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Epidemiology and clinical evolution of floating knee injuries in a tertiary referral hospital

Epidemiología y evolución clínica de las lesiones de rodilla flotante en un hospital de tercer nivel

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Abstract

Introduction: injuries known as floating knees are related to high-energy mechanisms, and represent a challenge in treatment due to the associated injuries. **Objective:** to assess the epidemiology and clinical evolution of patients with ipsilateral femoral and tibial fractures. **Material and methods:** all patients admitted to the emergency department with ipsilateral femoral and tibial fractures from March 2018 to October 2021 were included. Fractures were classified according to the Fraser classification. Clinical assessment was performed using the Karlstrom and Olerud scale with a 12-month follow-up. Data related to the injury and associated injuries were also evaluated. **Results:** a total of 24 patients were analyzed. The mean age of the sample was 31.3 ± 12.4 years, and 20 were male. There were 10 (41.7%) Fraser type I; 14 (58.3%) were articular fractures of which six were type IIa, two were type IIb, and six were type IIc. There was a 16.7% incidence of vascular injuries. It was observed that open fractures classified as Gustilo and Anderson type III ($p = 0.002$) and articular injuries ($p = 0.005$) showed worse clinical evolution. **Conclusion:** it was detected a high incidence of vascular injury. The presence of open fractures with extensive soft tissue injury and fractures involving the joint showed worse clinical evolution and limitation after treatment.

Keywords: floating knee, distal femoral fracture, tibial fracture, vascular injury.

Level of evidence: III

Resumen

Introducción: *las lesiones conocidas como rodillas flotantes se relacionan con mecanismos de alta energía y representan un reto en el tratamiento debido a las lesiones asociadas.* ***Objetivo:*** *evaluar la epidemiología y la evolución clínica de pacientes con fracturas ipsilaterales de fémur y tibia.* ***Material y métodos:*** *se incluyeron todos los pacientes admitidos en el servicio de urgencias con fractura ipsilateral de fémur y tibia de marzo de 2018 a octubre de 2021. Las fracturas fueron catalogadas siguiendo la clasificación de Fraser. Se realizó una evaluación clínica usando la escala de Karlstrom y Olerud con un seguimiento de 12 meses. Se evaluaron también datos referentes a las lesiones asociadas.* ***Resultados:*** *fueron incluidos 24 pacientes, de los cuales 20 fueron hombres. La media de edad fue de 31.3 ± 12.4 años. Se registraron 10 (41.7%) fracturas Fraser tipo I; el resto 14 (58.3%) fueron fracturas articulares de las cuales seis fueron tipo IIa, dos tipo IIb, y seis tipo IIc. Se registró 16.7% de incidencia de lesiones vasculares. Las fracturas Gustilo y Anderson grado III ($p = 0.002$) y las lesiones articulares ($p = 0.005$) mostraron la peor evolución clínica.* ***Conclusiones:*** *se detectó una alta incidencia de lesiones vasculares. La presencia de fracturas expuestas con un extenso daño de los tejidos blandos, así como las fracturas que involucraron la articulación, mostraron la peor evolución clínica y limitación después del tratamiento.*

Palabras clave: *rodilla flotante, fractura de fémur distal, fractura de tibia, lesión vascular.*

Nivel de evidencia: *III*

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Introduction

Blake and McBryde coined the term «floating knee» in 1975 to describe the injury pattern of ipsilateral femoral and tibial fractures that «disconnect» the knee from the rest of the leg.[1] These fractures are caused by high energy trauma and are commonly associated with other serious injuries.[2,3]

The incidence of this injury is unknown, but it generally occurs in young adult patients in their twenties where the most common mechanism of injury is a traffic accident.[3,4] Mortality has been reported to be as high as 8.6%,[5,6] with amputation rates up to 27%,[7] and vascular injury rates in 6% of cases.[8,9] Factors influencing the treatment and prognosis of these injuries include the patient's systemic status, fracture pattern, soft tissue injuries, neurovascular injuries, and injuries associated with other systems.[10] Additionally, a high rate of knee ligament injuries has been reported.[11,12] The rates of infection, pseudarthrosis, defective consolidation, and knee stiffness are relatively high. These complications can lead to functional impairment and often result in unsatisfactory outcomes, severely limiting patients' quality of life.[8,9] Fraser et al.[13] classified floating knee, depending on joint involvement. Type I shaft fractures of both bones, type II, were divided into three types, type IIa, with tibial plateau involvement, type IIb with distal femur involvement, and type IIIc involved both tibial plateau and distal femur within the knee joint. Ran et al. modified Fraser's classification, adding floating knee type 3, which includes injury to the extensor mechanism of the knee.[14]

The criteria of Kalstrom and Olerud are used to evaluate the functional assessment in these patients after the treatment of floating knee injuries. There are seven criteria: subjective symptoms (thigh or leg), subjective symptoms (knee or ankle joint), walking ability, work and sports, deformity (angulation, rotation, or both), shortening, and restricted joint mobility. And four forms to evaluate: excellent, good, acceptable, and poor.[15]

Since this severe injury is quite infrequent, there have been few studies among the Latin American population, where there is a high incidence of traffic accidents, which in turn is the cause most frequently associated with this injury.[16,17] Likewise, its clinical evolution among this population needs to be assessed. This study aimed to describe the epidemiology and clinical evolution of ipsilateral tibia and femur fractures that come to our institution and to compare them with what is reported in the literature.

Material and methods

Study design

This was a retrospective study conducted at a top-tier referral center in northeastern Mexico. It included all patients over 16 years of age admitted to the emergency department with ipsilateral tibia and femur fractures, from March 2018 to October 2021. They were subsequently followed up for 12 months to assess their clinical and radiographic progress. Excluded patients were those with isolated femur or tibia fractures, those with fractures of both contralateral bones, patients who did not attend follow-up at our hospital or who did not undergo surgical treatment at the institution. The study protocol was approved by our institutional research ethics committee.

Variables and data collection

Information was gathered from the clinical records from the Orthopedics and Emergency Departments, covering patients admitted to the hospital with musculoskeletal trauma-related injuries. They were sorted using the classification described by Fraser et al.[13] The following demographic variables were collected: age, gender, co-morbidities, diagnosis, open injuries classified by Gustilo and Anderson,[18] treatment performed, date of admission, and vascular injury evidenced by Doppler ultrasound, if it had an anatomical relationship with the fracture site. All the patients underwent surgery. Subsequently, to evaluate the 12-month evolution of the patients diagnosed with floating knee, the Karlstrom and Olerud criteria were applied.[15]

Initial management and treatment

Simple thorax, pelvis, and affected limbs x-rays were recorded. In addition, a portable ultrasound of the abdomen and thorax was performed on all patients to rule out intra-abdominal and thoracic trauma. In cases of suspected head injury, a cranial CT scan was performed. Patients who had an associated thoracic, cranial, or abdominal injury were treated following the extent of their injuries before surgical stabilization of any fractures. These patients were immobilized to stabilize the fracture site until definitive fixation

Table 1: Characteristics of the patients with floating knee fractures.

Variable	n (%)
Total subjects	24 (100.0)
Time until definitive treatment (days), mean ± SD	13.9 ± 7.7
Mechanism of injury	
Car accident	9 (37.5)
Motorcycle accident	11 (45.8)
Struck by motor vehicle	3 (12.5)
Gunshot	1 (4.2)
Open fractures	16 (66.6)
Gustilo and Anderson classification (grade)	
NA	8 (33.3)
I	1 (4.2)
II	4 (16.7)
III	11 (45.8)
Fraser classification (type)	
I	10 (41.7)
IIa	6 (25.0)
IIb	2 (8.3)
IIc	6 (25.0)

NA = not applicable. SD = standard deviation.

could be carried out. Methods used in these cases included stabilization by posterior above-knee plaster splinting and external fixation. The patients treated with initial external fixation were taken to surgery for definitive fixation within 7 to 10 days of stabilization. Furthermore, patients were monitored for symptoms of fat embolism, suspected cases were referred to and managed by the Intensive Care Unit.

Initial wound cleansing, tetanus immunization, and prophylactic antibiotic therapy were initiated for all open fractures. Surgical stabilization of fractures was programmed based on the severity of the open injury, local soft tissue damage, and availability of the operating room.

Statistical analysis

Analysis was carried out using the Statistical Package for the Social Sciences (SPSS) software version 25. The cumulative incidence was calculated as a measure of occurrence, with a corresponding 95% confidence interval. To compare the results with those previously reported in the literature, Z tests for a sample proportion were used as a hypothesis test. The Student's t-test was used to compare continuous variables, while the χ^2 test was used for categorical variables a p-value <0.05 was considered significant.

Results

A total of 24 patients with floating knee fractures were analyzed. The mean age of the sample was 31.3 ± 12.4 years, and 20 of the patients were male. The most common associated injuries were vascular injury (16.7%) and upper limb fracture (16.7%). The average time to definitive treatment was 13.9 days. Sixteen (67%) patients had open fractures, according to the Gustilo and Anderson classification they were 1 (4.2%) type I, 4 (16.7%) type II, and 11 (45.8%) type III. As for Fraser's classification, 10 (41.7%) participants had type I fractures, while 14 (58.3%) were articular fractures, distributed in type IIa (6), Type IIb (2), and type IIc (6). The rest of the baseline characteristics are listed in *Table 1*.

The definitive treatment given to patients with floating knee fractures in the Trauma department is shown in *Table 2*. A total of 54.2% were treated with intramedullary nails for both femur and tibia fractures, 12.5% with femoral nailing and tibial plate, 8.3% with femoral plate and tibial nailing, 4.2% with femoral and

Table 2: Final therapeutic intervention of patients.

Treatment	n (%)
Femoral IM nail and tibial IM nail	13 (54.2)
Femoral IM nail and tibial plate	3 (12.5)
Femoral plate and tibial IM nail	2 (8.3)
Amputations	2 (8.3)
Femoral plate and tibial plate	1 (4.2)
Femoral external fixation and tibial IM nail	1 (4.2)
External fixation	1 (4.2)

IM = intramedular.

Table 3: Association with clinical evolution according to the Karlstrom and Olerud scale.

Variable	Good-excellent n (%)	Poor-moderate n (%)	OR	p
Articular fracture	5 (23)	7 (32)	8.56	0.005
Gustilo and Anderson grade III	4 (18)	7 (32)	7.54	0.002
Definitive treatment > 7 days	13 (59)	7 (32)	1.03	0.455
Open fracture	9 (41)	7 (32)	3.85	0.067

tibial plate, 8.3% were amputated, 4.2% with femoral external fixation and tibial intramedullary nailing, 4.2% with external fixation on both femur and tibia and 4.2% were not treated with surgery.

Clinical evolution was evaluated using the Karlstrom and Olerud scale for the 22 patients whose fractures did not lead to amputations. Excellent clinical evolution was observed in two patients (9%), good in 13 (59%), moderate in five (23%) and poor in two patients (9%). It was observed that open fractures classified as Gustilo and Anderson type III ($p = 0.002$), and joint injuries ($p = 0.005$), showed worse clinical evolution *(Table 3)*. Nonetheless, no significant differences were observed in the clinical evolution of patients who were treated with definitive implants in the first seven days, compared to those who had a delay in treatment of more than seven days.

Discussion

Good evolution of the patients with floating knees was observed despite the delay in the definitive surgical management. Floating knee injuries pose a challenge not only in the treatment of femur and tibia fractures, prevention of bone deformities, and knee stiffness, but also in the treatment of systemic, visceral, and especially vascular injuries to prevent limb loss.

Most of the floating knee fractures in our study occurred in young men (83.3%), which is in line with the literature, where a mean age of around 35 years has been reported.[5,9,19-23] The most frequent etiology was traffic accidents (83%). Similarly, in their 14-year follow-up study of floating knee diagnoses, Dwyer et al. mention that 57/60 patients in their sample had suffered a high-energy injury due to a motor vehicle accident.[5] Nearly half of our patients (45.8%) were involved in motorcycle accidents, which corresponds to an increase in demand for motorcycle delivery drivers; the above concurs with those reported in the literature, especially for studies conducted in developing countries.[19,24,25]

The average number of days from injury to surgical procedure was greater in our study than that reported by Rethnam et al., which was 1.17 days until definitive treatment.[9] In our patients the time delay for surgical management was significantly greater, almost fourteen times. This delay is mainly caused by the lack of health insurance for patients, who must wait until our institution takes care of the corresponding paperwork to cover the necessary supplies for fracture fixation.

In our study, more than half of the patients had associated injuries, they were life-threatening injuries in the abdomen and thorax, so the definitive fixation of the fractures only took place once the patient's vital problem was stabilized. Chouhan et al. mentioned in their review that 66.7% of their population had associated injuries, which highlights the importance of treating the patient comprehensively, because of the high incidence of systemic injuries in patients who suffer high-energy accidents.[19]

Vascular injury is an important factor in the prognosis of the evolution of floating knee fractures. In our study, there was vascular injury in 16.7% of the patients, who were treated with autograft repair. Two of these patients (50%) had an irreparable lesion, which was managed by supracondylar amputation. In their retrospective study of 10 years follow-up, Rollo et al. reported that 9.7% of patients diagnosed with floating knee underwent supracondylar amputation following a vascular lesion.[25]

The final treatment in a floating knee, depends on the involvement of articular fracture. When no articular fracture is appreciated the internal fixation with an intramedullary nailing is used in most of the reports,[24,26] even one report describes the management with a closed reduction and hip spica,[26] none of our patients was managed with this conservative approach. The use of IM nailing in both fractures (femur and tibia) was used in 54.2% of our patients, and a combination of different methods was used in the rest.

In their retrospective study, Akinyoola et al. mention that one of the main sequelae for patients suffering from floating knee fractures is stiffness.[3] Early mobilization of the knee is essential for a positive outcome. In most of the patients in the study, stiffness was the main post-surgery complication mainly due to the delay in definitive treatment, poor adherence to follow-up consultation, and therapy schedules.

Of the 24 floating knees, 66.6% involved open fractures, a high rate only comparable to that published by Bansal et al. and Chouhan et al., who reported 77% and 75%, respectively.[19,26] This is probably due to the high rate of motorcycle accidents as a cause of the injury. Finally, it has been observed that this type of injury is associated with poor clinical and radiographic evolution in patients.[4,5,7,26] Similarly, in our study, 44% of bad functional results were recorded, and in most cases, these were associated with an articular or open injury. These poor clinical results are consistent with the high proportion of open fractures found in

our study. In their retrospective study, Hung et al. evaluated the evolution of 36 patients with a diagnosis of floating knee for 52 months and reported poor functional evolution in patients with intraarticular fractures, recording this factor as the most important for a poor prognosis.[7] In our study, 50% of patients suffered an intraarticular fracture, which is reflected in the 32% of the patients in our study with a moderate or poor clinical evolution according to the Karlstrom and Olerud scale.

Our study has some limitations that should be noted. This is a retrospective study with a low number of participants. Follow-up of our patients was complicated by the fact that most of them do not have sufficient economic resources for adequate follow-up through the outpatient clinic. Additionally, we had a significant delay in the patient receiving their final surgical treatment. However, we observed that despite the economic limitations and the delay in providing definitive treatment, our patients returned to work after a short period, probably for socioeconomic reasons. Further comparative studies with a population similar to ours are needed, focusing on the evolution of the patients and their return to daily activities. A comparison to determine if the joint stiffness was related to an articular involvement of the fracture or related to the soft tissue injury was not possible in our patients because of the lack of these data.

Conclusions

The presence of open fractures with major soft tissue damage and fractures involving the joint leads to worse clinical evolution and post-treatment limitations. In addition, there was a high incidence of vascular injury, in 16.7% of the patients in the study, and half of these patients ended up losing the affected limb. Exhaustive evaluation of patients with loating knee injuries is necessary to detect associated life-threatening and/or limb-threatening injuries, and thus to establish the appropriate surgical intervention for each fracture, which will reduce the risk of complications and promote prompt mobility.

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Conflict of interests

None to declare.