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FRACTURES OF THE PROXIMAL END OF THE FEMUR: EXPLORATION OF TREATMENTS AND ASSESSMENT OF OUTCOMES

Algiounidis Ioannis[1,2], Alexandros Eleutheropoulos[3], Anestis Karanikolas[2], Leonard Gurgas[4], Aurora Craciun[4], Petru Bordei[1]

[1] Doctoral School of Medicine, University "Ovidius" of Constanta, Romania
[2] Kilkis General Hospital, Greece
[3] Naousa General Hospital, Greece
[4] Faculty of Medicine, University "Ovidius" of Constanta

Algionidis Ioannis

email: giannisalgiounid@gmail.com

ABSTRACT

Fractures of the proximal extremity of the femur are some of the most common injuries treated by orthopedic surgeons, often associated with life-threatening polytrauma. Trochanteric fractures have an increased incidence, which is becoming more common due to the aging population. Femoral neck fractures are a particular type of intracapsular hip fracture, and the location of the junction makes the femoral neck prone to fracture. Fractures of the femoral shaft are found in approximately 6-9% of cases of femoral neck fractures. The management of these fractures is interdisciplinary, but in most cases, it requires surgical treatment to allow rapid elevation and recovery of autonomy.

The present study is retrospective in which 140 cases of fracture of the upper femur extremity collected at the trauma department of Naousa and Kilkis Hospital over 4 years from December 2018 to December 2022 were analyzed, processed, and reviewed with a minimum follow-up of 6 months.

The purpose of this article is to analyze the frequency of various types of fractures of the proximal extremity of the femur and to identify the etiological factors that contribute to these injuries, thus providing a comprehensive understanding of these traumatic events to treat them.

The study showed that there is a preponderance of trochanteric fractures, with an increased frequency in the 75-89 age group and a predominance of femoral neck fractures in women, mainly caused by falls. External surgical approaches, standard gamma nail, and bipolar treatment had "excellent/good" functional results reflecting the success of the surgical interventions. The high frequency of anatomical reductions underlines the attention paid to the quality of the procedures.

Keywords: Trochanteric fractures, femoral neck fractures, femoral shaft fractures.

Introduction

Proximally, the femur is composed of a specialized metaphyseal region consisting of the head, neck, and greater and lesser trochanters (1). Fractures of the proximal extremity of the femur are one of the most common injuries treated by orthopedic surgeons. These fractures are often associated with multiple injuries and can be life-threatening (1)

Fractures of the femoral neck have an increased incidence, which is becoming more common due to the aging of the population (2). There are obvious variations in the incidence of hip fractures depending on racial and ethnic groups. For example, women have a higher frequency of femoral neck fractures compared to men (2, 3). People of Caucasian origin have a higher incidence than those of African-American origin (4, 5). In the last decades, studies have shown that there is also a difference in hip fractures by geographical area, the largest being in the United States of America and Sweden (6). The healing potential of femoral neck fractures is limited due to their anatomical features (7). Fractures of the femoral neck are often the result of high-energy trauma in young patients (8). In elderly patients, fractures can also occur following low-energy trauma (9).

Recent trochanteric fracture in adults

affects elderly subjects. The frequency increases with the aging of the population despite the development of treatments for osteoporosis (10).

Femoral neck fractures are a particular type of intracapsular hip fracture. The hip joint is the articulation of the femoral head with the acetabulum, and the location of the junction makes the femoral neck prone to fractures (11). The femoral neck is located within the joint capsule and is surrounded by synovial fluid but lacks the periosteal layer (12). This leads to a reduced ability to form callus, which affects the healing process (13).

Femoral shaft fractures are found in approximately 6-9% of cases of femoral neck fractures (14). In such situations, initial treatment focuses primarily on the femoral neck fracture, followed by treatment of the diaphyseal fracture (15).

The management of these fractures is interdisciplinary, starting with the evaluation of the associated defects (16), and, in most cases, it requires a surgical treatment that allows a quick rise and recovery of autonomy, the only guarantee of simple consequences without complications (17).

In Greece, the incidence of hip fractures doubled between 1997 and 2007 among people aged 50 and over, but the most affected group is 80 and over (18).

This article aims to investigate and analyze the frequency of various types of fractures of the proximal extremity of the femur and to identify the etiological factors that contribute to these injuries, thus providing a comprehensive understanding of these traumatic events. By examining the specialized literature, we aim to highlight aspects such as the predominant types of femoral fractures, the most susceptible age groups and genders, the traumatic mechanisms involved, as well as the associated risk factors. Finally, the study will provide relevant information for medical practitioners, contributing to the improvement of the prevention, diagnosis, and treatment of fractures of the proximal extremity of the femur.

Material and methods

The present study is retrospective in which 140 cases of fracture of the upper femur extremity collected at the trauma department of Naousa and Kilkis hospital over a period of 4 years from December 2018 to December 2022 were analyzed, processed and reviewed with a minimum follow-up of 6 months.

Inclusion criteria: Femoral head fracture, femoral neck fracture, trochanteric fractures, usable medical record, patient who underwent surgical treatment. Follow-up at least 6 months.

Exclusion criteria: Unusable files. For the study of the files, an operational file was prepared that grouped the following data: Epidemiological, clinical, radiological, therapeutic, and scalable.

To evaluate our functional results, we used the MERLE D'AUBIGNE rating.

Score	Pain	Mobility	Ability to walk
0	Pain is intense and permanent	Ankylosis in abnormal position	Impossible
1	Pain is severe, disturbing sleep	Ankylosis in normal position or in a very slight abnormal position	Only with crutches
2	Pain is severe when walking, prevents any activity	Flexion < 40° (abduction = 0°) or very light joint deformity	Only with two canes
3	Pain is severe but may be tolerated with limited activity	Flexion < 40° - 60°	Limited with one cane (less than one hour). Very difficult without a cane
4	Pain only after walking and disappearing with rest	Flexion > 60° - 80° (can tie shoelaces)	Prolonged with one cane; limited without a cane (limp)
5	Very little pain and intermittent, does not preclude normal activity	Flexion > 80° - 90°. Limited abduction (>25°)	Without a cane but slight limp
6	No pain at all	Normal. Flexion > 90°, Abduction > 25°	Normal

Results

Between December 2016 and December 2019, we found 140 cases of fractures of the upper extremity of the femur including femoral head fractures, femoral neck fractures, and trochanteric fractures.

Table 1 Fractures of the upper extremity of the femur

Fracture type	Number	Percent (%)
Femoral neck fracture	37	26,43
Trochanteric fracture	100	71,43
Fracture of the femoral diaphysis	3	2,14
Total	140	100

According to the data (Table 1), we note the predominance of trochanteric fractures, 100 (71.43%) about femoral neck and diaphysis fractures.

Table 2 Analysis of fractures according to sex

Fracture	Male	Female
Femoral neck fractures	17	20
Trochanteric fractures	72	28
Fractures of the femoral shaft	3	0

Trochanter fractures had the highest frequency in men (72 cases) (Table 2). In women, femoral neck fractures predominate, and femoral diaphysis fractures are found only in men.

Table 3 Age group of different fractures of the upper extremity of the trochanter femur

Categories	<59 years	60-74 years	75-89 years	>90 years
Femoral neck fracture	9	14	12	2
Trochanteric fracture	26	31	38	5
Fracture of the diaphysis	3	0	0	0

The age group most affected in subjects with trochanteric fractures is between 75-89 years (Table 3). For femoral neck fractures, the age group with the highest frequency is 60-74 years, and the diaphysis fracture occurs before 59 years.

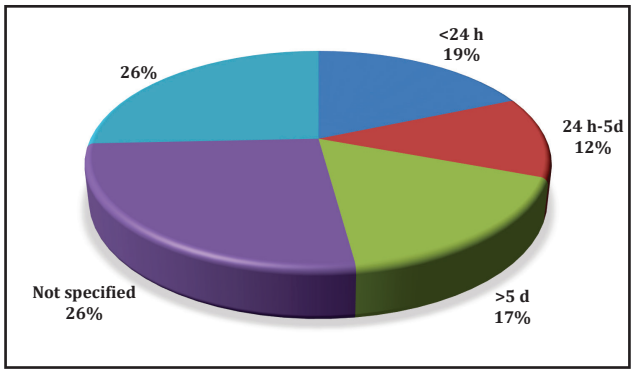


Figure 1 Patient consultation time at the Hospital

Regarding the consultation period, 26% of the patients were consulted in more than 5 days, 19% in less than 6 hours. There were 17.14% late 24h-5d and 12% in less than 24h. The consultation time was not specified in 36 of the patients (Figure 1).

Table 4 Distribution of fractures according to fracture etiology

Categories	Absolute frequency	Relative frequency (%)
Femoral neck fractures		
Falling	31	84%
AVP	5	14%
Accidents at work	1	3%
Trochanteric fractures		
Falling	71	71%
AVP	25	25%
Attacks	2	2%
Sports accident	1	1%
Work accident	1	1%
Fractures of the femoral shaft		
Road accident	1	33%
AVP	2	67%
Fractures of the femoral neck distribution on the affected side		
Right	22	59%
Left	15	41%
Trochanteric fracture distribution on the affected femoral side		
Right	49	49%
Left	51	51%
Fractures of the femoral shaft distribution on the trochanteric affected side		
Right	1	33%
Left	2	67%

Femoral neck fractures due to falls have the highest percentage, 82% (table 4), also in trochanteric fractures, fall from a height is the most common etiology, 71%, followed by public road accidents. For femoral neck fractures, the most affected side is the right side 59%. For trochanteric fractures, the most affected side is the left (51%). For fractures of the femoral shaft, the most affected side is the left (67%).

We observed from table 5 a clear predominance of cardiovascular risk factors, 12%, and metabolic, 16% (Table 5).

Table 5 Distribution according to risk factors

Risk factors	Absolute frequency	Relative frequency (%)
Cardiovascular diseases		
Hypertension	17	12%
Cardiopathy	7	5%
Metabolic		
Diabetes	23	16%
Neurologically		
Alzheimer's disease	1	1%
Dementia	1	1%
Asthma, bronchopulmonary diseases		
Asthma	4	3%
Tuberculosis	2	1%

Table 6 Distribution of fractures according to the GARDEN classification

TYPE	No. Cases	Percent
GARDEN I	2	5%
GARDEN II	3	8%
GARDEN III	7	19%
GARDEN IV	25	68%

There is a clear predominance of Garden IV femoral fractures with a percentage of 68% (table 6).

Table 7 Fracture of the neck of the femur according to the GARDEN classification by age group

AGE	GARDEN I	GARDEN II	GARDEN III	GARDEN IV
<60	1 (8.3%)	1 (8.3%)	5 (41,66%)	5 (41,66%)
>60	1 (4%)	2 (8%)	2 (8%)	20 (80%)

Depending on the age of the patients, we noticed that from the age of 60, there is a predominance of the GARDEN IV type for femoral neck fracture (Table 7).

Table 8 The results of our series according to the RAMADIER classification enhanced by DECOULX

The type of fracture	Number of cases	Percent
Simple pertrochanteric fracture	58	58%
Complex Pertrochanteric fracture	22	22%
Subtrochanteric fracture	3	3%
Cervico-trochanteric fracture	0	0%
Intertrochanteric fracture	3	3%
Trochantero-diaphyseal fracture	14	14%

Simple pertrochanteric fractures (58%) and complex pertrochanteric fractures (22%) are the most common in our series (Table 8).

Table 9 Results of our series according to Winquist and Hansen classification

The type of fracture	Number of cases	Percent
Small fragment in the butterfly	2	67%
Small fragments in the butterfly with at least 50% contact between the cortices of the fragments	1	33%
Large fragment in butterfly or comminute with < 50% contact between fragments	0	0%
Large fragment in butterfly or comminute with < 50% contact between fragments	0	0%

We observe for the fracture of the femoral diaphysis a predominance of type I (Small fragment in future), (67%), followed by type II (Small fragment in butterfly with at least 50% contact between the cortical fragments) (33%) (Table 9).

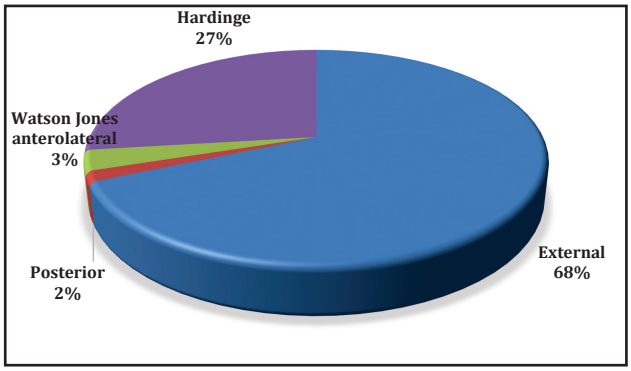


Figure 2 Number of approaches depending on the intervention and the material used

External approaches have the highest frequency (68%), followed by the Hardinge type (27%) (Figure 2).

Table 10 The type of treatment used in femoral neck fractures

Type of treatment	GARDEN I	GARDEN II	GARDEN III	GARDEN IV
THR	0	0	1	1
BIPOLAR	0	3	5	21
SCREWS	2	1	0	0
DHS	0	0	0	0

The GARDEN IV type, 21 cases, had the highest predominance in the bipolar treatment type (Table 10).

Table 11 The type of intervention used in trochanteric fractures

Type of intervention	Number (percentage)
Standard gamma nail	75 (75%)
Long gamma nail	25 (25%)

The type of intervention most used in the case of trochanteric fractures was the standard gamma nail in 75 cases (75%). The other type, in only 25 cases, was a long gamma nail (25%) (Table 11).

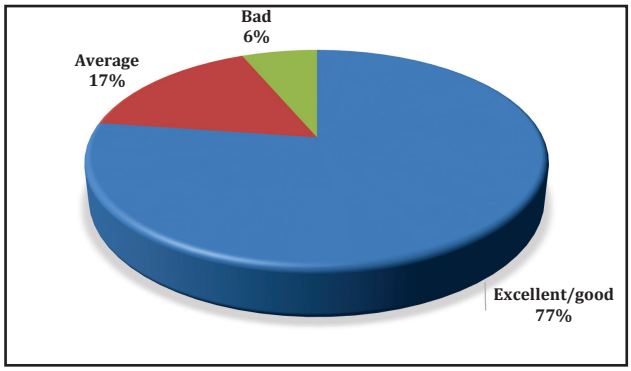


Figure 3 Functional results

As functional results, 77% registered in the excellent/good category (Figure 3)

Table 12 Anatomical results: Quality of reduction

Quality of reduction	
Anatomic reduction	105 (75%)
Acceptable reduction	35 (25%)
Poor reduction	0

The anatomical results showed a high frequency of anatomical reduction, in 105 cases (75%), but also an acceptable reduction in 35 cases (25%) (Table 12).

Discussions

In the current study, the predominance of fractures is trochanteric. Fractures of the femoral neck and diaphysis are also presented. Other studies have shown that trochanteric hip fractures represent a major public health problem and can lead to disability, reduced quality of life, and increased mortality. Hip fractures in general affect about 1.5 million people a year worldwide (19).

Trochanteric fractures had the highest frequency in men, and research has highlighted this discrepancy in frequencies between the sexes, with a higher incidence in men than in women. Several aspects may contribute to this notable difference. Men in general tend to have greater bone mass and bone density compared to women, but this does not always guarantee optimal strength of the trochanter bones (20). Certain medical conditions or nutritional deficiencies can affect bone quality and increase the risk of fractures (21). Differences in physical activities and risk behavior may influence the risk of trochanteric fractures. Men may be involved in more intensive activities or may be exposed to occupational hazards that increase the likelihood of accidents (22). However, these differences are the result of a complex combination of factors, and a further comprehensive approach is essential to understanding and managing this aspect in the medical field (22). It is a well-established fact in the medical field that femoral neck fractures predominate in women, and this aspect can be explored from various perspectives to better understand the implications and factors behind this predominance. Women generally have lower bone mass and lower bone mineral density which may contribute to bone fragility and increased vulnerability to femoral neck fractures (23). Then the decrease in estrogen production during menopause contributes significantly to the loss of bone density and increases the risk of fractures, including those of the femoral neck (24). The increased risk of falls due to factors such as aging, muscle weakness, or the presence of conditions that affect balance, can become a major factor in the occurrence of femoral neck fractures (25). In our study there are only three cases of femoral diaphysis fractures and all of them are men. Fractures of the femoral shaft can be the result of severe trauma, such as car accidents (26), falls from a height, or sports accidents (27).

The increased frequency of trochanteric fractures among patients aged 75-89 years can be explained by the onset of osteoporosis which increases the risk of fractures, including trochanteric ones, as bones become more fragile and more susceptible to fracture following minor trauma (28). The loss of muscle mass between these ages and the decrease in the ability to maintain balance are aspects that can

contribute to accidental falls, thus increasing the risk of trochanteric fractures (29). The multiple comorbidities that can occur at this age, such as cardiovascular problems, diabetes, or other chronic medical conditions that can contribute to increasing the risk of fractures following minor traumas, will be discussed in the subsequent sections of this study. Domestic accidents and decreased general levels of physical activity may be significant risk factors for trochanteric fractures (30). The fact that the frequency of femoral neck fractures is higher in the age group between 60 and 74 years highlights the fact that bone density in women can decrease significantly (23). The presence of diaphyseal fractures before the age of 59 may raise interesting questions and may require further investigation into age-specific factors, such as participation in certain sports or occupational activities, that increase susceptibility to such fractures (30). There is research that claims that genetic predisposition can play a role in the predisposition to diaphyseal fractures (31). There is research that claims that genetic predisposition can play a role in the predisposition to diaphyseal fractures.

A delay in femoral fracture consultations of more than 5 days may raise important questions about the health care system and the impact of this delay on patients such as the influence of prognosis and increased risk of complications (32). Surgical delay beyond 36 hours for surgery has a greater impact on mortality for patients with higher preoperative health grades (33).

In the present study, femoral neck fractures were most frequently caused by falls, underlining the importance of preventing these traumatic events and the need to develop effective strategies to reduce the risk of falls (34). Risk factors that predispose to falls leading to femoral fractures are advanced age, muscle weakness, balance problems, visual impairments, and medications that can affect stability (35). In trochanteric fractures, falling from a height is the most common etiology, this being a major determinant of hip fracture risk due to the force applied to the femur on impact (36). The fact that the right side of the femoral neck is more frequently affected, according to the data presented in our study, may raise questions and may lead to the exploration of the different factors that could contribute to this asymmetry. On the other hand, for both trochanteric and femoral diaphyseal fractures, it seems that the most affected side is the left one.

The results of this study show a clear predominance of cardiovascular and metabolic risk factors. A diagnosis of cardiovascular disease was significantly associated with the risk of subsequent hip fracture (37). Hypertension can have an impact on bone density, meaning bones can become more fragile and susceptible to fractures (38) because some medicines used to control high blood pressure, such as ACE (angiotensin-converting enzyme) inhibitors and diuretics, have been associated with decreased bone mineral density (39). Even though no proven link between diabetes and the reduction in bone mass leads to falls, an increased risk of hip fracture has been found in women with type I or type II diabetes and in older men with type II diabetes (40).

This study shows a predominance of Garden IV femoral neck fractures with the highest percentage. The Garden classification describes femoral neck fractures as a function of displacement, and levels III and IV include femoral displacements (41).

Current procedures in the orthopedic clinics where the patients were evaluated imply the use of Garden classification to select treatment for elderly patients with femoral neck fractures (42), and our study reveals a predominance of GARDEN IV for this type of fractures. This anatomical correlation of GARDEN IV means destruction of the supporting cervical posterior cortex that is necessary for repositioning (43).

Simple pertrochanteric fractures and complex pertrochanteric fractures are the most common in our clinic. Pertrochanteric fractures are classified according to the location and type of injury, and pertrochanteric fractures are considered simple when they do not involve significant comminution, that is, there are no significantly separated multiple fragments nostrum (44). The complicative ones are multi-fragmentary pertrochanteric fractures A 2 (44).

Regarding the Winquist and Hansen classification, we observe a predominance of types I, and II. The Winquist and Hansen classification is often used to assess femur fractures and provides information on the degree

of fracture comminution (spread) for diaphyseal femoral fractures (45). It is easy to remember and signifies the severity of the injury, the higher the number, the more serious the injury (46). The observation that type is predominant I may provide a relevant aspect, such as that they are like a small butterfly covering less than 25% of the width of the bone. Type II fractures are the ones with a larger wedge that covers less than 50% of the width of the bone (46).

External surgical treatment approaches have the highest frequency, followed by the Hardinge type. External approaches in the treatment of femoral fractures represent a surgical strategy that involves stabilizing the fractures without directly affecting the medullary canal of the femur. These approaches may vary depending on the specific technique used and external fixation modalities (47). The Hardinge surgical approach is a technique used in the treatment of femoral neck fractures when we aim to hip hemiarthroplasty (bipolar). Also lateral approach, involves accessing the trochanteric region of the femur through an incision located on the anterolateral side of the thigh (48).

For the type of treatment used in femoral neck fractures with a GARDEN IV classification, bipolar hip hemiarthroplasty had the highest prevalence. We previously showed that GARDEN type IV fractures are completely displaced and there is no contact between the femoral head and the femoral neck (49). Studies have shown that with bipolar hip hemiarthroplasty, the management of displaced femoral neck fractures was associated with a better mean score and the incidence of complications was limited (50).

The type of intervention most used in the case of trochanteric fractures was the standard gamma nail. Less frequently, the long gamma nail type was used. The use of the standard gamma nail in the treatment of trochanteric fractures reflects a common and well-established therapeutic approach in orthopedic practice (51). Gamma nails are surgical devices used to fix and stabilize proximal femur fractures, particularly trochanteric fractures (52). Long gamma nail intervention is an effective surgical approach in stabilizing femoral fractures (53). This technology involves the use of a longer intramedullary nail that extends over a larger portion of the femur to provide robust fracture fixation (53).

The majority of functional results in the "excellent/good" category indicates a significant recovery of function and highlight the effectiveness of surgical interventions for femur fractures.

The anatomical results relate to the quality of the reduction and they indicate a high frequency of anatomical reduction. High frequency of anatomical reduction is a technical challenge and involves returning the fractured fragments to their normal position, getting as close as possible to the natural anatomy (54). This is essential for restoring the normal function of the femur and minimizing the risk of complications (54).

Conclusions

There is a preponderance of trochanteric fractures, with an increased frequency in the 75-89 age group, and cardiovascular problems, diabetes, or other chronic medical conditions can contribute to increasing the risk of fractures.

The prevalence of femoral neck fractures in women may be explained by a combination of biological, hormonal, and lifestyle factors. Femoral neck fractures are predominantly caused by falls, and the predilection for the right side of the femoral neck in fractures emphasizes anatomical peculiarities.

Regarding femoral diaphysis fractures in men, a comprehensive view of the problems related to them, addressing medical, social, and technological aspects could improve the management and outcomes of these traumatic events.

This study highlighted the delay in femoral fracture consultations, facts that highlight the need for effective emergency management. For trochanteric fractures, external surgical approaches were preferred, the standard gamma nail, in femoral neck fractures GARDEN IV received bipolar hip hemiarthroplasty with or without the use of cement. The functional results "excellent/good" reflect the success of the surgical interventions, and the high frequency of anatomical reductions emphasizes the attention paid to the quality of the procedures.

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