and percutaneous cancellous screws.
Patients and methods
A prospective study was conducted at Mansoura University Emergency Hospital. Twenty-nine skeletally mature patients with complex femoral fractures included in this study were managed with antegrade interlocking nails and percutaneous cancellous screws. The orthopedic trauma association (OTA) classification was used for classifying fractures, and the Gustillo and Anderson classification was used for open fractures.
Results
All fractures in this study healed without complications. No statistically significant correlations were found between fracture type, fracture level, and healing time. Cases with open fractures of the femoral shaft had longer healing times, which were significant (P=0.03). There were no cases with malunion, femoral neck nonunion, or avascular necrosis of the femoral head.
Conclusion
Antegrade interlocking nail combined with percutaneous cancellous screws is a potent and effective method for fixing complex femoral fractures.

Keywords:
antegrade nailing, complex femoral fractures, femoral neck fracture, interlocking nails

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Introduction

Isolated fractures of the femoral neck, trochanter, subtrochanter, shaft, or condyles occur frequently, whereas ipsilateral combinations of these fractures are rarer [1]. Femoral neck fractures occur in 6–9% of all femoral shaft fractures. The association of femoral shaft fractures with ipsilateral condylar femoral fractures occurs in 3–4% of femoral shaft fractures [2–4].

Complex femoral fractures are considered unique fractures with challenging management [1]. Although there is a consensus about the ideal treatment options for each fracture in isolation, the ideal fixation method for these complex fractures remains controversial [1,5–8]. The purpose of this study was to assess the results of fixation of complex femoral fractures with antegrade interlocking nails and percuteneous cancellous screws.

Patients and methods

This study was conducted at Mansoura Emergency Hospital between January 2008 and May 2010. Thirty-four skeletally mature patients with complex femoral fractures were managed with antegrade interlocking nails and percutaneous cancellous screws. Of these patients, five were lost to follow-up before complete healing of their fractures, and thus were excluded from the study. The remaining 29 patients were included in the present study, and their fractures were classified according to OTA classification [9]. Ten patients had femoral shaft fracture (OTA 32-A, 32-B, 32-C) and femoral neck fracture (OTA 31-B), four patients had shaft fracture (OTA 32-A, 32-B, 32-C) and trochanteric fracture (OTA 31-A) (Fig. 1), seven patients had shaft fracture (OTA 32-A, 32-B, 32-C) and subtrochanteric fracture (OTA 32-A1.1, 32-A2.1, 32-B2.1) (Fig. 2), seven patients had shaft fracture (OTA 32-A, 32-B, 32-C) and femoral condyles fracture (OTA 33-B1, 33-C1, 33-C2), and only one patient had femoral neck fracture (OTA 31-B2.1), shaft fracture (OTA 32-C2.2), and femoral condyles fracture (OTA 33-C1.1) (Fig. 3).

All femoral neck fractures in this study were mid cervical (OTA 31-B2.2) except for two fractures,

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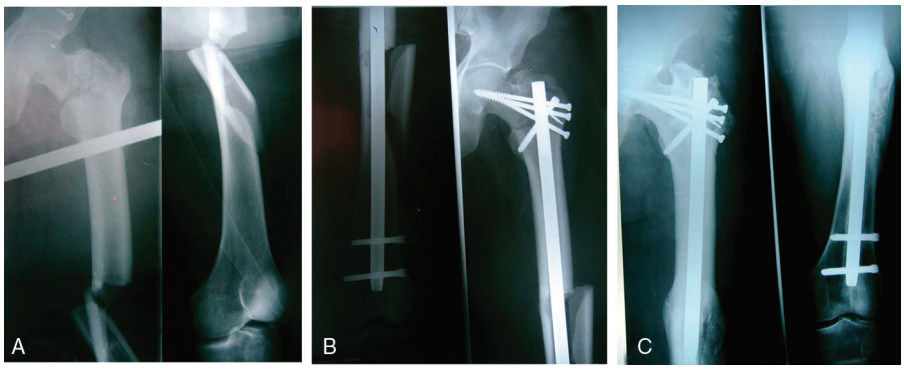
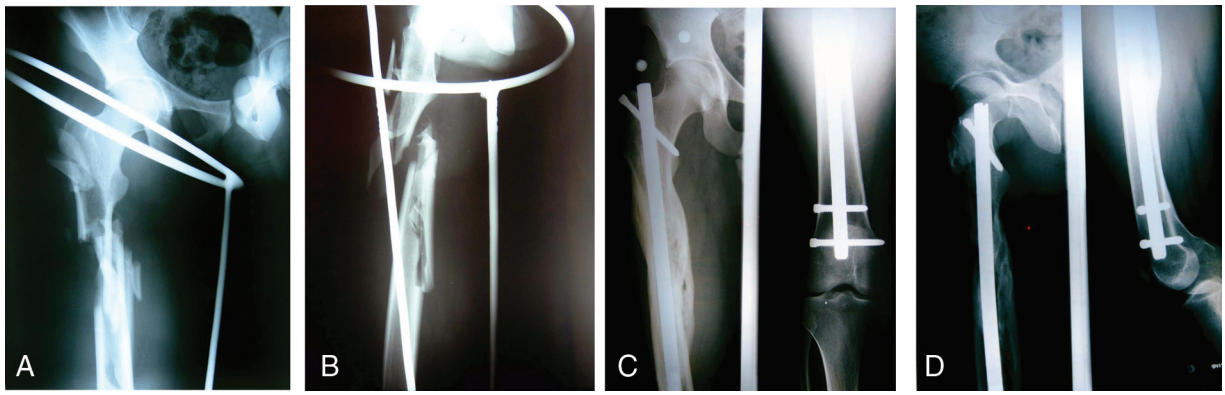
Figure 1



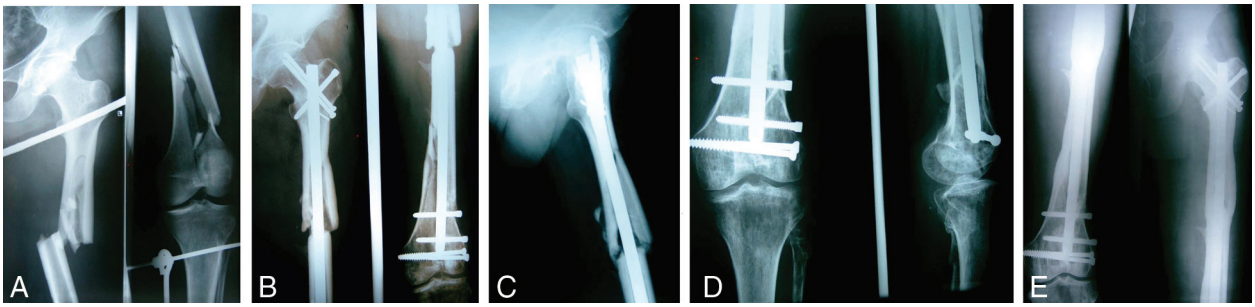
a: X rays of 42 years old male patient with trochanteric fracture femur and comminuted fracture shaft b: Postoperative x-ray after fixation with interlocking nail for the shaft and cancellous screws for the trochanteric fracture c: Two and half years after fixation showing complete union of the fractures.

Figure 2



a: 44 years old male patient with subtrochanteric fracture femur and comminuted fracture shaft, AP view. B: Lateral view c: Two years after fixation with interlocking nail, AP view showing complete union d: Two years after fixation with interlocking nail, lateral view showing complete union.

Figure 3



a: A male patient 36 years old with fracture neck of the femur, comminuted fracture shaft and bicondylar fracture b: AP view two months postoperative after fixation with interlocking nail for the shaft and cancellous screws for the neck and condylar fracture showing callus formation. C: Lateral view 2 months postoperative after fixation with interlocking nail for the shaft and cancellous screws for the neck and condylar fractures showing callus formation. d: Three years postoperative showing complete union of condylar fracture e: Three years postoperative showing complete union of shaft fracture.

which were basal neck fractures (OTA 31-B2.1). Nine of these fractures were either nondisplaced or minimally displaced and required reduction by closed manipulation, and the other two fractures required open reduction using the Watson–Jones approach [10].

In cases with displaced neck fracture, Schanz screws were used as joysticks to help reduction under an image intensifier, as the fractured shaft hinders proper control of the proximal fragments. The fixation screws are placed as anteriorly as possible to allow room for the nail to be inserted posterior to the screws.

Nine of the femoral neck fractures in this study were discovered during preoperative radiograph studies, and the remaining two fractures were discovered in the operation theater before fixation.

All femoral shaft fractures were displaced and consisted of 14 fractures in the upper third, seven in the middle third, and eight in the lower third.

Two of the eight condylar fractures were type 33-B1 according to the OTA classification with only lateral condylar fractures, whereas the remaining six fractures were type 33-C with bicondylar fractures.

The condylar fractures reduced closely with the aid of a large reduction forceps under an image intensifier using Schanz screws as joysticks and temporary K-wires fixation.

Seventeen of these fractures were on the right side and 12 on the left.

Anteroposterior (AP) views of the pelvis and AP and lateral radiographs of the femur were obtained for every patient. The initial injury radiographs were used to classify the fractures according to OTA classifications [9].

Radiological union is defined as the presence of bridging bone across the fracture site in three cortices in AP and lateral views. The continuity of the trabeculae was used as a guide for healing neck fractures, whereas nonunion was defined as persistence of the fracture line at 6 months after fixation.

All these fractures were managed within an average of 6 days ranging from 1 to 14 days with antegrade interlocking nails and cancellous screws. These patients were followed-up for an average of 26 months (range: between 23 and 48 months). Eleven of these patients had associated injuries, which are summarized in Table 1.

Eleven fractures were open injuries; all of them were Gustillo and Anderson type IIIA fractures [11,12].

After initial resuscitation, all open fractures were treated with emergency irrigation and debridement. Fixation was performed as soon as the patient's overall medical condition became suitable; this was accomplished with a single, rigid intramedullary AO/ASIF interlocking nail in combination with cancellous screws. For neck fixation, the cancellous screws were inserted before stabilizing the shaft.

Table 1 Summarization of associated injuries with complex femoral fractures in this study

Number of patients (total=11)	Associated injuries
3	Abdominal injury
1	Hemothorax+bladder injury+ipsilateral fracture patella+contralateral fracture shaft femur
2	Bladder injury
1	Head trauma
1	Head trauma+ipsilateral type III Gustilo open fracture lower third tibia+ipsilateral fracture patella
2	Ipsilateral fracture tibia+ipsilateral fracture patella
1	Contralateral femoral fracture

Patients seen at 2 weeks postoperatively, then every month for examination and repeat radiographs until healing, and after that they were followed-up every 3 months.

Mobilization was allowed on the second postoperative day. Partial weight bearing was allowed 3 weeks postoperatively with the aid of axillary crutches, and then weight bearing was gradually increased as tolerated. Patients with condylar fractures were not allowed to bear weight unless radiological union became evident.

This study was approved by the ethics committee at Mansoura University and performed in accordance with the pertinent ethical guidelines (i.e. Declaration of Helsinki, as laid down in 1964 and revised in 2008); informed consent was obtained from all patients.

Statistical analysis

Data entry and analyses were performed using SPSS statistical package (version 10; SPSS, Inc., Chicago, Illinois, USA). The χ^2-test was used to determine the association between raw and column variables of qualitative data. The Student's *t*-test was used to compare means and SDs of two groups. One-way analysis of variance was used to compare means and SDs of more than two groups. *P*-values less than or equal to 0.05 and less than or equal to 0.001 indicate significant and high significant results, respectively.

Results

In this study, 29 patients with complex femoral shaft fractures were treated with interlocking nails combined

with percutaneous cancellous screws. Twenty-one patients in this study were males and eight were females; the average age of patients was 38.6 years with an age range of 23–56 years. Fractures were due to motor car accidents in 20 patients, motor cycle accidents in six patients, and due to falling from heights in the remaining three patients.

All fractures in this study healed without delay except for two (6.8%) cases with subtrochanteric fractures – one of them needed only dynamization and healed at 34 weeks and the other required bone grafting in addition to dynamization and healed at 36 weeks. The mean healing time for femoral neck fractures was16.6±2.2 weeks (range: 13–20 weeks), the mean healing time for transcervical neck fractures was16.5±2 weeks, and for basal fractures 17±4 weeks, which was statistically insignificant.

The mean healing time for trochanteric fractures was 11±1 weeks, and the mean healing time for subtrochanteric fractures was 20.25±1.8 weeks (range: 18–36 weeks). The mean healing time for shaft fractures was 19.2±2.6 weeks (range: 14–23 weeks).

In this study, the mean time for condylar fracture healing was 14.9±1.1 weeks (range: 10–16 weeks). The healing time for type 33 bicondylar fractures was 11 weeks, and the healing time for type 33-C fractures was 14.5±1 weeks, which was statistically significant (P=0.02). No other significant correlations were found between fracture type and healing time. No significant correlation was found between fracture level and healing time.

In addition, the associated injuries had no significant correlation to healing time.

In this study, cases with open fractures of the shaft or condyles had longer healing times, which were significant at P=0.03 and 0.01, respectively.

All 11 patients with femoral neck fractures had excellent reduction at the final follow-up. All femoral neck fractures healed without complications; there was no case with femoral neck nonunions, malunions, or avascular necrosis of the femoral head as assessed by plain radiographs at the last follow-up.

Only one patient developed superficial infection, which was completely cured after wound irrigation, debridement, and proper antibiotic therapy; this patient had grade IIIA open fracture of the femoral shaft.

Good alignment of the femoral shaft was achieved in all cases, and only three of 29 (10.3%) patients had limb shortening greater than 1 cm (average: 1.7 cm). Only one of them needed a shoe lift of 2 cm, and no case with malrotation was encountered in this study.

Discussion

Isolated femoral shaft, femoral neck, trochanteric, subtrochanteric, and femoral condylar fractures are common, whereas ipsilateral combinations of these fractures are less common [1]. In this study, complex femoral fracture was defined as an ipsilateral combination of fractures in two or more femoral regions.

Patients who sustain complex femoral fractures, which are usually due to high-energy trauma, are relatively young and frequently have associated multisystem injuries [8,13].

Although there is a consensus about the ideal treatment options for each of these fractures in isolation, the ideal fixation method for these complex fractures remains controversial [1,5–8].

Complex fractures of the femur are difficult to manage because the preferred implant for one fracture may hinder the reduction and fixation of the other fractures [1].

Femoral neck fracture is ideally managed by fixation with cancellous screws, trochanteric fractures can be fixed with dynamic hip screws or condylar plates, femoral shaft fractures require intramedullary or plate fixation, and displaced distal femoral articular injuries are managed with anatomical reduction and rigid fixation with implants such condylar plates or dynamic condylar screw (DCS); plating for fixation of one fracture may interfere with intramedullary nailing [1,14–16].

In addition, the combination of these different methods of treatment may need a heroic exposure, which adds more insult to the already severe trauma to which the patient is subjected.

The authors' way of thinking was to find a method for managing complex femoral fractures that are associated with high-energy trauma and multisystem injuries with an easy, reliable, and nonlengthy fixation method without heroic exposures that may extend from the trochanters to the condyles.

Medullary nailing is the treatment of choice for diaphyseal femoral shaft fractures with satisfactory

results and low complication rates. The intramedullary placement and cylindrical shape minimize the moment arm and maximize the moment of inertia, making the nail suited mechanically for the treatment of comminuted shaft fractures [16].

Femoral neck fractures were stabilized with cancellous screws before fixation of the femoral shaft. The screws should be placed in an anterior position that allows antegrade femoral nailing, and the nail is then placed somewhat posteriorly in the piriformis fossa. Proper nail size selection is mandatory – not too small to avoid complications of small-diameter nails or too large to avoid fracture neck displacement [16].

The goals of treatment were to restore function through anatomical reduction of the femoral neck fracture, to re-establish length, alignment, and rotation of the shaft, and to create adequate construct stability.

Complex femoral fractures occur mainly in young adults, and hence maintenance of the femoral head is critical to prevent the need for arthroplasty with its complications in this young age. Femoral neck malunion and nonunion also require a more difficult management; hence, the femoral neck component of this fracture pattern is most critical, and early anatomical reduction and fixation as fast as the general condition of the patient allows are mandatory [1,2,8,13,17–20].

The diagnosis of acute femoral neck fractures may be missed in cases of complex femoral fractures. In this study, nine of 11 femoral neck fractures were discovered on admission, and the other two fractures were discovered in the operation theater before nailing with no missed diagnosis until after fixation of the femoral shaft.

It is generally accepted that not all-occult femoral neck fractures are iatrogenic, and great care should be taken preoperatively to search for an associated femoral neck fracture with femoral shaft fracture [21].

Difficulty in visualizing a minimally displaced neck fracture in the presence of a shaft fracture is due to polytrauma, as the pain associated with the shaft fracture masks hip pain and the external rotation of the limb associated with femoral shaft fractures limits visualization of the femoral neck. Moreover, internally rotating the fractured limb to obtain reasonable radiograph of the neck often does not internally rotate the proximal portion of the femur [17,22].

Postoperative AP and lateral hip radiographs in the operation theater before patient awakening is a convenient way to avoid missing such fractures [22].

In this study, all fractures healed with minimal complications and within a reasonable time.

Other management options for complex femoral fractures include [1] cephalomedullary nailing using proximal interlocking screws for neck fixation [2], plate fixation of the diaphyseal fracture with cancellous screw or sliding hip screw fixation of the neck fracture [3], retrograde intramedullary nailing for shaft fixation with cancellous screw or sliding hip screw fixation of the diaphyseal fracture, and [4] long DCS or condylar plates for femoral condyles and shaft fractures with cancellous screw or sliding hip screw fixation of the neck fracture. All these techniques have demonstrated varying degrees of success [17].

The cephalomedullary device can only be used if the femoral neck fracture is diagnosed preoperatively. This method is not familiar among all surgeons, and it may be difficult to reduce both fractures simultaneously, because nail insertion may displace the neck fracture and damage its blood supply [17,20].

The cephalomedullary stabilization improves the results of pertrochanteric and subtrochanteric fracture fixation; however, for fracture of the neck, the screws are not designed to function as a compression lag screw device, and the screws have poor sliding characteristics leading to compaction of the cancellous bone within the femoral head with bone resorption around the fracture site leading to failure in varus with femoral neck shortening [2,20].By using plate fixation for the diaphyseal fracture with cancellous screw or sliding hip screw fixation for the neck fracture, each fracture will be treated in a separate manner, but there is a need for two incisions with the potential for increased blood loss and operative time [20].

A long side plate for fixation of shaft fractures can be attached to a sliding hip screw for fixing neck fractures. Retrograde nailing can be used instead of plating to optimally treat both fractures and prevent stress risers by overlapping implants [21].

The retrograde nailing technique allows fixation of the shaft component of the fracture without interference with the femoral neck component. However, there is a need to diagnose the femoral neck fracture preoperatively, as there is a tendency of the femoral

shaft to angulate in a varus direction and requires opening of the knee joint [20].

Long DCS or condylar plates for the femoral condyles and shaft fractures with cancellous screw or sliding hip screw fixation of the neck fracture require long incisions that may reach from the trochanters to the condyles with more blood loss, more operative time, and greater risk for infection.

The use of interlocking nails and cancellous screws is a familiar technique to most surgeons and can be used for femoral neck fractures that are discovered intraoperatively, as it allows management of complex femoral fractures within short operative times with limited incisions and less blood loss.

Conclusion

From this study, the authors conclude that using antegrade interlocking nails combined with percutaneous cancellous screws is a potent and effective method for fixing complex femoral fractures without implants-related complications and without extensive soft tissue exposure.

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Conflicts of interest

There are no conflicts of interest.

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