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Clinical and Radiological Diagnosis of femur and Tibia (floating knee) type 1 and type 2 injuries

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ABSTRACT
Background: The incidence of fractures resulting from motor vehicle accidents is increasing. Consequently, high-velocity accidents are now more common. Such accidents produce violent and complex injuries. The floating knee is a complex injury and is typically more than a simple ipsilateral fracture of the tibia and femur and may involve both extra-articular and intra-articular fracture patterns. **Objective**: To evaluate the radiological and clinical outcome of minimally invasive osteosynthesis in ipsilateral fracture of femur and Tibia (floating knee) type 1 and type 2 injuries. **Conclusion**: It should be managed by step wise systemic approach according to the patient's associated injuries. Definitive fixation should be delayed until the patient's condition is suitable for surgery. Mobilization should be started as soon as possible keeping the patient non-weight bearing after the fixation of fractures for better functional outcomes.

Keywords: Minimally Invasive Osteosynthesis, Floating knee

INTRODUCTION
Floating knee is a flail knee joint resulting from fractures of the shafts or adjacent metaphyses of the femur and ipsilateral tibia. Floating knee injuries may include a combination of diaphyseal, metaphyseal, and intra-articular fractures.

Floating knee injuries are associated with high-velocity mechanisms and often accompanied by other injuries to other parts of the body, including severe soft tissue injury. These high-velocity mechanisms include[1]:

- Motor vehicle accidents.
- Falls from an extreme height.
- Pedestrian vs. auto accidents.
- Cyclist vs. auto accidents.
- Blunt trauma to the area.

Diagnosis
History:

The floating knee is often a result of high-energy trauma and may be associated with life threatening injuries. Fracture patterns are often complex with serious injuries of the soft tissues[2].

General examination and local Examination
The affected limb is always swollen and deformity is evident. After the first examination, resuscitation (if necessary), and splinting of the affected limb, the patient should be thoroughly

examined a second time from head to toe to exclude associated fractures. Besides bone and soft tissue injuries, the patients' general condition should be monitored carefully. Vascular assessment of the affected limb is of utmost importance in detecting any vascular injury by assessing the peripheral pulses by palpation or Doppler[3].

Imaging: X-ray

The long-leg x-rays of the affected limb are needed in the primary examination. The radiography of the unaffected side is helpful for the preparation of the preoperative plan. Radiographs of the chest, pelvis, affected lower limb including all its joints, and other suspected bony injuries are also needed[4].

CT scan

CT- scan is also helpful to determine the detail of the fracture pattern in some severely comminuted fractures[5]. If there is suspicion of intra-abdominal or cerebral injury, an urgent CT scan is indicated[5].

MRI

Knee ligamentous and meniscal injuries are mostly not visible in plain radiographs taken in the emergency department. So, when the patients' general conditions are stable, MRI of the affected knee is recommended[6].

Ultrasound and angiography

If vascular injury is suspected, ultrasound and angiography are needed. Evaluation of abdominal injuries should be performed by clinical assessment and ultrasound[6].

Preoperative Work-Up

The treatment of floating knee should initially manage the general conditions of the patients, solving the associated life-threatening injuries and preventing shock and fat embolism. Saving the life is the priority, replenishing the blood volume and treating the fat embolism syndrome[7]. When the general condition is stable, the treatment of fracture should be considered:

Open fractures,

In open fracture initial wound care, tetanus immunization, and antibiotic therapy should be initiated. The surgical timing depends on the general condition of the patients, and the severity of the associated injury, the condition of the local soft tissue and blood and nerve injury, the experiences and surgical techniques of the surgical team, and the condition of the hospital equipment's are also important[8].

Intra- articular fractures:

There is no evidence that these fractures need to be fixed definitively in emergency; however, temporary external fixation of the fracture is advised until the general and local conditions of the patient are stable. This time can be useful to correctly plan the surgery[8].

Vascular repair

Vascular repair and bone stabilization is debated. **McHenry et al**. [9] found no iatrogenic disruption of the vascular repair when bone stabilization followed vascular repair. The general consensus is that bone stabilization should precede vascular repair in unstable fractures, while in stable fractures, vascular repair should be done first to avoid prolonged ischemia to the limb[9].

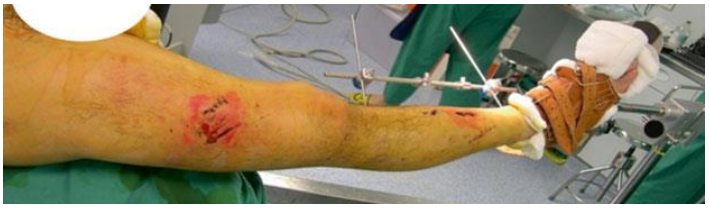
Surgical Techniques:

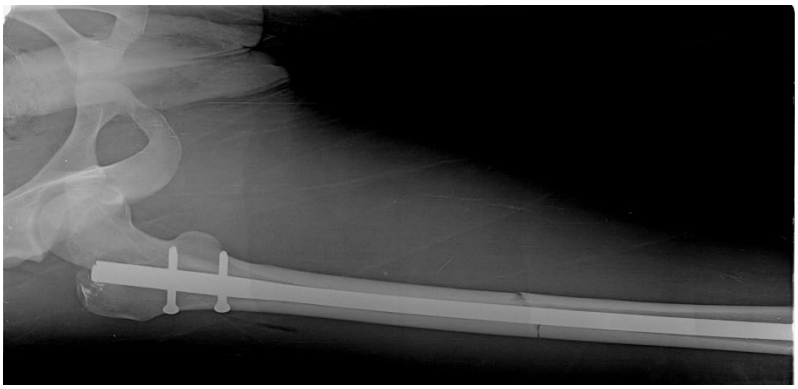
Anesthesia

Floating knee needs multiple operative sites and usually requires along surgical time. General anesthesia is usually recommended because it is safer and allows for control of the patient's general condition. A sterile tourniquet can be applied in some situations when dealing with tibia fracture, but in most patients it is contraindicated since the femur is also involved[3].

Patient Positioning

Patient positioning depends on the surgical plan. Supine position with a pad under the knee on a radiolucent table is the most common setup. When ante-grade femoral nailing is indicated, traction position is required (Figure 1). To avoid traction force affecting the definite fixation in tibia, we suggest nailing the femur first with traction and temporary external fixation of the tibia[3].



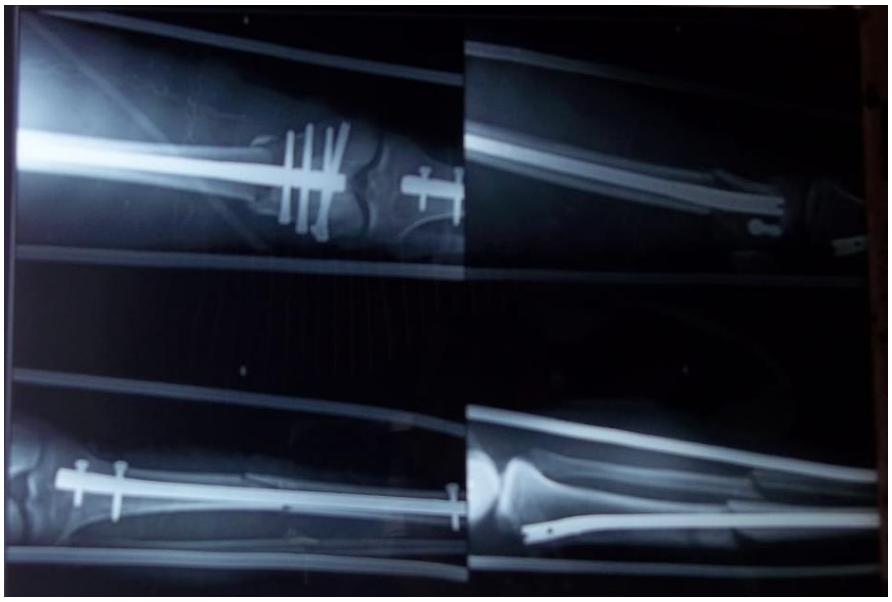


(Figure 1): Traction position for femoral ante-grade intramedullary nail with external fixation in tibia

Surgical Approaches, Reduction and Fixation Techniques:

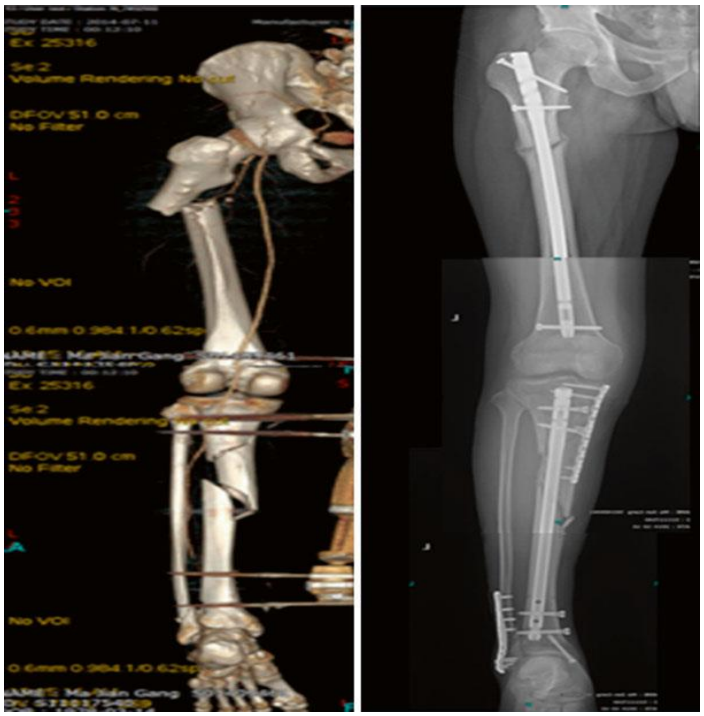
Reduction is one of the most challenging steps of the surgery. The goals of reduction of floating knee are restoration of the alignment of lower limb and anatomic reduction of the articular fragments[3]. To achieve realignment of femur and tibia, we recommend various closed reduction techniques, including traction, clamp, half pin, bone hook, etc[3]. To achieve anatomic reduction of the articular fracture, open reduction under direct vision remains the standard method. In terms of reduction sequence, there is no definite guideline[3]. The decision of reduction strategy and fixation pattern should be made cautiously according to the characteristic of each individual case[10]. For typical "true" floating knee, retrograde femoral nail plus tibial nail is usually a good indication, with fixation of both bones through a single knee incision. This will reduce the surgical time (Figure 2). The femoral shaft fracture is addressed first.

Stabilization of the femur allows for mobilization of the patient without traction and adequate flexion of the knee, in order to approach the proximal tibial entry point[10].



(Figure 2): Retrograde nailing for femoral fracture and nailing for tibial fracture[3].

If the femoral fracture extends to the proximal third of the shaft, ante-grade nailing is recommended for the femur (Figure 3). With simultaneous external fixation in the tibia, the surgical technique of ante-grade nailing is comparable to isolated femoral fracture[10].



(Figure 3): The femoral fracture site extended to upper one third of shaft.

Antegrade nailing for femur and nail with additional reduction plate for tibial segmental fracture[3].

If one or both fractures are too complex, a staged strategy is reasonable. Locking plates provide strong stability for metaphyseal fractures and can achieve anatomic reduction with or without free compression lag screws[10].

When the fracture involves the metaphyseal or articular part, locking plates and screws can be applied in this side combined with intramedullary nailing in the diaphyseal side (Figure 4) [10].

(Figure 4): Antegrade nailing for femoral segmental fracture and locking plates for tibial metaphyseal fracture[3].

A minimally invasive approach for the locking plates is strongly recommended in order to preserve the blood supply. In 21 patients with floating knee injury, Hung et al. [11] treated 16 cases of type II or "variant" injury with plates and screws. The authors concluded that when the knee joint is involved, intramedullary nailing is not recommended[11].

Plate fixation can offer anatomic reduction of the articular surface, allowing for early mobilization and maximizing the functional outcome.

Different fixation techniques can be combined according to the personality of the fracture. Commonly intramedullary nailing is combined with additional plating for segmental fractures involving the metaphysis of the tibia or femur[11] .

Complications:

Pulmonary Embolism

Intramedullary nailing is a widely used method for treating the floating knee but has a systemic physiological effects known as "second-hit phenomena." This phenomenon results in increased chances of pulmonary complications especially in poly-trauma patients[12].

Canal reaming and insertion of the nail liberate medullary fat with the risk of pulmonary embolism, which can be life threatening because of a fragile respiratory state secondary to the initial trauma. Cerebral injury has been found to be associated with high risk of pulmonary complications[13].

Delayed Union or Nonunion

This complication always results from infection or hardware failure. Patients with delayed union/ nonunion need either dynamization of the nail or removal of the external fi xator and functional bracing of the fracture[3].

Amputations

This is probably related to the severity of trauma, massive soft tissue crushing, and delay in presentation at the emergency room[3].

Mal-union

Mal-union can occur in open fractures and comminuted fractures treated by external fixation. In order to reduce the number of mal-unions, comminution must be addressed accurately by the use of lag screws. Ipsilateral nailing of femoral and tibial shafts increases the risk of malunion, rotatory instability due to shortening, and axial malalignment[3].

CONCLUSION

Floating knee injury is more than just an ipsilateral fracture of the femur and tibia with associated life-threatening conditions. It should be managed by step wise systemic approach according to the patient's associated injuries. Definitive fixation should be delayed until the patient's condition is suitable for surgery. Mobilization should be started as soon as possible keeping the patient non-weight bearing after the fixation of fractures for better functional outcomes. Patients treated with intramedullary nailing have better outcomes with a low complication rate compared to other methods of management. Hence, excellent clinical and functional outcomes can be achieved with individualized planning of treatment which is dependent on the patient's general condition, type of fracture, and severity of soft tissue injury by an experienced multidisciplinary team instead of a fixed definite management for all patients.

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