Rev Esp Cir Ortop Traumatol. 2018;62(6):393–400

Revista Española de Cirugía Ortopédica y Traumatología

www.elsevier.es/rot

ORIGINAL ARTICLE

Interimplant femoral fractures: Risk factors, treatment and evolution☆

D. Velasco Villa*, J. Mateo Negreira, Á. Los Santos Aransay, R. Castro Muñoz, L. Lanuza Lagunilla, P. Suárez-Anta Rodríguez

Departamento de Cirugía Ortopédica y Traumatología, Hospital Universitario de Cabueñes, Gijón, Asturias, Spain

Received 9 January 2018; accepted 26 June 2018

KEYWORDS
Femur;
Periprosthetic fractures;
Hip prosthesis;
Knee prosthesis

Abstract
Objective: The aim of this study is to determine the risk factors involved in the development of these fractures and analyze the treatments used as well as their influence on the clinical and functional prognosis of patients.
Materials and methods: We made an observational, retrospective case-control study, with a sample of 38 patients (40 femoral bones) operated in our hospital, who had two femoral ipsilateral implants, proximal and distal. We found 10 cases of interimplant fracture and 28 patients who had not suffered a fracture (2 of them had bilateral implants). We analysed the influence of different variables, such as age, gender, comorbidities, radiological variables, type of treatments employed, clinical evolution, etc.
Results: the female sex was predominant in both groups, 80.7 was the average age. Osteoporosis was statistically significant ($P = .007$) for the development of these fractures. We did not find statistical significance in the radiological variables. Surgical treatment was the most frequent, and the plate of osteosynthesis the most employed option. We found a death rate of 40% at 4 years. Although all fractures healed, the survivors' ambulation ability was reduced.
Conclusions: interimplant fractures are predominant in elderly women. Osteoporosis is a statistically significant risk factor. Despite optimal treatment and fracture healing, functional outcomes were decreased. Specific classification systems and therapeutic algorithms are necessary to improve the management and prognosis of these patients.

☆ Please cite this article as: Velasco Villa D, Mateo Negreira J, Los Santos Aransay Á, Castro Muñoz R, Lanuza Lagunilla L, Suárez-Anta Rodríguez P. Fracturas interimplante de fémur: factores de riesgo, tratamiento y evolución. Rev Esp Cir Ortop Traumatol. 2018;62:393–400.

* Corresponding author.
E-mail address: diego_velasco_villa@hotmail.com (D. Velasco Villa).

PALABRAS CLAVE
Fémur;
Fracturas periprotésicas;
Prótesis de cadera;
Prótesis de rodilla

Fracturas interimplante de fémur: factores de riesgo, tratamiento y evolución

Resumen
Objetivo: Determinar los factores de riesgo implicados en el desarrollo de las fracturas interimplante de fémur, analizar los tratamientos empleados en las mismas y su influencia en el pronóstico clínico y funcional de los pacientes.
Material y métodos: Estudio analítico, observacional, tipo casos y controles en una muestra de 38 pacientes (40 fémures) intervenidos en nuestro centro, con presencia de 2 implantes femorales ipsilaterales, proximal y distal. Se han registrado 10 casos de fractura interimplante frente a 28 pacientes sin fractura, y se ha analizado la influencia de diferentes variables, como la edad, el sexo, las comorbilidades, las variables radiológicas, los tipos de tratamiento empleados, la evolución, etc.
Resultados: El sexo femenino fue predominante en ambos grupos, con 80,7 años de edad media. La osteoporosis resultó estadísticamente significativa (p = 0,007) para el desarrollo de estas fracturas. Las variables radiológicas no mostraron significación estadística. El tratamiento quirúrgico fue el más habitual, siendo la osteosíntesis con placa la opción más utilizada. La mortalidad fue del 40% a los 4 años. Aunque todas las fracturas consolidaron, se objetivó un deterioro significativo en la deambulación en los supervivientes.
Conclusiones: Son fracturas predominantes en mujeres de edad avanzada. La osteoporosis constituye un factor de riesgo estadísticamente significativo. A pesar de un tratamiento óptimo y buena evolución de las fracturas se observó un deterioro en la capacidad funcional de los pacientes. Son necesarios sistemas de clasificación y algoritmos terapéuticos específicos que optimicen el manejo y pronóstico de estos pacientes.

Introduction

Interprosthetic femoral fractures are produced between 2 ipsilateral prostheses, such as the stem of a proximal hip prosthesis and a knee prosthesis with or without distal femoral shaft. In spite of the fact that this is usually the most common combination, we can include any other type of femoral prostheses, such as anterograde or retrograde osteosynthesis plates or nails.

These fractures are erroneously considered to be knee or hip periprostheses depending on their proximity to one of the prostheses. However, they present a series of distinguishing characteristics. Examples are the modification of basal anatomy, lack of bone stock, development of osteolysis and the biomechanical demands stemming from the existence of both prostheses in the same femur.[1]

The risk factors can be considered similar to those of periprosthetic fractures, depending on the patient (comorbidities, rheumatisms, steroid therapy and osteoporosis), the prosthesis (design, loosening, infection and other complications) and the surgical technique (poor alignment, cementation or not, osteolysis and surgeon experience).[2]

The true incidence of these fractures is unknown, because many times there is no correct classification and the series published refer to a limited number of patients. Kenny, in his study published en 1998,[3] found an incidence of 1.25% for interprosthetic fractures. In the next few years, this is expected to rise in proportion to the growth in life expectancy and quality of life, with patients whose functional demands become higher and higher; this in turn conditions an increase in the number of femoral prosthetic surgery and, accordingly, of possible subsequent periprosthetic fractures.[4,5]

There are no specific and validated treatment systems or algorithms for classifying such fractures. They are normally classified using typical systems for knee or hip periprosthetic fractures (Vancouver, Rorabeck and Lewis, Su). Few authors have attempted to develop a system or modify existing ones to make them valid for this type of fractures.

They represent characteristic injuries in elderly patients (who normally show multiple pathologies), which are principally caused by low-energy trauma and whose treatment poses biological and mechanical problems.[5] Adding the scarcity of conclusive studies on their classification and prognostic-treatment algorithms makes these fractures an authentic challenge.

The main objectives of our study were to determine the risk factors that predispose to this type of fractures and to analyse the indication and suitability of the treatments used, as well as their impact on the clinical and functional prognosis of these patients.

Material and methods

All patients having femoral prosthetic surgery in our centre during an 8-year period, between 2008 and 2016, were reviewed, selecting those who had 2 ipsilateral prostheses, proximal and distal. The selection was carried out by analysing the arthroplasty and fracture lists (prepared by our hospital's codification services in that time period), yielding a total of 1440 knee prostheses, 2389 hip prostheses and

Figure 1 Radiological measurements at the level of the distal end of the proximal prosthesis. Diameter of the femoral canal = 39.2 mm, diameter of the medullary canal = 16.2 mm, cortical diameter = 11.5 mm.

2990 hip fractures. We obtained 40 femora from 38 patients (2 patients were operated bilaterally), consisting of 10 cases of interprosthetic fracture and 30 without a fracture.

We designed a retrospective case-control study, using different types of variables: demographic (age, gender, laterality), associated comorbidities such as chronic corticosteroid treatment, rheumatological diseases and osteoporosis (prior diagnosis in the clinical history or established antiresorptive therapy), prosthesis types and most common combinations (partial or total hip prosthesis, long or short proximal intramedullary nails, primary or revision knee prosthesis, retrograde intramedullary nail, distal femur locking plate), time since fracture appearance and prosthesis insertion, reason for prosthesis (fracture, osteoarthritis, avascular necrosis), presence of cement and mortality.

To study the radiological variables, simple x-rays in lateral and anteroposterior (AP) views were reviewed. Using an x-ray image viewing software (Agfa IMPAX, version 6.3.1.4095), different measurements were taken, such as femoral diameter, medullary canal diameter, cortical thickness and the distance between prostheses (all of them in millimetres). These measurements were always done in AP view at the level of the distal end of the proximal prosthesis (Fig. 1). The statistical method used was logistic regression analysis, establishing a 95% confidence interval (CI) and accepting statistical significance as $P < .05$.

In the group of cases, the fractures were classified using the systems by Vancouver (validated for periprosthetic hip fractures) and by Rorabeck and Su (for periprosthetic knee fractures). We also used the system proposed by Platzer in 2011 (based on fracture contact with the prostheses), establishing 3 types of fracture: type I, lacking contact with any prosthesis; type II if there is contact with 1 of the prostheses; and type III if there is contact with both prostheses. In addition, 3 subtypes were established according to component

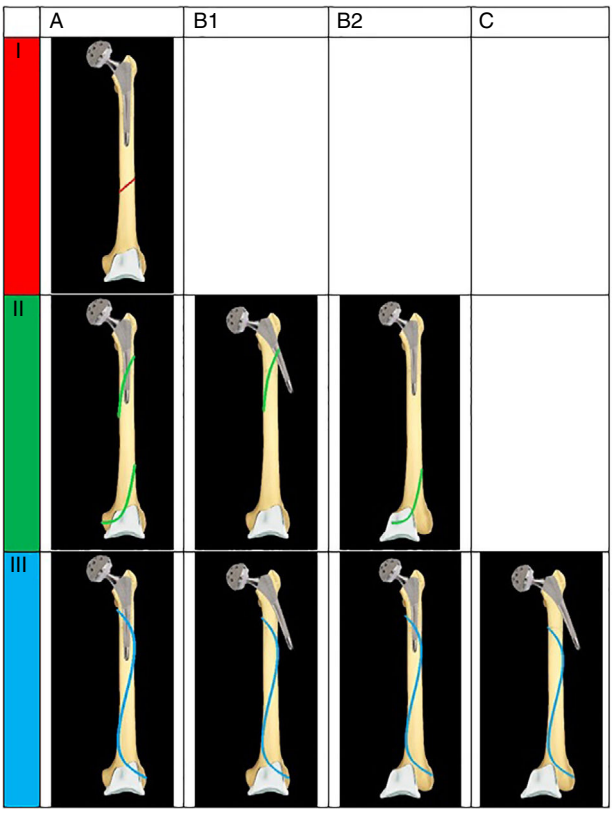

Figure 2 Classification system of interprosthetic fractures according to Platzer.

stability: subtype A, when both components remain stable; subtype B, if one of the components is loose, whether the hip (B1) or the knee (B2); and type C, when both components are loose (Fig. 2).[6]

Patient anaesthetic risk was recorded using the American Society of Anesthesiologists (ASA) classification, as well as the different types of treatment used for the fractures (orthopaedic, osteosynthesis with intramedullary plate or nail, revision surgery or a combination of the aforementioned treatments). We also established these patients' functional deterioration comparing mobility ability to walk before and after treatment, according to whether it was nonexistent, dependent with the help of a cane, dependent with the help of 2 canes or a walker, or independent. To determine fracture consolidation, the principles used by Albareda[5] were followed; it was considered clinical consolidation when the patient was capable of painless walking, and radiological consolidation when the fracture callus was seen in 2 views.

Results

The 2 groups were demographically similar. Mean age in the cases was 81.9 (range, 74–90) years, with predominance of females (8/10) and of the left side (6/10). The control group had a mean age of 79.5 (64–95) years and a larger proportion of women (20/28) and of prostheses located on the left side (16/28).

As for the types of prosthesis used, the most frequent combination in both groups was partial or total proximal hip

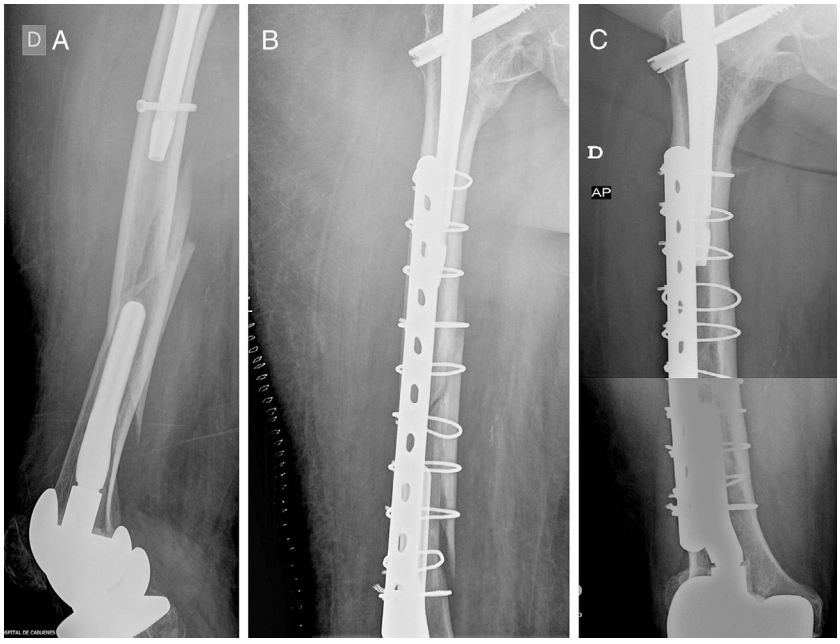

Figure 3 Clinical case. (A) Interprosthetic femoral fracture in an 81-year-old female with a proximal intramedullary nail and a revision knee prosthesis. Platzer type IIA. (B) Treatment using a osteosynthesis plate with cerclage wires bridging both prostheses. (C) Result at 2 years after fracture, showing radiological consolidation.

arthroplasty and primary distal knee arthroplasty (8/10 in the cases and 18/28 in the controls). The other 2 cases were 1 patient with a hip arthroplasty and a revision knee prosthesis, and 1 individual with a proximal intramedullary nail and a revision knee prosthesis (Fig. 3A). Among the control patients, 10 presented intramedullary nails combined with primary knee prostheses, 7 of them proximal and 3 long; in addition, 1 patient with a proximal intramedullary nail and distal revision prosthesis was found.

In the controls, the mean time between the initial prosthetic surgery and the end of follow-up was 8.81 years for the hip prosthesis, and 7.35 years for the knee prosthesis. In the cases, the mean time since prosthesis insertion until the appearance of the fracture was slightly less, with 7.23 years for the proximal prosthesis and 5.85 years for the distal prosthesis. That is, the cases presented a shorter evolution time since the insertion of their prostheses. However, the time of exposition in which the patient has both prostheses simultaneously was greater in the cases (2.83) than in the controls (1.42).

The most common reason for insertion of proximal prostheses was different in the 2 groups: 7 of the cases were operated for degenerative arthropathy, while in the controls, 15 were operated for hip fracture, 12 for degenerative osteoarthritis of the hip joint and 1 for avascular necrosis. At the distal level, all individuals were operated for gonarthrosis.

At least 1 cemented prostheses in all the patients was found; the knee prosthesis was the most common. In the cases, distal cement predominated (7/10), with 1 case of proximal cement and 2 cases of cement in both prostheses. As for the controls, 21 patients presented distal cement, 1 patient presented solely proximal cement and 7 patients had both prostheses cemented.

With respect to the comorbidities studied as likely risk factors for developing these fractures, osteoporosis was present in 80% of the cases, with a crude odds ratio of 11 and of 19.3 adjusted for age and sex, which was statistically significant ($P = .007$); no other comorbidity (rheumatological diseases, steroid therapy) was statistically significant. In the controls, 8 patients had a diagnosis of osteoporosis, 2 patients presented rheumatological diseases, and 1 was given steroid therapy; however, the most frequent result was not finding any associated comorbidities (17/28).

The measurements for the radiological variables were very similar in the two groups. Femur diameter was slightly larger in the controls, with a mean of 34.72 mm, while the mean was 32.98 mm in the cases. As for the femoral canal diameter, both groups revealed similar measurements, with means of 16.13 mm and 16.96 mm in the cases and in the controls, respectively.

Mean cortical distance was also comparable in the 2 groups, with 8.42 mm in the cases and 8.88 mm in the controls.

There was a greater difference in the 2 groups in the value of the distance between both prostheses. In the cases, the mean was 197.63 (107.7–279.6 mm). In the controls, this mean distance was 177.08 (0–251.7 mm). The value 0 corresponded to a case of overlapping between the prostheses in the controls, with the presence of a total knee prosthesis and a long intramedullary nail that extended beyond the superior border of the femoral component of the prosthesis. None of the radiological variables studied yielded statistically significant differences.

As for the fracture types, according to the Vancouver classification, 5 of them were type C and 3 were type B1. One type B2 fracture and 1 case of type B3 were found. Classified according to Rorabeck and Lewis, 6 fractures were type

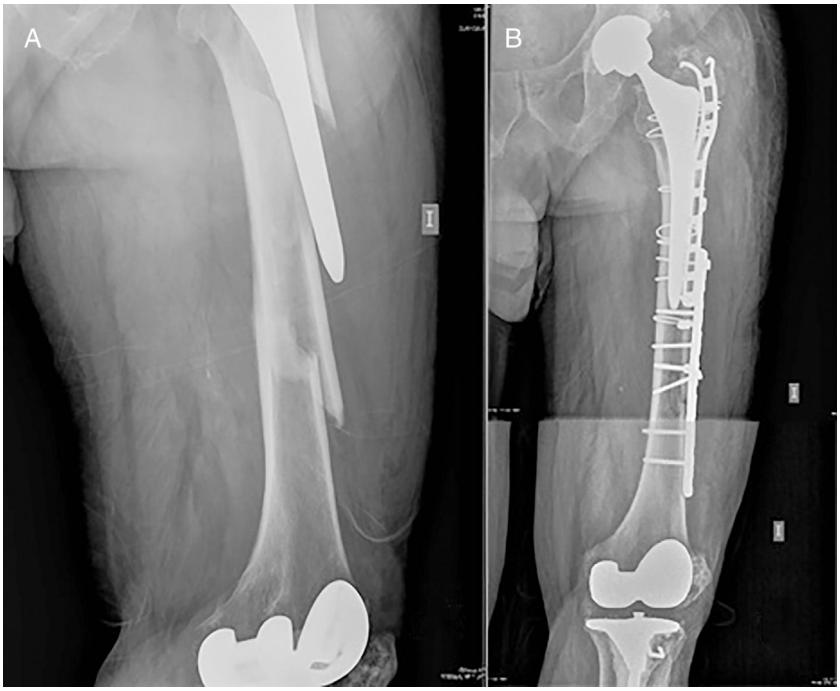

Figure 4 Clinical case. (A) Interprosthetic femoral fracture in a 74-year-old male that had a total hip and a total knee prostheses. Platzer type IIB1. (B) Final result of the treatment of the previously-mentioned fracture using double plate osteosynthesis, attempting to increase unit stability given the comminution at the fracture site.

I and 4 were type II. No loose distal component was found. Finally, with the Su classification, 5 fractures were type I, 3 were type III and 2 were type II.

Using the system proposed by Platzer, we found 8 cases of type IIA fractures (adjacent to 1 of the prostheses, with prosthetic stability) (Fig. 3A). We also found 2 cases of type IIB1 fracture (loose hip prosthesis) (Fig. 4A).

Reviewing the anaesthetic risk of these patients revealed that 6 of them were ASA III, with a moderate anaesthetic risk, 2 were ASA IV and 1 was ASA II.

As for types of treatment, 8 patients were treated surgically. Of the 2 patients not operated, 1 died during admission and other chose the option of conservative treatment, due to the patient's poor basal condition and to the benign nature of the fracture (simple, nondisplaced). Of the patients operated, 5 were treated with lateral plate osteosynthesis (Fig. 4B), using cerclage with intramedullary prostheses (Fig. 3B). One of the cases was treated by retrograde intramedullary nail, another by revision hip surgery and the other underwent revision hip surgery with insertion of an additional plate.

Focusing on the functional capability of these patients, 5 of them were independently mobilised before their fracture. Two patients walked helped by 2 canes, 1 used only a cane, and another patient relied on a walker. One case was limited to bed-armchair life. Following fracture treatment, just 1 of the patients managed to walk independently; the rest needed some type of help (canes or walker). Radiological consolidation was found in 7 of the 10 patients (Fig. 3C), with a mean radiological follow-up of 15.6 months.

Mortality in this study was high, with 4 deaths. One of the patients died before operation and the rest, during follow-up: 2 patients at 3 years and the last at 4 years after the fracture.

Table 1 presents the most relevant data corresponding to the case group.

Discussion

The true incidence of interprosthetic femoral fractures is unknown, probably because they are underdiagnosed due to the fact that they normally considered periprosthetic fractures of the hip or knee (depending on the closest prosthesis). According to Hou et al.,[7] the incidence of periprosthetic hip fractures is approximately 0.1–6%, while that of the knee ranges from 0.3% to 5.5%. In the study by Kenny et al.,[3] 4 interprosthetic fractures were found in a series of 320 patients, which represents an incidence of 1.25% of the femoral fractures. In our study, 10 fractures of this type have been found in a sample of 38 patients (40 femora), yielding an incidence of 25% in 8 years.

Solarino et al.[2] consider that the presence of a proximal prosthesis increases by 30% the risk of fracture if there is a fall from the height of the patient him- or herself. This risk rises with half the energy if there is another ipsilateral prosthesis.

One of the problems posed in approaching this type of fractures is the limited number of references in the literature, with a lack of classification systems and specific, valid treatment algorithms. The systems traditionally used for periprosthetic hip or knee fractures do not take into consideration whether there is another prosthesis in the same femur, a condition that modifies the basal characteristics and places us in a new landscape. Some authors

Table 1 Case data.

Case No.	Sex	Age	Comorbidities	Prostheses	Motive	Interprosthetic distance (mm)	Cortical thickness (mm)	Platzer type	Treatment
1	M	83	Osteoporosis	HP + TKP	Osteoarthritis	180.6	7.3	IIB1	HRS + plate
2	F	74	Osteoporosis	HP + RKP	Osteoarthritis	214.1	11.5	IIB1	Double plate
3	F	83	Corticosteroids	HP + TKP	Osteoarthritis	279.6	10.05	IIA	(Preop. demise)
4	M	78	Osteoporosis	HP + TKP	Osteoarthritis	221	8.6	IIA	Plate
5	M	90	Osteoporosis	HP + TKP	Fracture	193	7.6	IIA	Orthopaedic
6	M	81	Osteoporosis	HP + TKP	Fracture	181.9	5.2	IIA	Plate
7	M	80	Osteoporosis	IMN + RKP	Fracture	107.7	9.35	IIA	Plate
8	M	85	Osteoporosis	HP + TKP	Osteoarthritis	233.6	7.3	IIA	SCN
9	M	79	Corticosteroids	HP + TKP	Osteoarthritis	190.4	7.55	IIA	HRS
10	M	86	Osteoporosis	HP + TKP	Osteoarthritis	174.4	9.45	IIA	Plate

F: female; HP: total/partial hip prosthesis; HRS: hip revision surgery; IMN: intramedullary nailing; M: male; Preop.: preoperative; RKP: revision knee prosthesis; SCN: supracondylar nail; TKP: total knee prosthesis.

have attempted to solve this problem modifying the existing classification systems. Duncan and Haddad[8] added type D fractures to the Vancouver classification, to include those that occur between 2 prostheses in 2 adjacent joints. In 2011 Platzer et al.[6] proposed a prognostic-therapy method based on the contact between the fracture and the prostheses and on their stability, according to which the most appropriate type of treatment is recommended: in type A fractures, the treatment indicated is lateral plate osteosynthesis (cerclage wires can be added if there is comminution or a need for additional stability; in type B, revision surgery is necessary, using longer stems and even considering the use of allo- or autografts depending on bone stock or the support of other osteosynthesis methods; and in the rare cases in which a fracture type C fracture is produced, other options such as tumour or complete femur prostheses should be considered. Then, in 2014, Pires et al.[9] also published their own system, achieving moderate results in concordance and validity in their 2017 validation study.

These fractures can occur with any type of femoral prostheses, without there necessarily being prosthetic components. In fact, Lehman et al.,[4] in their study on cadaver femora, conclude that the risk of suffering this type of fracture is greater in the presence of a proximal hip stem and a distal intramedullary nail, while the risk does not increase when a femoral component of a knee prosthesis is involved. In our study, the most frequent prosthesis association was the stem of a hip prosthesis, together with the femoral component of a primary knee arthroplasty. However, we also found other types of prostheses, such as short and long proximal intramedullary nails, or stems from revision knee arthroplasties that formed various combinations. Precisely because the presence of some prostheses or others did not reveal statistically significant differences, the concept of interimplant femoral fracture should replace that of interprosthetic femoral fracture.

Degenerative arthropathy was the most common reason for insertion of the prostheses, both in the cases and globally. However, in the controls, the most habitual cause of initial prosthetic surgery was a fracture. At any rate, this fact was not statistically significant. Neither were the time since prosthesis insertion or time of exposition (which was slightly higher in the cases). Cement was evidenced in all the study patients; while it was most frequently found at the distal level, this fact was not statistically significant either.

Multiple factors have been studied with respect to the appearance of these fractures. However, solely osteoporosis yielded statistically significant results in all these studies, multiply the risk of suffering an interprosthetic fracture by 11. In their respective studies, Albareda and Iesaka[5–10] concluded that the influence of the level of osteoporosis, translated to the cortical thickness of the interprosthetic femoral segment, constitutes the most determining risk factor.

In our study, the radiological variables analysed were not statistically significant. Cortical thickness and femoral and canal diameters were similar in both groups, measured in the interprosthetic gap. The risk factor that achieves the best consensus in the bibliography is a reduced interprosthetic distance. According to Soenen,[11] interprosthetic distances less than 110 mm increase the risk of fracture, especially in osteoporotic bone. It seems that this is related to the accumulation of stress risers in that area, stresses that also depend on the stability of the prostheses and on cortical thickness. According to Iesaka,[10] cortical thickness is a factor of great importance for the development of these stresses. In our study, all the patients had interprosthetic distances longer than 110 mm, except for 1 case of overlapping in the control group (long proximal intramedullary nail and primary knee prosthesis); in contrast to what would be expected based on what has previously been mentioned, our mean interprosthetic gap was greater in the cases than in the controls. In their respective studies, Valle Cruz and Mamczak[1–12] concluded that, in addition to the distance between both prostheses, the location of the interprosthetic gap is a determining factor; they stated that fracture risk grows as this segment is located more distally, due to the relative decrease in cortical thickness compared to the width of the medullary canal in the distal third of the femur. In fact, in our study the majority of the fractures were located at the level of the supracondylar area, distal to the proximal component and closely related to the knee prosthesis. Prosthetic loosening of the hip prosthesis was found in only 2 cases.

After classifying the fractures following the system proposed by Platzer,[6] the types of treatment used to analyse concordance with the treatment algorithm suggested by that author could be observed. It turned out that, in the type IIA fractures, lateral locking plate osteosynthesis was the treatment most often used. The only exceptions were 1 case treated using retrograde intramedullary nail and 2 nonoperated cases (1 because the patient died during admission and 1 because the patient was not a candidate for surgical treatment, given his basal characteristics and those of the fracture itself). When a loose prosthetic was evidenced, the treatment chosen was replacement surgery, requiring a bone graft and 2 additional osteosynthesis plates in 1 case. Focusing on the literature on this, we can consider that these therapeutic indications have, in general, been the best. In a systematic review of 15 articles about interprosthetic femoral fractures, Solarino et al.[2] concluded that plate osteosynthesis is the most appropriate treatment in the case of stability of the prostheses, as long as the stem is overlapped by twice the shaft diameter. For cases of loosening, these authors recommend prosthesis replacement surgery; if there is an important loss of bone stock, they consider that using grafts (preferably autografts) increases the possibility of consolidation and reduces the risk of refracture. For Hou,[7] locking plate osteosynthesis is a very good option, both mechanically and biologically, especially in osteoporotic bone, as long as the stem overlaps a distance equal to 2 diameters from the femoral canal. Hoffmann[13] also concluded that the locking plate is a reliable method for these fractures, respecting soft tissue damage by submuscular plate insertion. According to Liporace,[14] the most appropriate system, biomechanically speaking, is one that achieves a balanced stress distribution all along the femoral axis, with proper axial and rotational stability; such stability is achieved by overlapping the prostheses and linking the concomitant systems, spanning the entire bone length. As for the use of other osteosynthesis methods, such as cerclage, authors such as Albareda[5] feel that they should not be the main fixation system, but should rather be used as a complement to increase the stability of the unit.

At any rate, it seems clear that the main objective of treatment should be early mobilisation of the patients, as prolonged immobilisation increases mortality considerably in the elderly. In our study, the death rate was approximately 40% in a sample of patients with multiple pathologies basally, involving an important anaesthetic risk. In terms of functional prognosis, Sah[15] found functional results similar to preoperative mobility status after treating 22 consecutive interprosthetic fractures using locking plate. We observed a generalised deterioration in mobility capability after surgery, in spite of the fact (as stated earlier) that the treatments applied were correct and fracture consolidation was optimal in all surviving patients.

This study has some important limitations, such as its retrospective nature and the lack of uniformity in the series treatments. Another weak point to remember is the limited number of fractures, which can condition obtaining results that are difficult to understand, such as the fact that the interprosthetic distance was greater in the cases than in the controls, and that the main motive for initial prosthetic surgery in the cases was degenerative osteoarthritis of the hip joint, with hip fractures being more frequent in the controls. Finally, using walking ability as the main functional parameter, without other objective scales or tests, might be an imprecise criterion for establishing the clinical prognosis of the patients.

Conclusions

Interprosthetic femoral fractures are more prevalent in elderly women. Osteoporosis is the only statistically significant risk factor. Such fractures have high mortality rates due to the seriousness of the fracture, the fragility of patients with multiple base pathologies and the aggressiveness of the surgery in a population at high surgical risk.

Despite high consolidation rates and treatment considered appropriate according to current literature, a deterioration in general function (understood in terms of reduced walking ability) can be seen.

Specific, valid classification systems and treatment algorithms are needed to make it possible to optimise patient management patients and improve the prognosis of lifespan and functionality of interprosthetic femoral fractures.

Level of evidence

Level of evidence III.

Conflict of interests

The authors have no conflicts of interest to declare.

References

1. Valle Cruz JA, Urda AL, Serrano L, Rodriguez-Gonzalez FA, Otero J, Moro E, et al. Incidence of and risk factors for femoral fractures in the gap between hip and knee implants. Int Orthop. 2016;40:1697–702, http://dx.doi.org/10.1007/s00264-015-2978-1.
2. Solarino G, Vicenti G, Moretti L, Abate A, Spinarelli A, Moretti B. Interprosthetic femoral fractures—a challenge of treatment. A systematic review of the literature. Injury. 2014;45:362–8, http://dx.doi.org/10.1016/j.injury.2013.09.028.
3. Kenny P, Rice J, Quinlan W. Interprosthetic fracture of the femoral shaft. J Arthroplasty. 1998;13:361–4, http://dx.sdoi.org/10.1016/S0883-5403(98)90187-5.
4. Lehmann W, Rupprecht M, Nuechtern J, Melzner D, Sellenschloh K, Kolb J, et al. What is the risk of stress risers for interprosthetic fractures of the femur? A biomechanical analysis. Int Orthop. 2012;36:2441–6, http://dx.doi.org/10.1007/s00264-012-1697-0.
5. Albareda J, Gómez J, Ezquerra L, Blanco N. Fracturas interprotésicas femorales. Tratamiento con placa lateral de estabilidad angular. Rev Esp Cir Ortop Traumatol. 2017;61:1–7, http://dx.doi.org/10.1016/j.recot.2016.09.002.
6. Platzer P, Schuster R, Luxl M, Widhalm HK, Eipeldauer S, Krusche-Mandl I, et al. Management and outcome of interprosthetic femoral fractures. Injury. 2011;42:1219–25, http://dx.doi.org/10.1016/j.injury.2010.08.020.
7. Hou Z, Moore B, Bowen TR, Irgit K, Matzko ME, Strohecker KA, et al. Treatment of interprosthetic fractures of the femur. J Trauma. 2011;71:1715–9, http://dx.doi.org/10.1097/TA.0b013e31821dd9f1.

8. Duncan CP, Haddad FS. The Unified Classification System (UCS): Improving our understanding of periprosthetic fractures. Bone Joint J. 2014;96-B:713–6, http://dx.doi.org/10.1302/0301-620X.96B6.34040.
9. Pires RES, Silveira MPS, Resende ARS, Junr EOS, Campos TVO, Santos LEN, et al. Validation of a new classification system for interprosthetic femoral fractures. Injury. 2017;48:1388–92, http://dx.doi.org/10.1016/j.injury.2017.04.008.
10. Iesaka K, Kummer FJ, di Cesare PE. Stress risers between two ipsilateral intramedullary stems. J Arthroplasty. 2005;20:386–91, http://dx.doi.org/10.1016/j.arth.2004.05.002.
11. Soenen M, Baracchi M, de Corte R, Labey L, Innocenti B. Stemmed TKA in a femur with a total hip arthroplasty. J Arthroplasty. 2013;28:1437–45, http://dx.doi.org/10.1016/j.arth.2013.01.010.
12. Mamczak CN, Gardner MJ, Bolhofner B, Borrelli J, Streubel PN, Ricci WM. Interprosthetic femoral fractures. J Orthop Trauma. 2010;24:740–4, http://dx.doi.org/10.1097/BOT.0b013e3181d73508.
13. Hoffmann MF, Lotzien S, Schildhauer TA. Clinical outcome of interprosthetic femoral fractures treated with polyaxial locking plates. Injury. 2016;47:934–8, http://dx.doi.org/10.1016/j.injury.2015.12.026.
14. Liporace FA, Yoon RS, Collinge CA. Interprosthetic and peri-implant fractures: principles of operative fixation and future directions. J Orthop Trauma. 2017;31:287–92, http://dx.doi.org/10.1097/BOT.0000000000000784.
15. Sah AP, Marshall A, Virkus WV, Estok DM, Della Valle CJ. Interprosthetic fractures of the femur. J Arthroplasty. 2010;25:280–6, http://dx.doi.org/10.1016/j.arth.2008.10.008.