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The floating knee: retrospective review of 15 cases treated over a 5-year period

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Purpose. The purpose of this study is to conduct a retrospective analysis of the floating knee cases managed in our center between 2000 and 2005, as well as the results achieved by treatment, comparing them with the cases reported in the literature.
Materials and methods. A retrospective review was carried out of all patients with ipsilateral femoral and tibial fractures treated in our hospital between 2000 y 2005. Seventeen patients were included in the study, of which 15 could be followed up clinically after a mean 4-year period. Data related to demography, fracture-type, associated injuries, treatment type and complications were recorded. Finally, patients were assessed on the Karlström and Olerud scale.
Results. Results were good for five patients, fair for four and poor for six. As regards complications, there were two cases of infection, one of fat embolism, three pseudoarthroses and five lateral popliteal sciatic nerve palsies. One of the patients required a supracondylar amputation and another died.
Conclusions. Floating knee is an extremely severe lesion, with significant associated injuries and frequent complications and sequelae. In our series, results have been poor in 6 patients according to the Karlström and Olerud scale, which confirms the severity of the lesion. We believe that currently the best treatment is early stabilization of both fractures by means of a combined (retrograde femoral and antegrade tibial) nailing procedure. Finally, we suggest a modified evaluation scale (based on the Karlström and Olerud scale), which might prove more accurate in classifying results. Using this suggested classification, our series would have obtained a mean of 59 points, with a total of 6 excellent results, 1 good, 3 fair and 5 poor.

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Rodilla flotante: revisión retrospectiva de 15 casos tratados durante un periodo de 5 años

Objetivo. Analizar retrospectivamente los casos de rodilla flotante atendidos en nuestro hospital entre los años 2000 y 2005, así como los resultados de su tratamiento, comparándolos con los de la bibliografía.
Material y método. Se realizó una revisión retrospectiva de todos los pacientes con fracturas ipsilaterales de fémur y tibia tratados en nuestro hospital entre 2000 y 2005. Fueron incluidos 17 pacientes en el estudio, de los cuales 15 pudieron ser revisados clínicamente tras una media de 4 años. Se recogieron datos demográficos, tipo de fractura, lesiones asociadas, tipo de tratamiento y complicaciones. Finalmente se evaluó clínicamente a los pacientes según la escala de Karlström y Olerud.
Resultados. Cinco pacientes presentaron buenos resultados, en 4 fueron regulares y en 6 malos. Las complicaciones halladas en la serie fueron dos infecciones, una embolia grasa, tres pseudoartrosis y 5 parálisis del nervio ciático poplíteo externo. Un paciente requirió una amputación supracondílea y otro falleció.
Conclusiones. La rodilla flotante es una lesión muy grave, con importantes lesiones asociadas y frecuentes complicaciones y secuelas. En nuestra serie los resultados han sido malos en 6 pacientes según la escala de Karlström y Olerud, lo que confirma la gravedad de esta lesión. Creemos que el mejor tratamiento en la actualidad es la estabilización precoz de ambas fracturas mediante doble enclavado (femoral retrógrado y tibial anterógrado). Finalmente sugerimos una escala de evaluación modificada de la anterior, que podría ser más precisa en cuanto a la clasificación de los resultados. Con esta clasificación nuestra serie habría obtenido una media de 59 puntos, con un total de 6 resultados excelentes, uno bueno, tres regulares y 5 malos.

Palabras clave: *rodilla flotante, fractura de fémur, fractura de tibia, ipsilateral.*

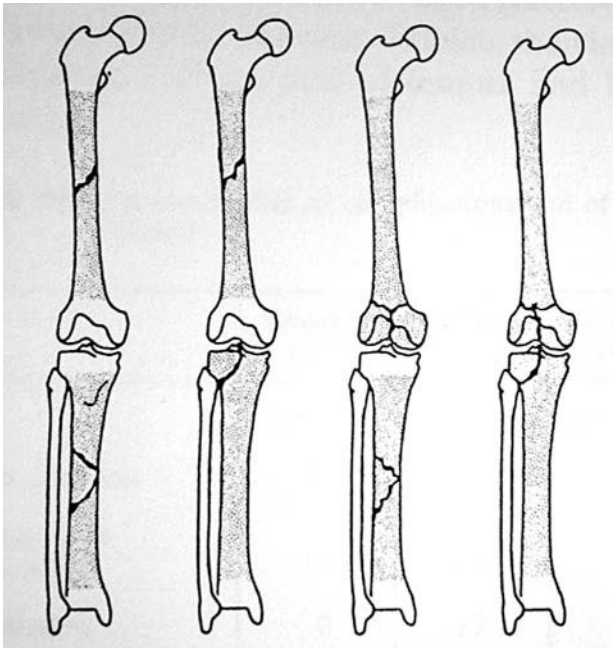

Figure 1. *Fraser et al's[2] classification of the floating knee.*

In 1975 Blake and McBryde[1] introduced the term "floating knee" to describe a kind of lesion consisting in the presence of simultaneous ipsilateral femoral and tibial fractures that "disconnect" the knee from the rest of the limb. The term suggests the presence of a diaphyseal femoral and tibial fracture that bypasses the knee joint, but can be used to describe any type of ipsilateral tibial and femoral fracture, including a knee joint fracture. Fractures that run through the distal femoral or proximal tibial growth plate in children can well provoke a floating knee.

It is a relatively infrequent injury; however the increased prevalence of high-energy trauma leads to a larger number of cases being diagnosed with a floating knee. These lesions are most frequently observed in young male patients, as is the case with severe traumatic injuries. In the longest series published to date, Fraser[2] collected 222 cases, 80% of which were males of a mean age of 28 years. The most frequent cause for the injury was a vehicle accident[1].

The purpose of this study is to review the different occurrences of this injury in our environment, paying special attention to any associated lesion and to the related complications. We also would like to find out about the medium-term results of these patients, comparing them with the reports in the existing literature.

MATERIALS AND METHODS

A retrospective review was made of all cases diagnosed with simultaneous ipsilateral femoral and tibial fractures that revealed that 17 subjects had been diagnosed with that condition between 2000 and 2005. We excluded pediatric patients (those under age 14) and those with pathological fractures. Of the 17, 11 were male and 6 female, with a mean age of 32.9 (16-67) years. The affected side was the left one in 8 cases and the right one in 9. The most usual mechanism of injury was a vehicle accident in 16 cases (one vehicle hitting a pedestrian, 6 motorcycle accidents, 8 car accidents and one truck accident) and in one single case the cause was a fall from a great height (30 meters).

Fractures were rated according to Fraser et al's classification[2] (fig. 1), which distinguishes type I fractures (genuine floating knee), i.e. fractures where neither of the two fractures has articular involvement at the level of the knee, from type II fractures ("false floating knee") where at least one of the fracture lines involves the joint surface. Type II fractures comprise 3 subtypes:

1) Type IIA: a diaphyseal femoral fracture and a tibial plateau fracture.

2) Type IIB: an articular distal femoral fracture with a diaphyseal tibial fracture.

3) Type IIC: an articular fracture of both bones.

In our series 12 cases (70%) were type I fractures, 2 type IIA, one type IIB and 2 type IIC. Furthermore, 3 of the femoral fractures and 7 of the tibial fractures were open

Table 1. Result assessment criteria (Karlström and Olerud3) used in this study

Criterion	Excellent	Good	Fair	Poor
Subjective symptoms in the leg and the thigh	0	Intermittent, mild	Affect function	Pain at rest
Subjective symptoms in the knee and the ankle	0	Intermittent, mild	Affect function	Pain at rest
Ambulation	Normal	Intermittent, mild	Restriction to distance covered	Requires crutches
Work and sports	As before accident	Gave up some sport Same job	Changed jobs	Permanent disability
Angulation and/or rotational deformity	0	< 10°	10-20°	> 20°
Shortening	0	< 1 cm	1-3 cm	> 3 cm
Limitation to joint motion (hip, knee or ankle)	0	< 10° ankle < 20° hip and/or knee	10-20° ankle 20-40° hip and/or knee	> 20° ankle > 40° hip and/or knee

Table 2. Main data and results of this series

	Gender	Age	Etiology	Femur Fx	Initial tx	Finaltx tx	Time	Tibial Fx	Initial tx	Final tx	Time	Classif.	Complic.	K & O result	New classif.
1	M	24	VA	Open grade middle third	II Traction	Nailing	6	Open grade middle third	II Nailing	Nailing	0	1	femoral nonunion+ tibial nonunion	Fair	5 1
2	M	19	VA	Distal third	Fixator	Nailing	23	Proximal third	Fixator	Nailing	23	1	LPSN palsy + artery rupture	Poor	28
3	M	58	VA	Distal third	Traction	Nailing	7	Distal third	Splint	Orthopedic	0	1		Poor	25
4	M	26	VA	Proximal third	Traction	Nailing	8	Middle third	Fixator	Fixator	0	1		Poor	33
5	F	52	VA	Open grade III middle third	Traction	Nailing	14	Middle third	Fixator	Nailing	108	1	ARDS+ *degloving* 80% + nonunion	Poor	85
6	F	22	VA	Middle third	Traction	Nailing	6	Tibial plateau Schatzker type I	Splint	Screws	6	2A		Good	95
7	F	16	VA	Open grade I supraintercondylar	Traction	Plate	6	Distal third	Fixator	Fixator	0	2B	Extensor mech. failure LM, PCL rupture	Good	86
8	F	35	VA	Middle third	AO Plate	Plate	0	Middle third	Nailing	Nailing	0	1	Fat embolism	Fair	75
9	F	25	VA	Interconylar	Splint	Screws	5	Tibial plateau Schatzker type I	Splint	Orthopedic	0	2C	PCL tear	Good	85
10	M	67	Pedestrian	Open grade II	Traction	Nailing	63	Middle third	Traction	Nailing	75	1	Bowel perforation ARDS, ARF. LPSN palsy	Good	90
11	M	42	VA	Open grade II	Traction	Nailing	4	Middle third middle third	Nailing	Nailing	0	1		Good	81
12	M	21	VA	Open grade middle third	II Traction	Nailing	4	Open grade I middle third	Splint	Nailing	4	1		Fair	51
13	M	33	VA	Middle third	Traction	Plate		4 Tibial Plateau Schatzker type VI	Splint	Plate	4	2A		Fair	56
14	F	26	VA	Middle third	Traction	Nailing	11	Open grade I distal third	Cast	Plate	11	1	Spleen rupture LPSN, MPSN palsy	Poor	36
15	M	25	VA	Proximal third + supraintercondylar	Fixator	Nail +23 nail plate	Tibial	Plateau Schatzker type IV	Fixator	Plate	23	2C	Joint injury LPSN palsy Infection Amputation	Poor	8

VA: vehicle accident; LPSN: lateral popliteal sciatic nerve; MPSN: medial popliteal sciatic nerve; ARF: acute renal failure; PCL: posterior cruciate ligament; F: female; LM: lateral meniscus; ARDS: adult r respiratory distress syndrome; M: male.

(femoral fractures: 2 grade II and one grade I according to Gustilo-Anderson; tibial fractures: one grade IIIA, 3 grade II and 3 grade I on the same classification).

In all cases we recorded data on any associated injury and found 7 instances of head and neck trauma of varying degrees of severity, 7 cases of thoracic trauma and 2 cases of abdominal trauma (one splenic rupture and one bowel perforation), two cases of adult respiratory distress syndrome, one case of fat embolism and one of acute renal failure. In addition, there were 17 associated fractures, the most usual ones located in the contralateral lower limb (4 cases), the forearm and the pelvis (3 cases each). Neurovascular lesions of the involved knee are relatively common. In our series we had two instances of artery ruptures, which required the performance of an arterial *by-pass* surgery, and 7 neurologic lesions (2 lateral popliteal sciatic nerve [LPSN] neuropraxias, 3 complete LPSN palsies and one sciatic nerve palsy).

Of the 17 patients included in the study 15 could be clinically examined after a mean of 50 months (12-70). The two remaining cases were not reviewed because of the death of one of them and the relocation of the other to another province. These 15 patients were assessed by a single author by means of Karlström and Olerud's scale[3]. This classification (table 1) takes into account the symptoms in the thigh, the leg, the knee and the ankle, the ability to ambulate, the patients' return to their previous work and to sports activities as well as any deformity, shortening and limitations to motion. Each of these criteria is rated as excellent, good, fair or poor. The mere presence of one poor result under any of the headings above causes the overall result to be rated as poor.

In all cases, we considered the treatment applied on arrival at the hospital in order to stabilize the fractures as well as the definitive treatment administered. We also studied

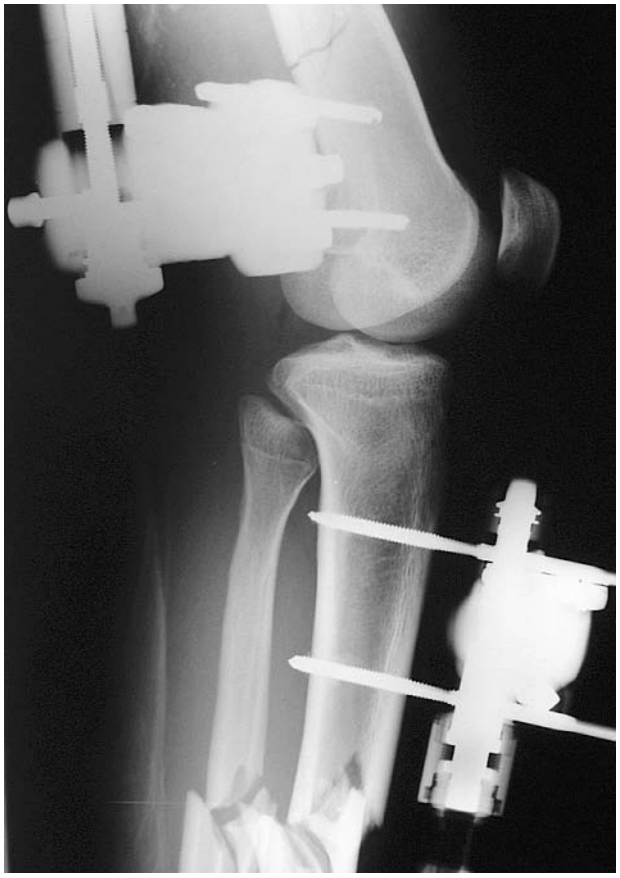

Figure 2. *Case 2 in our series. Stabilization of a floating knee by means of 2 external fixators. The patient presented with an open tibial fracture and a lesion in the femoral artery. This method of initial stabilization was chosen as the most appropriate solution.*

the time elapsed between admission and definitive treatment. An evaluation was also made of the seriousness of the patient's condition using the ISS score (*Injury Severity Score*)[4] (table 2).

In the case of femoral fractures, emergency treatment (fig. 2) consisted in transskeletal traction in 12 cases, 2 external fixation procedures, one plate and screw osteosynthesis and one plaster cast immobilization; one patient died before he could be stabilized. As regards the tibia, 7 fractures were immobilized with a plaster cast, 5 with external fixators, in 3 cases an intramedullary nail was placed initially and one case was treated with calcaneal traction and the patient who died received no tibial stabilization. Interestingly, in only 8 of the 34 fractures was the treatment initially applied also the definitive treatment of those injuries.

Alter a stabilization phase, considering that a substantial portion of the patients were severe multiple-trauma patients at high vital risk, permanent treatment was implemented (fig. 3), which in the case of the femur consisted in 11 intramedullary nail fixations, 3 plate osteosyntheses and one interfragmentary screw fixation (an intercondylar joint fracture). Of the 11 cases of nail fixation, 10 were antegrade and one retrograde, the nail types used being 5 AO, 5 UFN and one DFN nails.

Definitive treatment of the tibial fracture was intramedullary mailing in 7 cases, plate osteosynthesis in 3, in 2 cases the external fixator was retained as permanent treatment, 2 undisplaced fractures were treated orthopedically and one tibial plateau fracture was treated with 3 interfragmentary screws.

Seven cases were operated on for both fractures in the same surgical procedure, one of these was an emergency case and the remainder were handled electively. Mean time elapsed before definitive treatment was 12.3 days for the femoral fracture and 16.9 days for the tibial one. Twenty-one reoperations were performed in 10 of the 15 patients with a long follow-up, with the most frequent surgery being hardware extraction (11 cases) and nail dynamization (on 5 occasions). Mean hospital stay was 39.2 days (range: 9-125).

RESULTS

Our study contained no excellent results according to Karlström and Olerud's scale[3]; 5 results were good (33%), 4 fair (27%) and 6 poor (40%).

Figure 3. *Case 1 in our series. Definitive treatment of a floating knee patient by nailing both fractures. The tibial nailing was performed in the first few hours and the femoral nailing was deferred 6 days given the degree of instability shown by the patient. The clinical result was fair according to Karlström and Olerud's scale[3].*

We observed leg length discrepancies in 9 of the 14 patients evaluated (without considering the patient who had his limb amputated), with a mean discrepancy of 1.4 cm. Seven of these patients presented with some degree of deformity of angulation in the limb, but in only two did the deformity exceed 10º in any of the axes of the limb. As regards knee range of motion, patients had a 7º extension lag and 121º flexion. 67% of patients reported some degree of residual pain in the affected limb.

Associated complications were severe and frequent, including one early death.

Two cases of severe infection were diagnosed. The first of them had chronic *Staphylococcus aureus* osteomyelitis in the tibia as a result of an open fracture; the condition is currently being treated with suppressive therapy with oral levofloxacin because the patient rejects surgical treatment. The second case arose following popliteal artery reconstruction; infection resulting from *Aeromonas* sp. was detected, which eventually led to the limb being amputated.

One patient developed fat embolism, which was diagnosed in the course of the emergency operation. Surgery had to be suspended and postponed 29 days.

There were 2 instances of artery ruptures, one in the femoral artery and the other in the popliteal artery (fig. 4); both required a by-pass procedure. The first one resolved uneventfully but the second developed distal hypoperfusion that caused the limb to become infected. In 4 cases there was complete nerve palsy (3 palsies of the lateral popliteal sciatic nerve and one of the common sciatic nerve).

In one case, a compartmental syndrome in the deep posterior tibial compartment was diagnosed that required the performance of fasciotomies.

Three cases of pseudoarthrosis were diagnosed in 2 patients. The patient who developed pseudoartrosis of both fractures presented with 2 (Fraser type II) diaphyseal fractures and had been treated initially with undreamed nailing of both bones; pseudoarthrosis was satisfactorily addressed by subjecting both fractures to a reamed nailing procedure in 2 surgical stages, without having to open the fracture site. The other patient developed femoral pseudoarthrosis following a comminuted diaphyseal fracture; the nonunion was treated by means of osteosynthesis with a compressive AO plate and autologous grafting.

Figure 4. *Case 15 in our series. Arteriography of a patient with floating knee and an arterial lesion at the level of the popliteal artery. The patient was initially stabilized with an external fixator and then was subjected to an arterial by-pass procedure. He subsequently suffered an infection which required a transtibial amputation of the affected limb.*

DISCUSSION

The combination of ipsilateral femoral and tibial fractures constitutes a severe instance of trauma that often involves other vital organs and is associated to abundant musculoskeletal lesions. The incidence of associated life-threatening lesions has been estimated at up to 74%[2,5], with the severity of these associated lesions being reflected by the mortality rate, which varies between 5 and 15%.

Patients with an ipsilateral femoral and tibial fracture are usually multiple-trauma individuals and are often characterized by more severe injuries than those presenting with isolated femoral or tibial fractures. In some series, up to 62%[5] of patients present with severe trauma in the head, the trunk or the limbs. The most frequent associated lesions are head and neck trauma (27% of cases[2]), pelvic fractures (15% of patients) and thoracic trauma (10%). The incidence of fat embolism, more frequent in diaphyseal than in articular fractures[7], ranges between 9 and 20%[6].

Vascular lesions have been reported in the floating knee of 5 to 29%[5] of patients, with the posterior tibial and popliteal arteries being the most severely affected (fig. 2). Vascular lesions are most often associated with intraarticular fractures[8]. Artery lesions are one of the factors leading to the high amputation rate in these patients. The most usually involved peripheral nerves are the lateral popliteal sciatic nerve and, to a lesser extent, the common peroneal portion of the sciatic nerve[9]. This is often the result of a neuropraxia, which tends to resolve spontaneously. Cases of irreversible lesions with permanent sequelae are rare.

The high energy involved in these fractures tends to cause serious lesions to the soft tissues, with a high incidence of open fractures (much higher than in the series of isolated femoral or tibial fractures). Between 58 and 81%[5,6] of these fractures are open, especially tibial fractures.

The few studies published on this kind of injury generally include a limited amount of cases affected by heterogeneous lesions collected over a long period of time. For that reason, there is still controversy as to when the procedure

must be performed and what surgical technique must be used. Treatment of these fractures includes such diverse techniques as closed reduction followed by a plaster cast, skeletal traction, internal fixation and external fixation, both in the femur and the tibia. It has been shown[6,10,11] that the patients operated on for both fractures, who were initially considered to have a worse prognosis, presented with better final results, fewer complications and reoperations (without considering the extraction of the hardware), shorter hospitalization and a faster return to normal activity.

Advances in surgical techniques have exerted a decisive influence on the management of these fractures. The use of retrograde femoral nails permits to simultaneously treat both fractures through a single incision. Several authors[12,13] have reported good results with retrograde femoral and antegrade tibial nailing. The use of a single incision could reduce OR time and trauma associated with surgery, mainly in cases where the skin and soft tissues are significantly involved. The most recent series published in Spain[14,15] recommend that the mailing procedure should be carried out as promptly as possible, even in the case of open fractures.

The analysis of our cases reflects worryingly poor results as compared with those in the literature. This could be at least partly attributed to the severity of the cases reported in our series, since they include significant associated knee injuries, a very high rate of neurologic (6 of the 15 patients) and arterial (2 cases) lesions, infections and even one amputation. Table 3 shows a comparison of our results with another Spanish series[14] and with more recent series[12,13] that use a single incision; it also compares the initial severity of the different series (according to the ISS), as well as the percentage each one contains of articular and open fractures and of neurovascular lesions.

Another factor that could explain our poor results in the delay in performing the surgical procedure necessary to address the fractures (over 12 days for the femur and almost 17 for the tibia). This delay is clearly related to the poor health status of the patients, most of were admitted into the Intensive Care Unit on account of their life-threatening lesions. The mean score of our patients on the ISS[4] was 23 points, whereas other studies[12,13] report scores between 14 and 19 points. In spite of this, we consider it essential to make an effort in terms of promptly and permanently stabilizing these fractures as this will permit a more efficient management of multiple-trauma patients and prevent the appearance of multiple complications related to the presence of these fractures. Achieving this goal requires that the different departments involved in treating these severe lesions should work as a multidisciplinary team.

We were struck by the fact that, in our series, the values obtained for objective parameters like mobility, deformity and shortening are relatively good, whereas those for subjective criteria (pain and especially return to work) are worse. The fact that Karlström and Olerud's scale[3] considers only the poorest store in a given section could have overrated the significance of the poorer scores causing a deterioration of the overall results. This leads to the loss of a great proportion of the information obtained in each case, as well as to the potential underrating of some of the cases with good scores in all sections but one. For that reason, we propose turning Karlström and Olerud's scale into a quantitative scale that uses the same variables (table 4), but attributing each of them a numerical score. In this way, a scale between 0 and 100 points could be used, whereby scores above 80 points would be considered excellent, scores between 60 and 80 good, scores between 40 and 60 fair and scores lower than 40 poor. Using this pro-

Table 3. Comparison of different series as regards severity criteria and results

Series	% Fraser type 1	% Open	ISS	Vascular lesion	Neurologic lesion	Results
Our series	70%	47%	23	13%	27%	0% Excellent 33% Good 27% Fair 40% Poor
Ríos et al[14].	67%	57%	NA	5%	5%	10% Excellent 34% Good 38% Fair 19% Poor
Gregory et al[12]	100%	61%	14	NA	NA	65% Excellent or good 35% Fair 0% Poor
Ostrum et al13	100%	41%	19	5%	NA	88% Excellent or good 6% Fair 6% Poor

ISS: Injury Severity Score; NA: not available.

Table 4. Karlström and Olerud scale as modified by the authors of this study.
We suggests that this modified scale could be more realistic that the original one in terms of result assessment.

Criterion	Excellent		Good		Fair		Poor	
Symptoms in the thigh and the leg	0	15	Intermittent, mild	10	Affect function	5	Pain at rest	0
Symptoms in the knee And the ankle	0	15	Intermittent, mild	10	Affect function	5	Pain at rest	0
Ambulation	Normal	15	Intermittent, mild	0	↓distance covered	5	Crutches	0
Work and sports	Same	10	Less sport Same job	6	Changed jobs	3	Disability	0
Angulation and/or Rotational deformity	0	15	< 10°	10	10-20°	5	> 20°	0
Shortening	0	15	< 1 cm	10	1-3 cm	5	> 3 cm	0
BA (hip, knee or ankle)	0	15	< 10° T < 20° H and/or K	10 20	10-20° T 40° H and/or K	5	> 20° T > 40° H and/or K	0

H: hip; K: knee; A: ankle.

posed classification, our series would have obtained a mean of 59 points, with 6 excellent, one good, 3 fair and 5 poor results.

In summary, the floating knee is a severe injury that must be treated promptly by permanently fixating femoral and tibial fractures. Delay in achieving such stabilization considerably increases the possibility of a poor result. Finally, we suggest a new classification, based on Karlström and Olerud's scale, which provides a more realistic final assessment of results. It seems that, currently, the best treatment option for these injuries is early nailing of both fractures (antegrade for the tibia and retrograde for the femur).

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Conflict of interests

The authors have declared that they have no conflict of interests.