**Introduction**

Proximal femoral fractures (PFF) constitute a significant medical and social problem, as they cause reasonable economic loss throughout the world. In 1990, the number of such traumas reached about 1.3 million, and by 2050, it is expected within 7-21 million cases. With the share of 17% in the structure of locomotion system traumas, they have large mortality and invalidity rate among the injured. The research analyzes international literature sources on incidence, factors of occurrence, mechanisms of development, and known classifications of PFF patients; basic methods of conservative and surgical treatment, as well as rehabilitation principles for this category are provided. We have found that, despite a large amount of literature, a clinical and diagnostic approach to the differentiated use of internal fixation for PFF is still not finally developed.

**Key words:** proximal femoral fractures; analysis of literature sources; factors of occurrence; known classifications; treatment, rehabilitation.

In 1990, the number of such traumas throughout the world was about 1.3 million, and by 2050, it may reach 7-21 million cases. In the USA, cases of PF fractures reach about 30% of the total number of hospitalized patients, and expenses for their treatment make approximately 8 billion USD a year. In the UK, the total annual number of hospitalized PFF patients makes 1.5 million; they occupy about 20% of orthopedic beds in the total number of patients with locomotion system disorders [9].

There are many factors of PFF occurrence in senior patients. The frequency of femoral fractures depends directly on the way of life and increases in a group of persons with low body mass [10, 11] and low physical activity [12, 13]. These factors may also include smoking tobacco [14, 15] and unfavorable social status [16]. The risk of PFF increases in patients after an acute cerebrovascular accident (insult) [17], in a terminal stage of renal impairment [18, 19], and with a reduced visual function [20].

The matter of what occurs first – fracture of fall – remains open. In practice, over 90% of all PF fractures result from a fall. By trauma mechanism, all PFF may split into two main groups. In young patients, the fractures occur after a high-energy trauma: road accidents or fall from height. About 90% of all fractures in senior persons are the result of low-energy trauma, i.e. just fall on their trochanteric area. A PFF requires a combination of 4 factors to take place: 1) a fall on the upper third of a thigh, 2) weak protective reflexes to prevent the strong fall, 3) a rapid muscle contraction during the fall and improper quantity of subcutaneous adipose tissue,
a local shock-absorber, and 4) low bone tissue density [21]. Elderly patients with PF fractures after low-energy traumas quite often have concomitant injuries, such as radial distal metaepiphysis and proximal shoulder fractures. Cranio-cerebral injuries, traumas to the cervical spine, thorax, abdomen, and extremities are typical of young PPF patients after high-energy trauma [22].

In femoral neck fractures, in the majority of cases, the fracture line goes transversely through the neck in its thinnest part or is slightly oblique. The first displacement of fragments after a femoral fracture caused by external factors is extended upon the influence of muscular retraction. If the fracture occurs in the proximal fragment, no muscles influence the femoral head, and it remains in a neutral position or (comparatively rear case) turns in the acetabular cavity with a simultaneous distal fragment displacement. Regularly, the distal fragment gets displaced upward, backward, and outside. Long biarticular femoral muscles displace the extremity upwards, while m. iliopsoas turns it outwardly [23].

In lateral fractures, displacement of fragments’ is also typical: the neck-shaft angle decreases, the proximal fragment is in abduction, the ruptured small trochanter shifts upwards under the influence of muscular retraction. If the fracture occurs in the proximal fragment, no muscles influence the femoral head, and it remains in a neutral position or (comparatively rear case) turns in the acetabular cavity with a simultaneous distal fragment displacement. Regularly, the distal fragment gets displaced upward, backward, and outside. Long biarticular femoral muscles displace the extremity upwards, while m. iliopsoas turns it outwardly [23].

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In lateral fractures, displacement of fragments’ is also typical: the neck-shaft angle decreases, the proximal fragment is in abduction, the ruptured small trochanter shifts upwards under the influence of m. iliopsoas. Under the influence of gravity, the thigh shifts backwards, and the whole lower limb rotates externally. Usually, a different displacement of fragments is not observed due to a wide fracture area, and in presence of a periost and many muscular attachments [23].

Garden had subdivided fractures into 4 types depending on femoral neck fan-shaped trabeculae (a medial bundle) displacement [24].

**Garden classification**

Type I – the angle between trabeculae in the femoral head and neck metaphysis is over 160°. In the author’s opinion, this fracture type is followed by minimum blood circulation impairment and is considered classical incomplete.

Type II – trabeculae and the lower cortical layer are ruptured but not displaced. The femoral head viability prognosis is relatively positive.

Type III fracture is followed by varus deformation of the femoral neck. The distal fragment remains in an external rotation and abduction; the rear lower block remains intact, forming an angle, open forward. Such fractures are frequently accompanied by comminuted rear neck fractures.

Type IV fracture is associated with the rupture of all synovial connections. On radiograms, femoral head trabeculae are slightly displaced downwards regarding the femoral neck metaphysis trabeculae. These fractures are often complicated with femoral head aseptic necrosis. In the author’s opinion, type 4 fractures extend the indications for hip arthroplasty [25]. According to many authors, this classification allows prognostication of femoral head viability.

The Pauwels classification includes only subcapital femoral neck fractures. Its background is the relation between the fracture line and a horizontal one [24, 26].

**Pauwels classification**

Type I – the fracture line is in 30° inclination to a horizontal one; displacement forces are focused on compression of fragments.

Type II – the fracture line is in 50° inclination to a horizontal line.

Type III – the fracture line is in 70° inclination to a horizontal line.

Carrying out metal osteosynthesis considering this classification, the author recommends the following: in type I, osteosynthesis should be performed with three screws because they dislocate the forces focused on compression. In type II and type III fractures, the angle between the fracture line and a horizontal one increases and sliding forces grow, demanding more rigid fixation to obtain a stable osteosynthesis. For these fractures, it is recommended to support nail osteosynthesis with a cancellous screw [24].

**AO Fellowship in Switzerland** has the following classification:

1. (B1) subcapital fractures without a displacement;
2. (B2) transcervical;
3. (B3) subcapital displaced fractures.

In his more detailed classification, Muller (1990) has distinguished fractures of the head, neck, and trochanter [24, 26].

**Muller classification**

A – fractures in the trochanteric area:

A1 – a juxta-articular fracture in a trochanteric area, pertrochanteric, simple;
A2 – a juxta-articular fracture in a trochanteric area, pertrochanteric, comminuted;
A3 – a juxta-articular fracture in a trochanteric area, intratrochanteric.

B – femoral head fractures:

B1 – subcapital with a slight shift;
B2 – transcervical femoral neck fracture;
B3 – subcapital femoral neck fracture, not impacted, displaced.

C – femoral head fractures:

C1 – split femoral head fracture;
C2 – pressed femoral head fracture;
C3 – head and neck fracture.

Pipkin has offered a much more detailed classification of femoral head dislocation fractures [24].

**Pipkin classification**

Type I: femoral head fracture interior to the **fovea centralis**;

Type II: fracture extended superior to the **fovea centralis**;
Type III: any femoral head fracture with an associated femoral neck fracture;
Type IV: any femoral head fracture with an associated acetabular fracture.

Nowadays, the most frequently used is AO classification [27].

**AO classification**

This classification reflects the whole range of proximal femoral fractures:

**A** – trochanteric fracture, pertrochanteric, simple:
A1 – the fracture line goes along the intertrochanteric line;
A2 – the fracture line goes through the greater trochanter;
A3 – the fracture line goes below the lesser trochanter.

A2 – comminuted pertrochanteric fracture, pertrochanteric comminuted: 1 intercalated fragment; 2 – two or more intercalated fragments; 3 – the fracture line extends 1 cm below the lesser trochanter.

A3 – the fracture in the intertrochanteric area:
1 – simple, oblique; 2 – simple, transverse; 3 – comminuted.

B – femoral neck fractures:
B1 – femoral neck fracture, subcapital, with slight displacement: 1 – compressed valgus over 150°; 2 – compressed valgus less than 150°; 3 – compressed valgus.
B2 – transcervical neck fracture: 1 – neck base; 2 – neck diaphysis, adduction; 3 – transcervical, not displaced;
B3 – subcapital neck fracture, not impacted, without a displacement: 1 – a moderate displacement, varus, external rotation; 2 – moderate displacement, varus, with a vertical shortening and external rotation; 2 – expressed displacement.

C – femoral head fractures:
C1 – split head fracture; 1 – ligamentum teres avulsion; 2 – ligamentum teres rupture; 3 – large fragment.

Especially essential is the study of PFF patients’ mortality. According to WHO, mortality in this category of senior patients with PFF makes 12-15% [28]. From 18% to 28% of senior patients die within one year after the injury [29-33]. According to German experts, the in-hospital mortality associated with this trauma is about 6%. The long-term mortality in these groups demonstrates, that 10% of patients die in half of a year, and in one year, this value grows to 22.2-27.6 % [34, 35]. As a rule, this is connected to the fact that senior PFF patients have severe concomitant pathologies, which almost always leads to their decompensation stage.

Exacerbation of concomitant diseases (coronary heart disease, arrhythmia, arterial hypertension, diabetes mellitus type II, renal and liver impairment) and complications (myocardial infarction, pneumonia, pulmonary edema, pulmonary arteria thromboembolism, vascular impairment, cystitis, bed sores) may lead to death [36-38].

Anatomic features of this area stipulate a large share of complications during treatment of fractures, i.e. fragments nonunion, femoral head aseptic necrosis, pseudoarthrosis, hip contractures, shortening, or malposition of a limb [39]. These complications make the extremity unable to dead load, and the patients become weak and need nursing care. Many of them become bedbound, and others die from complications: bedsores, pneumonia, or decompensated concomitant diseases [40].

Surgical treatment of PFF decreases significantly the mortality of patients. Nowadays, it is a method of choice, and frequently the only chance to save a patient's life and to restore the lost workability, ability to move independently, and fulfill daily routine tasks [41-43]. Compared to skeleton traction, surgical treatment does not lead to rapid growth in mortality. It allows early activation of patients and makes the care easier [44]. The period when the surgery should take place is ambiguous. Of course, the surgery must be performed as early as possible, although pre-surgical preparation is also required. If a patient is in stable condition, the surgery is recommended if possible within the first 24 hours after the injury. Postponing the surgery to more than 2 days increases the risk of post-surgical mortality within the first year, even among the patients who took care of themselves, are in an adequate mental health, and were able to walk independently before the injury [45]. As a rule, the method of anesthesiology does not affect the outcome [46]. A prospective study of senior patients with trochanteric fractures demonstrated that the older a patient is, the weaker is his somatic status. They need a longer in-hospital period, compared to femoral neck fracture patients. In 2 months after the surgery, neck fracture patients demonstrated better recovery compared to trochanteric fractures patients, and they have lower mortality risk within the period from 2 to 6 months after the trauma [47, 48].

The choice of a method of treatment, terms of surgical intervention, reposition accuracy, fixation strength, and early activation of the patients are essential for outcomes. To choose an appropriate method of treatment and predict the outcomes, important factors are the age of a patient, general and local status, type of a fracture, gender, physical activity extent before the injury.

Nowadays, developed countries widely implement minimally invasive, less traumatic technologies for
proximal femoral nails (Trochanteric gamma nail G3 – STRYKER, PFN A – SYNTHES, ChFN – ChM). This method of surgical treatment of long bone fractures is applied in 60–70% of cases [49, 50]; it is an organ-preserving surgery, on the contrary to total hip arthroplasty.

There are a few literature sources paying attention to elaboration of clinical and diagnostic approaches to the differentiated use of internal fixation devices in PFF treatment [3, 27], and a few of them enlighten the ways to solve this problem. Out of the recent researches devoted to this matter is the one performed at the SI “Institute of Traumatology and Orthopedics of NAMS of Ukraine” (Ph.D. dissertation by Yuriichuk L.M.) [51], where the author has extended indications to total hip arthroplasty, especially in pertrochanteric fractures of senior and old patients.

The long-term outcomes of PPF treatment may be assessed as positive only if a patient remains alive within 1 year after the injury, does not require external assistance, and is returned to the previous activity level. However, only 25% of PFF patients after the surgery boast a quality of life recovery. The share of the 1st and 2nd groups of disability among the initially examined patients according to these consequences of fractures reach 15%; 28% of them are persons of workable age [1].

Rehabilitation after the surgical treatment stipulates the return of patients to their previous activity level. Senior and old persons should be independent in their everyday living and unburdensome for their relatives. Those of workable age will return to their work, not burdening the society; otherwise, they should be maintained as disabled. To solve this medical social problem, rehabilitation potential, the index of the summary, general conditions, anatomical and functional potential, and social adaptation of a patient must be determined.

Conclusions

We have discovered that, despite a large amount of literature, a clinical and diagnostic approach to the differentiated use of internal fixation for PFF is still not finally developed.

Conflict of interests. The authors declare no conflict of interest towards the present article.

References


23. Анкин НЛ, Анкин ЛН. Травматология. Европейские стандарты диагностики и лечения. Киев: Книга-плюс; 2012. 464 c.


Переломи проксимального відділу стегнової кістки: структура, чинники виникнення та принципи лікування (Огляд літератури)

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Резюме. Переломи проксимального відділу стегнової кістки (ППВСК) є великою медико-соціальною проблемою та завдають значних матеріальних збитків у всіх країнах. Кількість подібних травм у світі в 1990 році становила близько 1,3 млн, а до 2050 року передбачається в межах 7-21 млн випадків. Вони становлять 17% у структурі травм опорно-рухової системи, з високим відсотком летальності та інвалідності уражених хворих. Проведено аналіз джерел світової літератури щодо розповсюдженості, чинників виникнення, механізму розвитку та відомих класифікацій пацієнтів із ППВСК, наведено основні методики консервативного й оперативного лікування та принципи реабілітації цієї категорії хворих. Визначено, що, незважаючи на велику кількість літературних джерел, остаточно не розроблений клініко-діагностичний підхід до диференційованого застосування внутрішньої фіксації при ППВСК.

Ключові слова: переломи проксимального відділу стегна; аналіз літературних джерел; чинники виникнення; відомі класифікації; лікування; реабілітація.