Floating knee injuries: treatment with a single approach

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Introduction
The 'floating knee', a term first used by Blake and McBride in 1974, describes concomitant fractures of the ipsilateral femur and tibia. 'Floating knee' injuries may include combinations of diaphyseal, metaphyseal and intra-articular fractures.
Patients and methods
We report a series of 21 patients who had Fraser type I floating knee injury treated with the retrograde femoral and antegrade tibial intramedullary nail using a single knee incision during a period between 2005 and 2009.The mean age of the patients at the time of injury was 30.6 years (range: 19–50 years); 17 of them were male and four were female. All patients had sustained their injuries in motor vehicle accidents.
Results
The average time for union of femoral shaft fractures was 15.8 (range: 8–56) weeks. The average time for union of tibial fractures was 22.9 (range: 18–30) weeks. There was no malunion exceeding 10° of angulation or rotation in either fracture. There was no patient leg length discrepancy. There was no deep infection. The final functional outcomes after bony union using the criteria of Karlström and Olerud were as follows: 11 excellent results (52.3%), six good (28.5%), three fair (14.3%) and one poor result (4.7%). The overall satisfactory outcome rate was 81% (17/21).

Keywords:
floating knee injuries, retrograde femoral nail

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Introduction

The 'floating knee', a term first used by Blake and McBride in 1974, describes concomitant fractures of the ipsilateral femur and tibia. 'Floating knee' injuries may include combinations of diaphyseal, metaphyseal and intra-articular fractures. Collateral ligament and meniscal injuries may also be associated with this fracture complex [1].

This fracture combination has been shown to result from high-energy trauma, particularly motor vehicle accidents. The incidence of associated life-threatening injuries of the head, chest and abdomen has been reported to be as high as 74% and the severity of these associated injuries is reflected by the mortality rates, ranging from 5 to 15%. The energy imparted to the soft tissue is also significant, with open fractures occurring in one or both bones in 59–67% of cases [2].

They tend to occur among the more seriously injured trauma patients and have a higher incidence of associated injuries compared with patients with isolated femoral or tibial fractures [1].

In 1978, Fraser and colleagues offered their classification system of floating knee injury. Type I fracture is extra-articular, and type II fracture is classified according to the nature of the knee injury. Patients with type IIA injury have a tibial plateau fracture and an ipsilateral femoral shaft fracture. Type IIB injury is characterized by an intra-articular distal femoral fracture and tibial shaft fracture. Type IIC injury involves ipsilateral intra-articular fracture of both the tibial plateau and the distal femur [3].

For type I injuries, intramedullary nailing of both femoral and tibial fracture is often the optimal form of fixation. Application of retrograde intramedullary nailing of femoral shaft fracture and antegrade nailing of the tibia would seem to be particularly suited to the management of ipsilateral fractures of the femur and tibia. The patient can be managed on a standard radiolucent operating table with no need for repositioning between fixation of the two fractures. A single incision allows ready access to the starting points for both the tibial and femoral nails. If necessary, other surgical teams can operate simultaneously on head, truncal, or other extremity injuries [1,2,4,5].

Patients and methods

This was a prospective study conducted over a 4-year period (2005–2009) at the Department of Orthopaedics, Assiut University Hospitals, Egypt, after approval of the Research and Ethics Committee. We report a series of 21 patients who had Fraser type I floating knee injury (ipsilateral fracture of the shaft of the femur and the tibia). They were treated with the retrograde femoral and antegrade tibial intramedullary nail from a single knee incision, transpatellar tendon approach. Informed consent was obtained from the patients following the guidelines set forth by our institution and by the Declaration of Helsinki and Good Clinical Practice.

On admission, all patients were carefully evaluated to detect and manage the life-threatening conditions. Initial management involved resuscitation and haemodynamic stabilization of the patient, splinting of the affected limb in a Thomas splint and a thorough secondary survey to identify other injuries. Radiographs of the chest, pelvis, affected lower limb including all its joints and other suspected bony injuries were obtained. Open fractures were classified according to Gustilo and Anderson's classification [6]. Initial wound toilet, tetanus immunization and antibiotic therapy was initiated for open fractures. Debridement was performed in all open fractures within 12 h after injury.

Surgical management of both fractures was carried out once patients were haemodynamically stable and fit to undergo surgery. The femur fracture was fixed before tibia fracture.

Surgical procedures

The procedure is performed after adequate resuscitation and stabilization of the injured patient. The patient is placed supine on a radiolucent operating table and the injured extremity is prepared from the iliac wing to the toes. A small bolster is placed under the involved knee to obtain ~45° flexion. The femoral shaft fracture always is addressed first.

An incision is made in the midline of the palpable patellar tendon. It starts at the superior pole of the patella and ends at the top of the tibial tubercle. The patellar tendon is split longitudinally in its midline the full length of the incision, and the fat pad is reflected inferiorly. In the cases of associated fracture of the patella, access to entry points is gained by reflecting the displaced fracture fragments.

With the knee flexed ~40°, a guide pin is positioned ~1 cm anterior to the attachment of the posterior cruciate ligament. The pin is checked with lateral fluoroscopy to ensure that it is just above Blumensaat's line. A rigid reamer is used to open the distal femoral metaphysis. An unreamed retrograde femoral nail is used without reaming of the diaphysis. Care is taken so that that distal end is not over the articular surface. The nail is locked statically. The knee is then hyperflexed to allow access to the proximal tibia. The starting point can be made using a reamer over a guide pin or an awl. The unreamed tibial nail is then introduced in standard unreamed manner. After manual reduction, the nail is passed across the fracture site. Two locking screws are placed proximally and distally. The knee incision is irrigated, and a suction drain is frequently placed into the knee.

Postoperative care

The drain usually is removed at 48 h postoperatively. It is important to use early range of motion (ROM) exercises in the early postoperative period. Active exercises for the knee and ankle are then initiated with weight-bearing progressing as the femoral and tibial callus increases.

Thromboprophylaxis was initiated in all patients in the postoperative period.

Physiotherapy and mobilization were started as soon as possible after surgery.

The average hospitalization was 11.6 days ranging from 6 to 17 days.

Patients were followed up regularly until bony union (clinical and radiological). Routine follow-up radiographs (anteroposterior, lateral and oblique) were obtained every 4 weeks until they showed solid continuous callus formation.

Clinical union was defined as the ability to perform a single leg stance on the injured limb without pain or instability. Radiographic union was defined as three bridging cortices seen on the combined anteroposterior and lateral radiographs. These definitions were used for the tibia and femur fractures.

The average length of follow-up period was 27.5 months, ranging from 16 to 40 months after the original injury.

Functional assessment and final outcome evaluation were carried out using the grading system of Karlströ mand

Olerud [7] after bony union. We defined satisfactory (S) outcomes as those cases with excellent or good results and unsatisfactory (US) outcomes as those cases with acceptable or poor results.

Briefly, the details of the above grading system are as follows: an excellent result required no subjective complaints related to the lower extremity, unimpaired ambulation, no change in preinjury work or sporting activities, no evidence of malunion and no loss of motion. A good result entailed intermittent or slight symptoms, no change in working ability but a decrease in sports activities, angulation and rotational deformities of less than 10°, less than 1 cm of shortening, and a loss of less than 10° of motion at the ankle and less than 20° at the hip, knee, or both. An acceptable result meant that there was some functional loss secondary to symptoms, decreased ambulatory tolerance, a change to less strenuous work, angulation or rotational deformities of less than 20°, less than 3 cm of shortening, and a loss of less than 20° of motion at the ankle and less than 40° at the hip, knee, or both. A poor result was associated with considerable impairment of function secondary to symptoms, use of ambulatory aids, permanent disability and greater degrees of malunion and loss of motion (Figs. 1–3).

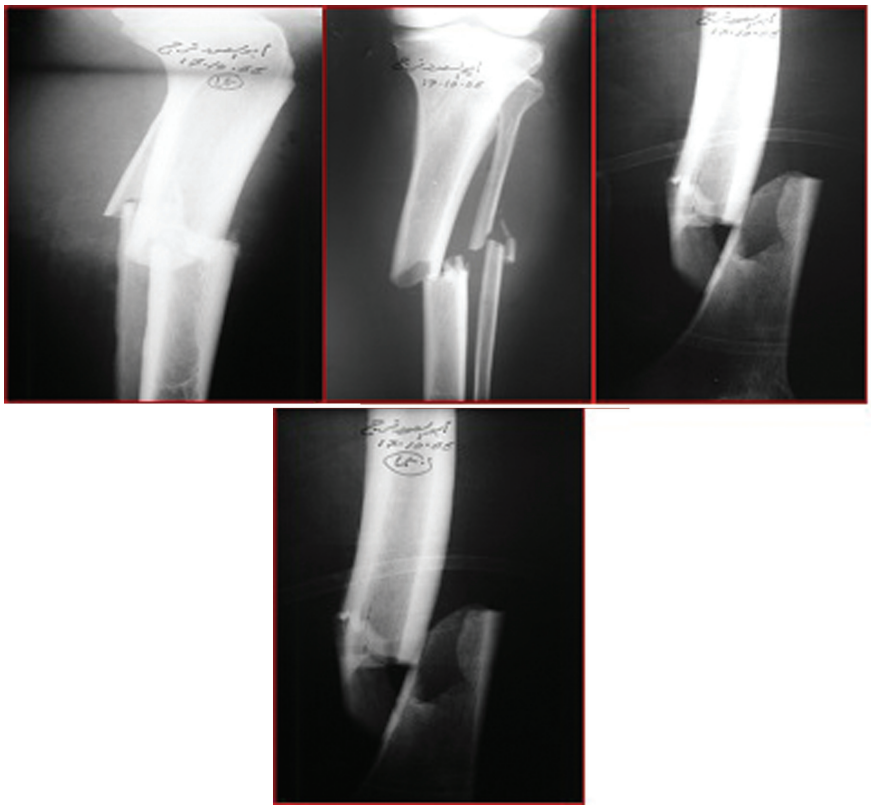
Result

The mean age of the patients at the time of injury was 30.6 years (range: 19–50 years); 17 of them were male and four female. All patients had sustained their injuries in motor vehicle accidents: 16 were drivers or passengers in cars and five were injured in motorcycle accidents. The right side was involved in 13 patients, and the left side in eight patients. The mean Injury Severity Score [8] of the 15 patients was 18.5 (range: 9–29).

There were five cases of open type II fracture of the tibia, four of which were associated with ipsilateral open type II fracture of the femur.

Of 21 patients included in this series, six had contralateral fracture of the shaft of the femur and two had ipsilateral patellar fractures. One patient had fractures of the forearm bones, one patient had Colles' fracture, one patient had ipsilateral fracture of the medial malleolus, one patient had ipsilateral trochanteric fracture and three patients had metatarsal fractures. Five patients had intraperitoneal haemorrhage, for which urgent abdominal exploration was carried out with repair of liver tears. Four patients had fracture of the ribs;

Figure 1



33-year-old male patient had fracture left femur and ipsilateral fracture Tibia.

Figure 2

Closed reduction and statically locked retrograde femoral nail for lt. Femur and antegrade closed statically locked IMN Lt. Tibia were done.

Figure 3

Final follow up visit 9 months PO; patient had full knee ROM (0–140°).

two of them had haemopneumothoraces that needed tube thoracostomies. The chest drains were kept until the haemothorax was drained as monitored on serial chest radiographs. Three patients sustained head injuries, for which a computed tomography scan of the brain was performed. None of these

patients had intracranial bleeding or haematomas that needed intervention by the neurosurgeons. There was no major vascular injury.

The mean fixation time after injury was 8.2 days (range: 8 h–17 days). The delay in fixing the fractures was due to late referral to our hospital or due to the time needed to stabilize patients with extraskeletal injuries.

The operating room time averaged 138.7 min (range: 90–200 min).

The average knee ROM was 121.3° (range: 100–140°). Moreover, two patients who had ipsilateral comminuted fracture of the patella were treated with partial patellectomy and protection wire. All patients had regained their knee motion by 12 weeks.

Knee pain was a common problem in our series. There were 10 (47.7%) patients having some type of knee pain or knee discomfort. Three patients had long protruding distal locking bolts. All had pain in the distal thigh and knee region that was insignificant as it did not interfere with daily activities and needed no analgesics. Two patients suffered from associated fracture of the patella ipsilateral to the femoral fractures that required frequent analgesic use, and a change in their previous activity levels. There were two patients with femoral and tibial nonunion after nailing; they had knee pain that may be a referred pain. The origin of the pain was unknown in three patients, probably due to undiagnosed internal knee derangement.

Nonunion developed in one femoral fracture and one tibial fracture. Dynamization and bone grafting in both patients with nonunion were performed. These fractures went on to unite following these interventions. Removal of patellar protection wires was performed about 6 months after surgery.

The average time for union of femoral shaft fractures was 15.8 (range: 8–56) weeks. The average time for union of tibial fractures was 22.9 (range: 18–30) weeks.

There was no malunion exceeding 10° of angulation or rotation in either fracture. There was no patient leg length discrepancy. There was no deep infection.

The final functional outcomes after bony union using the criteria of Karlström and Olerud were as follows: 11 excellent results (52.3%), six good (28.5%), three fair (14.3%) and one poor (4.7%). The overall satisfactory outcome rate was 81% (17/21).

Discussion

Concomitant ipsilateral fractures of the femur and tibia, the so-called 'floating knee', are important because of the high mortality with associated injuries. The mortality rates from floating knees range between 5 and 15%, and amputations are reported in ~25% of patients. The incidence of knee ligament injuries in the floating knee is as high as 53% as documented in the literature [3,9].

Floating knee injury tends to be among the more seriously injured trauma in patients and has a higher incidence of associated injuries compared with patients with isolated femoral or tibial fractures [1].

In this series, all patients had sustained their injuries in motor vehicle accidents. In a study of 222 cases of floating knee [4], all cases were involved in road traffic accidents. Rethnam *et al.* [10] stated that most of the studies showed road traffic accidents as the only mode of injury.

Associated injuries were noted in all our patients. The average Injury Severity Score in our series was 18.5 (range: 9–29), which is similar to that reported previously. It was 19 (range: 10–38) in the study by Ostrum RF [6], 16.9 (range: 9–50) in the study by Yokoyama *et al.* [14], 18.8 (range: 9–38) in the study by Oh *et al.* [9] and 18 (range: 9–34) in the study by Hung *et al.* [11].

The best results achieved in floating knee injury were seen when both fractures were treated with intramedullary nailing.

The single incision technique (antegrade tibial and retrograde femoral nailing through a single incision at the knee) can be used to operatively stabilize type I floating knee injury. This approach decreases operative time and surgical trauma. With the patient in the supine position and the use of a radiolucent table, the time required for the setup of the fracture table is eliminated. Therefore, the patient can be more quickly stabilized, and the operative time may be reduced. Rapid stabilization of ipsilateral femoral and tibial fractures has been shown to decrease the incidence of the systemic problems common to the multiply injured patient [1].

Rios *et al.* [12] compared single incision versus traditional antegrade nailing of the fractures and found the former to have shorter surgical and anaesthesia time, with reduced blood loss.

The average knee ROM reported by Veith *et al.* [3] and Gregory *et al.* [5] was 129° and 120°, respectively. In our series, the average knee ROM was 121.3° (range: 100–140°). The two patients with limited ROM (100 and 110°) had associated ipsilateral comminuted fracture of the patella that was treated with partial patellectomy and protection wire.

Knee pain was a common problem in our series. There were 10 (47.7%) patients having some type of knee pain or knee discomfort. However, in most patients, knee pain was not severe enough to interfere with activities of daily living, and most of them obtained their preinjury levels of activity.

The average time for union of femoral shaft fractures was 15.8 (range: 8–56) weeks. The average time for union of tibial fractures was 22.9 (range: 18–30) weeks. This is comparable to that reported in published results. Ostrum [6] reported that the average time to union of femoral fractures was 14.7 weeks and that for tibial fractures was 23 weeks. Rethnam *et al.* [10] reported that the bony union time ranged from 15 to 22.5 weeks for femur fractures and 17 to 28 weeks for fractures of the tibia. Chang *et al.* [9] reported that the average time for union of femoral shaft fractures was 27.6 (range: 18–40) weeks. The average time for union of tibial fractures was 24.5 (range: 18–30) weeks.

The overall satisfactory outcome rate in our series was 81% (17/21). Using the criteria of Karlstrom and Olerud, most published series reported over 60% of the results to be excellent and good in cases of floating knee. The excellent and good results were obtained in 86% of patients in the study by Karlstrom and Olerud [2], in 72% of patients in the study by Veith *et al.* [3], in 81% of patients in the study by Anastopoulos *et al.* [13] and in 65% of patients in the study by Gregory *et al.* [5]. However, most of the above-mentioned series focused on type I floating knee. Hung *et al.* [11] concluded that the outcome of cases of type II floating knee seems poorer than that of the type I.

The viewpoint of Yokoyoma *et al.* [14] that the criteria of Karlstrom and Olerud include some problems seems to be logic because these criteria are not a point system; if only one factor indicates a poor result, the functional outcome has a dangerous possibility of being poor.

Limitations

First, we studied only type I floating knee injury, which has good outcome compared with type II in published series.

Second is the lack of assessment of knee ligaments. We think it is important in type II injuries with intra-articular extension.

Conclusion

Ipsilateral fractures of the femur and tibia, or floating knee, are major injuries occurring frequently among an active population.

High-energy mechanisms, extensive soft tissue trauma and other severe associated injuries make the treatment of patients with ipsilateral fractures of the femur and tibia difficult. Knee involvement will make the situation more complicated.

In type I floating knee injury, appropriate management of the associated injuries, intramedullary nailing of both fractures, knee ligament assessment to detect injuries and postoperative rehabilitation are necessary for good final outcome.

The treatment of patients with ipsilateral femoral and tibial fractures using retrograde femoral and antegrade tibial nailing with a single incision showed high union rates and a positive functional outcome.

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Conflicts of interest

There are no conflicts of interest.

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