RESEARCH ARTICLE

Injuries Associated with Femoral Shaft Fractures with Special Emphasis on Occult Injuries

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Abstract

Background: Fractures of the femoral shaft are mostly the result of high-energy accidents that also cause multiple trauma injuries, in particular ipsilateral knee and hip injuries.
The purpose of this study was to investigate the incidence of injuries associated with femoral shaft fractures and how many of them were undetected.

Methods: We studied 148 patients (150 femoral shaft fractures) with an average age of 52 (range: 18-97). Femoral shaft fractures were treated with antegrade intramedullary nailing in 118 cases (78.7%), and with open reduction and internal fixation in 32 cases (21.3%). Unlocked reamed intramedullary nailing was performed in Winquist type I and type II fractures, while statically locked unreamed intramedullary nailing was carried out in Winquist type III and type IV fractures.

Results: There were 70 patients with associated injuries (46.4%). The associated injuries went undetected in 18 out of 70 patients (25.5%). Six femoral nonunions (4%) occurred in patients under 70 years of age (high-energy accidents) treated by open reduction and internal fixation.

Conclusion: Injuries associated with femoral shaft fractures were very frequent (46.4%) in our series, with 25.5% undetected. Open reduction and internal fixation was a poor prognostic factor of nonunion in these fractures.

Keywords: Associated injuries, Diaphysis, Femur, Fracture, Treatment

Introduction

Diaphyseal femur fractures are mostly the result of high-energy trauma, for which reason they endanger life itself, account for important handicaps, and are usually associated with multilevel injuries. Their most frequent sequelae are limb shortening, poor alignment and stiffness in the knee (1-4).

The incidence of diaphyseal femur fractures ranges from 9.9 to 12 for every 100,000 persons/year: 60% occur in men and 40% in women. The average age is 25, with a maximum incidence peak among 15 and 24 years of age (1-4).The cause in the majority of cases is high-energy trauma, mainly traffic accidents (80-90%). The fractures caused by minor trauma occur in patients above 60 (1, 2). The considerable energy required to cause many of these fractures often also provoke injuries in other structures, above all in the ipsilateral hip and knee and they often go undiagnosed (1-4).

With respect to fracture type, numerous classifications exist in the literature on the subject, based on fracture location and geometry, comminution, the seriousness of injuries on soft tissue, and the absence of associated injuries. However, in practice, none of these classifications are broadly accepted.

The AO classification, which defines 27 diaphyseal femoral fracture patterns based on the location of the fracture (proximal, mid-shaft or distal), its anatomy (transverse or oblique) and the degree of comminution, does not have implications on therapy or prognosis.

However, the Winquist *et al* classification, based on degree of comminution, has therapeutic implications (5). Four types are defined: type I, with non-existent or minimal comminution; type II, with comminution of less than 50% of the circumference of the femoral shaft; type III, with comminution affecting 50-100% of the circumference of both major fragments; and type IV, with circumferential shaft comminution and no contact between the cortical parts of the larger fragments after reduction. Types I and II resist shortening and malrotation with a non-locking intramedullary nail, whereas types III and IV require a distal and proximal locking nail.

The purpose of this study is to identify the incidence of

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Table 1. Data collected in this series

Affiliation data, case number, age, sex and personal history
Fracture: date of fracture, type of fracture, type of treatment.
Complications:

- Delay of consolidation, nonunion, whether surgical treatment was necessary and what it consisted of.
- Infection, type of infection (surgical wound, depth, pin infections) and whether surgery was required.
- Defective consolidation: limb shortening, inward or outward angling, antecurvatum, recurvatum, rotation; and whether surgery was required.

Associated lesions:

- Fracture on another level of the ipsilateral limb.
- Soft tissue injuries in ipsilateral knee.
- Neurological or vascular injury in affected limb.
- Craneal trauma
- Pulmonary injury
- Other injuries

Missed / Not missed

injuries associated with diaphyseal femur fractures and how many of them are not detected.

Materials and Methods

This is a case series study for which the data were obtained by revising the clinical cases of diaphyseal femur fractures in patients above 18, who were admitted into "La Paz" University hospital in a 10-year period (2001-2010). Exclusion criteria were age under 18, periprosthetic fracture, and patient not admitted to the hospital. Table 1 shows the collected data.

The fractures in this study were defined according to fracture pattern (transverse, oblique, spiral, segmental or comminuted) and according to the Winquist *et al* classification (5).

The descriptive statistics of the samples were done using the SPSS version 13.0 analysis software program (SPSS Inc. Chicago, IL).

Table 2. Fracture types according to the classification of Winquist et al (5)

Fracture pattern		Winquinst & Hansen[5]	
Transverse	37 (24.3%)	Type I	89 (59.5%)
Oblique	26 (17.6%)	Type II	32 (21.6%)
Spiral	44 (29.7%)	Type III	20 (13.5%)
Butterfly	32 (21.6%)	Type IV	9 (5.4%)
Comminuted	5 (2.7%)		
Segmental	6 (4.1%)		

Table 3. Type of treatment of femoral fractures in this series

Treatment type	Total (N=150)
Antegrade intramedullary nail (Unlocked in Winquist and Hansen´s type I and type II fractures; statically locked proximally and distally in Winquist and Hansen´s type III and type IV fractures)	118 (78.7%)
Open reduction and internal fixation (Plate and screws)	32 (21.3%)

Table 4. Associated undetected injuries and the time of diagnosis

Associated injuries	N=70	Undetected (n=18; 12%)		
		Emergency	Post-Operative	Outpatient Clinic
Hip fracture	12			
Femoral neck	0			
Intertrochanteric	12	2	2	
Supracondylar femoral fracture	7			
Ipsilateral tibial plateau fracture	20	4		4
Patellar fracture	6	2	2	
ACL tear	4			2
Nerve injury	10			
Vascular injury	6			
Ipsilateral acetabular fracture	2			
Phalanx fracture	4			
Ipsilateral cuboid fracture	4			

Results

This study deals with 148 patients with diaphyseal femur fractures (150 fracture cases). Average age was 51.95 (range: 19-97, SDE 25.5). There were 86 males (58.1%) and 62 females (41.9%). There was high-energy traumatism in 68 of the cases (45.9%). We divided the patients into two age groups, under and over 70 In the under 70 age group we found 100 patients with an average age of 36.3 (age range: 19-68, SD 13.4), 78 male (78%) and 22 female (22%). Additionally, there were 68 patients with high-energy traumatisms (68%). In the over 70 age group, we found 48 patients with an average age of 84.54 (age range: 72-97, SD 6.6), eight male (16.7%) and 40 female (83.3%). There was no case of high-energy trauma. Fracture type and treatment are shown in Tables 2 and 3.

Antegrade implantation of an intramedullary nail was performed in 118 fractures (with the patient in the lateral position on a traction table), while 32 fractures were stabilized with open reduction and internal fixation (plate and screws).

With respect to the diagnosis of associated injuries, 70 patients suffered associated injuries (Table 4). In 18 patients (25.8 %) the injuries were not diagnosed initially. These were: eight injuries not diagnosed in emergency but diagnosed in the course of the operation (four tibial plateau fractures, two ipsilateral hip fractures and two fractures of the lower pole of the ipsilateral patella); four injuries were diagnosed during the immediate postoperative period (two fractures of the lower pole of the ipsilateral patella and two ipsilateral hip fractures); and six injuries were diagnosed during patient monitoring in the outward clinic (four ipsilateral tibial plateau fractures and two ACL tears). Fourteen of the 18 patients with missed injuries had suffered a high-energy trauma. Six femoral

Table 5. Hip fractures associated to diaphyseal femoral fractures

Laporte *et al* (6)	5.6%	All cases after high-energy traumatisms. One case was undetected (did not suffer avascular necrosis or nonunion). Affirms that priority should be given to the diaphyseal fracture.
Watson and Moed (7)	6-9% (femoral neck)	
Casey and Chapman (8)	73 patients	All cases of non-union or avascular necrosis occurred in patients with delayed diagnoses and treatment of the hip fracture
Wiss *et al* (9)	2.5-5% (femoral neck)	Describe 18% of cases with symptomatic nonunion of the hip fracture
Rockwood (10)		One third of hip fractures are not detected initially. Priority should be given to the treatment of the hip fracture
Barquet *et al* (11)	13 patients (intertrochanteric)	Two cases were not detected
Current study	8%	83.3% in the context of high-energy traumatism. All cases in the intertrochanteric region

Table 6. Tibial plateau fractures associated to diaphyseal femoral fractures

Paul *et al* (12)	25 cases in five years (5 per year)
Elmrini *et al* (13)	18 cases in eight years (2.2 per year)
Schiedts (14)	24 cases in five years (4.8 per year)
Gregory *et al* (15)	47 cases in six years (7.8 per year)
Current study	20 cases in 10 years (2 per year)

Table 7. Percentage of ACL tears associated to diaphyseal femoral fractures

Walling *et al* (16)	33%
Moore *et al* (17)	5.3%
Szalay *et al* (18)	11%
Lakshman and Scotland (19)	52.3%
Walker and Kennedy (20)	48%
Current study	2.7%

Table 8. Mechanisms of nerve injuries in the context of diaphyseal femoral fractures

Mechanism of Nerve Injuries
Sciatic nerve: distension (excessive or prolonged traction)
Common peroneal nerve: compression (leg in external rotation in a patient wearing a plaster splint)
Femoral nerve / Pudendal nerve: compression by the perineal support of the traction table

nonunions (4%) occurred in patients under 70 years of age (high-energy accidents) who were treated by open reduction and internal fixation. We found 10 temporary nerve injuries (four of the sciatic nerve, six of the peroneal nerve) where in eight of them involved high-energy trauma.

Diaphyseal femur fractures are accompanied by femoral neck fractures in 2.5% to 9% of the cases, with approximately one-third of such cases remaining undiagnosed (Table 5). Moreover, ipsilateral fractures of the femur and tibia and tibial plateau fractures associated with diaphyseal femoral fractures are uncommon (Table 6). However, the frequency of knee laxity is at 53% (Table 7). Nerve injuries due to medical error may occur in the context of diaphyseal femur fractures (Table 8).

Considering the infrequency of ipsilateral fractures of the femur and tibia, three of the 10 cases from this series were late diagnoses (one in the intra-operative period and two in the monitoring of evolution during consultation). This

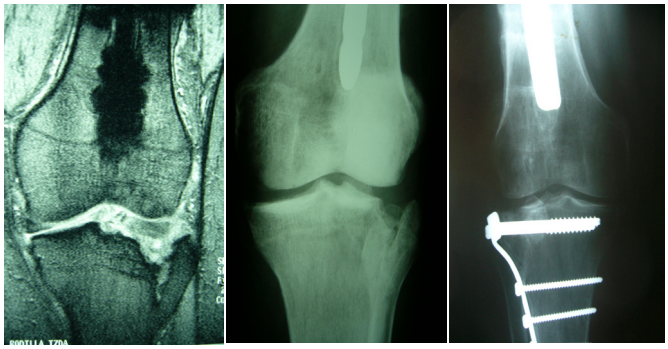

Figure 1. Patient with diaphyseal femoral fracture after a traffic accident. Six months later, after complaining from chronic knee pain, MRI of the ipsilateral knee was performed showing a fracture of the lateral tibial plateau (A). The fracture was treated with open reduction and internal fixation, with a satisfactory result (B, C: preoperative and postoperative x-rays).

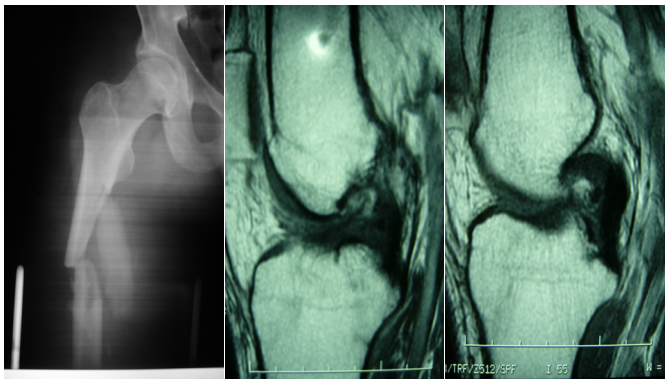

Figure 2. Patient with diaphyseal femoral fracture after a high-energy accident (A). Eight months after the fracture, ipsilateral knee MRI was performed when the patient complained of knee instability. The absence of ACL (B) could be observed, suggesting chronic tearing (C). A bone-tendon-bone ACL patellar tendon autograft reconstruction was performed 1 month after diagnosis of the ACL tear.

implies a very high associated missed tibia fracture rate, with the high probability that this rate is actually greater (Figure 1). There were two cases of ACL tear (2.7%) in our series, both after high-energy traumatisms (Figure 2).

Discussion

The treatment of choice for diaphyseal femur fractures is intramedullary nail stabilization, it achieves correct alignment and high rates of bone healing (95-99%), has a low incidence of complications and permits early limb mobility (21-23). Nonetheless, there are still some controversies with respect to diaphyseal femur fracture treatments. Also, since the mechanism causing the injuries in many cases is a high-energy accident, injuries associated with diaphyseal fractures are frequent.

The literature states that a diaphyseal femur fracture is accompanied by a femoral neck fracture in 2.5% to 9% of cases, with approximately one third of such cases remaining undiagnosed (6-12). In this series, all of the cases were fractures of the trochanteric region, with no femoral neck fracture having been diagnosed. In our series it is possible that either no femoral neck fracture associated with the diaphyseal fracture existed, or that the percentage of fracture undetected extended to 100% of the cases.

None of the ten cases of ipsilateral fracture of the femur and tibia in this series was associated with an ipsilateral knee injury, which is not consistent with the literature. Moreover, Schiedts states that knee instability is the main reason for the unsatisfactory results of his series (14). Thus, this under-diagnosis may imply significant prevalence.

Since the majority of diaphyseal femur fractures are caused by high-energy traumatisms, it is logical to think that knee ligaments may be injured due to their being subjected to great stress. In effect, the frequency of ipsilateral ACL knee lesions in a femur fracture varies between 5.3% and 48% in the literature and the frequency of knee laxity reaches up to 53%. There are two cases of ACL tear (2.7%) in our series, both after high-energy traumatisms. These two cases represent 2.7% of the patients, a percentage significantly lower than those in the literature.

The examination of the knee in the presence of a mobile fracture is difficult. De Campos *et al* examined the knees of 40 patients and conducted arthroscopy with closed diaphyseal femur fractures under anesthesia (24). More than half of the patients with significant arthroscopy findings showed effusion or laxity greater than degree I. This author recommends a high index of suspicion for injuries in the ipsilateral knee of femur fracture patients. Dickson *et al* give details of injuries found in the magnetic resonance of the ipsilateral knee during the first ten days after the fracture and related it to the discoveries of examination under anaesthesia, describing the sensitivity and specificity of the examination under anaesthesia for ACL, PCL, LCL and MCL lesions, respectively (25). They concluded that given a high index of suspicion, it is necessary to undertake an examination of the knee under anaesthesia, with magnetic resonance being indicated if the said examination is suggestive. In the histories of our patients, there is no record of any examination done under anaesthesia in the surgical protocol of the final treatment of the femur fracture, no exploratory arthroscopy and no MRI in the acute phase of the fracture. This, together with the low incidence of knee injuries in our series, leads us to think that perhaps there is under-diagnosis in our hospital with respect to these injuries.

Furthermore, injury of the superficial femoral artery in approximately 2% of diaphyseal femur fractures has been described (26). Isaacson *et al* described five vascular injuries associated with closed diaphyseal femur fractures (27). Barr *et al* stated that the delay in the diagnosis of these injuries led to unsatisfactory results in a group of young patients (26). They found 15% of the patients with significant hemodynamic abnormalities in the injured limb when their ankle/arm indices were subjected to Doppler measurements an average of 13 months after the fracture. There was one vascular injury in this series, which ended up in amputation.

Femoral and sciatic nerves are not usually injured in diaphyseal femur fractures and the majority of these injuries occur with penetrating traumatisms. Nonetheless, nerve injuries may occur during fracture treatments. The majority of these nerve injuries are temporary. Rockwood affirms that these injuries may be prevented by taking a series of measures: cushioning the plaster splint around the head of the fibula, revising the scrotum and groin of the patient after positioning the perineal support to see that this is not exerting excessive traction, using traction only when necessary, applying traction to a distal femur through a Steinmann pin in a way that permits knee flexion, or relaxing intraoperative traction once the pin has been put in place (10). We found 10 temporary nerve injuries (four of the sciatic nerve, six of the peroneal nerve). Eight of them involved high-energy traumatism.

In conclusion, injuries associated with diaphyseal femur fractures were very frequent (46.4%). In 25.5% of our cases that had associated injuries, these were not detected. It is necessary to pay special attention to the diagnosis of possible hip and tibial fractures and to possible ACL injuries in the ipsilateral knee. The six nonunions of this series (4%) occurred in high-energy femoral shaft fractures in patients younger than 70 years treated with open reduction and internal fixation.

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