

# Modern Aspects of Diagnostics and Surgical Treatment of Proximal Femoral Fractures (Literature Review)

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**Abstract** The article contains a literary review of domestic foreign and scientific publications over the past 10 years, devoted to the diagnosis and treatment of trochanteric fractures of the proximal femur. The paper presents widely used classifications of these injuries, indications for surgical treatment, highlights the features of the use of internal osteosynthesis, characteristics and rationale for the choice of modern metal fixators with restoration of the integrity of the supporting medial complex, and initially stable osteosynthesis with supporting metal fixators, according to the literature, can achieve positive results.

**Keywords** Trochanteric fracture, Proximal femur, Osteosynthesis, Surgical treatment

## 1. Introduction

Currently, the incidence of diseases of the musculoskeletal system is growing and a high level of injuries remains, their social consequences are great (temporary disability and disability) [Agadzhanian V.V. et al., 2016, 2018; Ardashev I.P. et al., 2015, 2018; Eskin N.A., Andreeva N.M., 2017; Karres J. et al., 2018]. Fractures of the proximal femur are recorded in 2 million people annually [Cook A.C. et al., 2016]. According to L.J. Melton by 2050, the number of hip fractures in the proximal section will be about 6 - 6.5 million [Melton L.J., 2016]. The number of patients with fractures of the proximal femur is growing in parallel with the number of elderly people [Joseph B. et al., 2014, 2015; Nance M.L., 2015], accounts for 20% of all osteoporotic fractures and is the cause of the majority of deaths [Cook A.C. et al., 2016].

The population of elderly and senile people is constantly increasing in the world [5], and at the same time, the number of hospitalizations of elderly patients with traumatic injuries in medical institutions is also increasing [9]. In 90% of cases, a fracture of the proximal femur in the elderly occurs as a result of a fall from a height of one's own height, and in young people it occurs as a result of road accidents, cata-traumas, sports and industrial injuries [13].

Literature data indicate that more patients with fractures of the proximal femur receive outpatient treatment. Fractures of the proximal femur in adults account for 5–14% of all skeletal fractures and 32–65% of hip fractures [10]. Fractures of the femoral neck are more common 75.3-80.2% versus 19.8-24.7% of trochanteric fractures. Globally, although proximal femoral fractures account for less than

20% of all osteoporotic fractures, they are responsible for the majority of deaths related to fractures over 50 years of age [8].

## 2. The Main Findings and Results

Fractures of the proximal femur require a special approach to treatment for a number of reasons, since this is a complex surgical, therapeutic, social and psychological problem that doctors of various specialties and social workers must solve. An interdisciplinary approach in the treatment of fractures of the proximal femur can significantly reduce the number of complications and mortality [Vidan M., Serra J.A., Moreno C. et al., 2005; Joseph B. et al., 2014, 2015; Cook A.C. et al., 2016]. According to systematic reviews and meta-analyses, several predictors are clearly associated with mortality after surgery for hip fractures, including the type of injury, older age, male gender, preoperative mobility, cognitive impairment, and the presence of comorbidities [Evans D.C. et al., 2012; Lakomkin N. et al., 2017].

It has long been known that it is practically impossible to obtain a consolidation of a fracture of the proximal femur without osteosynthesis [Adams S.D. et al., 2012], so this method remains the standard of care. The issue of choosing the optimal treatment tactics regarding indications for a particular method of surgical treatment (osteosynthesis and arthroplasty) remains the subject of active discussion [Gilfanov S.I., 2010; Kavalersky G.M., Chensky A.D., Prokhorova M.Yu., 2014; Pavlov V.V., Sadovoy M.A., Prokhorenko V.M., 2015; Adams S.D. et al., 2012].

However, there is still no consensus on the effect of age, gender, comorbidities, mental state and social activity on postoperative outcome, morbidity and mortality [Duvall D.V. et al., 2015; Zhao F.Z., 2015]. At present, the importance of

risk assessment of surgical interventions is beyond doubt [Endo A. et al., 2017; Karres J. et al., 2017]. International scales are known for assessing risk factors for postoperative complications and mortality. So, for example, ISS [Baker S.P. et al., 1974], TRISS [Boyd C.R., Tolson M.A., Copes W.s., 1987], RTS [Taylor M.D. et al., 2002], ASCOT scale [Champion H.R. et al., 1996] has been recognized as an improved predictor of morbidity and outcome, but the complexity of the scoring limits its widespread use. Other attempts have been made to predict the risk of complications after injury [Rogers F.B. et al., 2012].

Anatomical and biomechanical features of fractures of the trochanteric region of the femur, the specific structure of the proximal femur can be seen on a vertical section of a bone devoid of soft tissues. On such a section, cancellous bone plates will be visible, which are located in two systems of trabeculae. These trabeculae correspond to lines of force.

The main system consists of two groups of trabeculae that fan out at the femoral neck and head. The first group starts from the cortical layer of the outer surface of the femoral diaphysis and ends in the lower part of the cortical layer of the head - the so-called arcuate bundle of Galois and Bosquette. The second group starts from the cortical layer of the inner surface of the diaphysis and the lower part of the neck, diverges like a fan upwards and ends in the cortical layer of the upper part of the head (the so-called head bundle, or supporting fan).

The additional system is formed from two bundles diverging in the form of a fan towards the greater trochanter. The first bundle coming from the cortical layer of the inner part of the diaphysis is called the trochanteric bundle. The second bundle, consisting of vertical trabeculae located parallel to the outer cortical plate of the greater trochanter, is the subcortical bundle.

There are three points to highlight here:

1. In the greater trochanter, the arcuate and trochanteric bundles at their intersection form a Gothic arch and a denser capstone descending from the superior cortical plate of the femoral neck. The inner column is less powerful and weakens with age as osteoporosis progresses.
2. The head, together with the neck of the femur, form another Gothic arch at the intersection of the arcuate and supporting bundles. Here the bundles are denser and form the "core of the head". This system of trabeculae rests on the thick cortical layer of the lower femoral neck, which is a very powerful structure known as the Adams arch (femoral calcar).
3. The zone of least resistance is located between the gothic arch of the trochanter and is the supporting cervical-capitate system, which becomes weaker with age-related osteoporosis; mainly in this area, basal fractures of the trochanteric region of the femur occur.

The proximal femur has a neck-diaphyseal angle of 125° to 130° and an ante-version of 10° to 15°. When synthesizing such fractures, it is necessary to take into account the

biomechanical resistance of the structures of the fracture zone, which predetermines the localization of medial neck fractures in the region of Ward's triangle, as well as the quality of the internal resistance of the Adams arch (femoral calcar), which accounts for most of the compressive stress.

The trabecular system of the proximal femur can change throughout life. At the same time, in the case of osteoporosis, the number of bone trabeculae significantly decreases. Using simple radiographs, using the M. Singh index (1970), which characterizes seven levels of bone density, it is possible to assess the severity of osteoporosis of the proximal femur (Singh M., 1970). With osteoporosis of the trochanters, large cells and "voids" form in the spongy substance, the cortical layer of the trochanters becomes thinner and becomes very weak and fragile. Fractures of the trochanteric region of the femur, especially in elderly and senile patients, are often comminuted, which is primarily due to weakening of the bone as a result of resorption (Kaplan A.V., 1979).

The anatomical features of the muscular system of the trochanteric region of the femur are of practical importance in fractures and affect the displacement of bone fragments (Dorofeev Yu.N., 1990; Popsuishapka A.K. et al., 2006; Narayan K.K. et al., 2006). A large mechanical stress during flexion justifies the use of adapted and biomechanically resistant types of osteosynthesis. The trochanter area is characterized by good blood supply, as it is represented by spongy bone and soft tissues of the muscle attachment zone (Prives M.G., 1974; Sklyanchuk E.D., 2009), which contributes to high consolidation of fractures in this areas. In order to more thoroughly assess the outcomes of the disease and determine the method of treatment, it is important to note the division of trochanteric fractures into anatomically clearly defined subgroups, as well as subgroups that differ from biomechanical positions. In the literature, there are a number of Classifications of extra-articular fractures of the proximal femur: according to A.V. Kaplan (1977); according to M.E. Muller (1996); according to R. Kyle (2005); according to E.M. Evans (1949); according to R. Tronzo (1974) and others.

The most significant prognostic factor for all classifications of trochanteric fractures is stability. So, stable fractures (cervical-trochanteric, simple per-trochanteric fractures with two fragments) and unstable fractures (comminuted per-trochanteric fractures with more than two fragments, sub-trochanteric fractures, diaphyseal trochanteric fractures) are distinguished. E.M. Evans (1949) also proposed to divide all fractures of the trochanteric-sub-trochanteric region into stable and unstable. It should be noted that here the integrity of the concentric extent of the cortical bone is very important for the orthopedic surgeon. R. Tronzo (1974) improved the original classification of Boyd and Griffin, proposing 6 types of fractures, taking into account mechanical factors and instability due to the destruction of the posterolateral support. H. Ender divided trochanteric fractures into impacted fractures and fractures with diastasis. According to the researcher, the fracture is considered stable if there is no

proximal femur on the radiograph in the lateral projection of the fissure in the region of the lesser trochanter or in the projection of the Adams arch. M.E. Müller in 1988 proposed a new classification of extra-articular fractures of the proximal femur, which took into account the shortcomings of previous classifications (Müller M.E., 1996). Based on the classification of M.E. Müller, all fractures of the trochanteric region of the femur are type A and are divided into three groups. Group A1 consists of simple, two-piece fractures with good bone support along the medial cortical layer. Type A2 fractures are multi-comminuted with multiple fractures of the medial and dorsal cortical layer (lesser trochanter) at several levels, but with an intact lateral cortical layer. In type A3 fractures, the lateral cortex is also fractured (reverse, or reverse, fracture type). The horizontal line at the level of the lesser trochanter defines the inferior border of the trochanteric region. If the center of the fracture is below this line, then such a fracture is classified as sub-trochanteric. The classification of trochanteric fractures according to AO made it possible to navigate the choice of an implant for their osteo-synthesis. Thus, the dynamic hip screw (DHS) is the implant of choice for stable fractures (A1, A2.1). It provides secondary compression along the fracture line along the long axis of the sliding femoral screw, which is correctly placed in the center of the femoral head. For unstable multi-comminuted trochanteric fractures, PFNA and TFN intramedullary fixators are recommended.

Thus, we have considered the most popular classifications of fractures of the trochanteric region of the femur that currently exist. However, it should be noted that despite such a variety of classifications, progress in the field of examination of victims with the help of CT and MRI again causes the formulation of this problem into the category of topical ones.

There are also theories that most hip fractures result from low-energy trauma, a combination of weak reflexes to cushion the effects of a fall, and bones weakened by osteoporosis. Among patients with hip fractures, taking into account age, the risk of mortality within 1 year is approximately 20-30%, while 30-day mortality is 5-10%, and with conservative therapy up to 63%. Patients over 65 years of age are characterized by a significant risk of complications in the postoperative period [22], higher mortality after injury compared with younger people. This is due to comorbid diseases, a decrease in the physiological reserve of the body [13]. In order to reduce direct and indirect losses through prevention and reduce morbidity, disability and mortality, it is necessary to further improve the surgical tactics of treating this group of patients.

Conservative treatment of patients with fractures of the proximal femur is still used in clinical practice [24]. However, it is known that prolonged immobilization of the injured limb in bed rest leads to physical inactivity, the development of muscle hypotrophy, joint contractures, as well as to aggravation of the general somatic status, bedsores occur, and mortality increases [20]. With this method of treatment, the development of false joints of the proximal

femur is 60-80% [15], and mortality among them reaches 5-15%. Conservative management of elderly patients with hip fracture leads to higher morbidity and mortality. Over the past decade, it is necessary to note the prevalence of surgical methods of treatment [3]. Osteo-synthesis of fractures of the proximal femur is still the standard of care. An operative method of treatment with reliable fixation of fragments improves the quality of life of patients, drastically reduces the time of their stay in the hospital due to early activation and allows the patient to quickly return to daily activities [1]. Early mobilization of this group of patients by surgical fixation of fractures helps in the prevention of pressure ulcers, urinary tract infections, atelectasis and respiratory infections, thrombophlebitis, deep vein thrombosis and pulmonary embolism. Currently, two methodologies for fracture stabilization are known: absolute and relative stability, which is more justified from the point of view of osteogenesis [14]. Based on this, various methods of both reposition (open or closed) and osteo-synthesis are used. Attempts continue to be made to determine the dependence of the choice of implant on the mechanism of injury, the plane of the fracture, and changes in the axis of the limb [11].

Given that the principle of absolute stability cannot be fully implemented in patients with low structural organization of bone tissue, various systems have been proposed by associations of orthopedic surgeons from different countries for osteo-synthesis of fractures of the proximal femur: lockable screws, plates with limited contact, plates with angular stability (the principle of an internal biological fixator), and to implement the principle of relative stability, compression screws with the effect of self-dynamization of fragments during walking, intramedullary pins, external fixation devices (pins, rods) have been developed [23].

According to the data of domestic and foreign literature, taking into account the peculiarities of the blood supply to the proximal femur, namely the priority of the branches of the medial circumflex artery of the femur, the presence of intraosseous anastomoses between the anterior and posterior cervical arteries, the likelihood of developing a false joint in a fracture of the femoral neck remains high. In this regard, osteosynthesis operations with metal structures are relevant, and according to some authors, operations of choice. It is important to take into account not only the location of the femoral neck fracture, but also the state of the peripheral index of structural changes in bone density [26]. Despite the generally observed unification of prosthetic systems, many unresolved issues remain, in particular, the optimal choice of an implant for a particular patient, taking into account the individual characteristics of the pathology and anatomical situation, low-traumatic surgical approaches, features of postoperative insertion, prevention and treatment of complications [7]. Many authors consider the first day after injury to be the optimal time for surgical treatment of elderly patients with fractures of the proximal femur, as this allows for early activation and prevention of hypostatic complications [27]. In practice, this principle is not always

implemented. These are not only organizational problems, but also questions of the interdependence of the degree of surgical invasion on the physiological resource of the body [26]. For younger patients with a satisfactory state of the bone tissue, closed reposition with internal fixation of the fracture can be used as the optimal tactic for surgical treatment [2]. In older patients with low bone density, and often with a multi-comminuted fracture, osteo-synthesis with metal structures is optimal. Depending on the patient's expected result of treatment, his level of physical activity and cognitive status, this type of operation is chosen, which is more preferable in terms of returning the function of the joint and the level of quality of life of patients to those they had before the injury. Correctly performed osteo-synthesis with metal structures leads to better functional indicators, greater satisfaction with the result of the operation in patients of the older age group in comparison with bipolar prosthetics, after which the incidence of complications associated with loss of fixation strength is high [12]. In addition, secondary arthroplasty, caused by complications after primary arthroplasty, is associated with difficulties due to anatomical disorders in the area of primary surgical intervention, incorrect reposition, and severe myofibrosis [21].

### 3. Conclusions

The studied data of the literature and dissertations do not lead to the final conclusion of the treatment of fractures of the proximal femur due to the diverse and distinctive clinic. In our study, we plan to develop a working algorithm in the diagnosis of fractures of the proximal femur, depending on the etiology, diagnosis and clinic of the fracture, and to obtain the most optimal treatment option and operation method depending on the type of fracture. We believe that osteo-synthesis with metal structures is a standard and more optimal type of surgery for this pathology. Thus, our study will also contribute to the establishment of a unified algorithm for the treatment of fractures of the proximal femur.

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