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Fractures of the femoral head (clinical lecture)

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Fractures of the femoral head are often associated with hip dislocation. A high percentage of unsatisfactory functional treatment outcomes and complications (such as aseptic necrosis, heterotopic ossification, osteoarthritis, etc.) remains a challenge. Objective. To analyze the available information on the treatment approaches for femoral head fractures associated with hip dislocation using the Pipkin classification. Methods. A search of modern literature sources was conducted in the PubMed and Scopus databases using the following keywords: fracture, femoral head, Pipkin, hip joint, diagnosis, treatment, osteosynthesis. Results. The Pipkin classification enables the systematization of treatment approaches for patients and, when applied correctly, reduces the rate of complications and improves functional outcomes. Computed tomography is an essential procedure in diagnosing femoral head fractures associated with hip dislocation to facilitate the prompt reduction of the dislocation. The specific features of blood supply and the risks of aseptic necrosis formation, considered in the Pipkin classification, influence the treatment strategy, along with the type of fracture. For type I fractures, both conservative and surgical methods are possible. For type II fractures, screw fixation is preferred: using hidden compression screws, self-compressing headless screws, or bioresorbable screws. For type III fractures, urgent surgery is required, typically open reduction with primary endoprosthesis replacement. For type IV fractures, if the fracture type permits, open reduction and osteosynthesis are recommended. In postoperative care, early functional treatment is critical, with partial weight-bearing for 6–12 weeks, and avoiding excessive flexion of the hip beyond 45°–50°. Conclusions. A properly selected treatment strategy during the initial admission can reduce recovery times and improve treatment outcomes.

Переломи головки стегнової кістки часто поєднуються з вивихом стегна. Залишається великим відсоток незадовільних функціональних результатів лікування й ускладнень (асептичний некроз, гетеротопічна осифікація, остеоартроз тощо). Мета. Проаналізувати наявну інформацію щодо підходів лікування переломів головки стегнової кістки, які поєднуються з вивихом стегна, використовуючи класифікацію за Pipkin. Методи. Виконано пошук сучасних літературних джерел у базах даних PabMed, Scopus за такими критеріями: перелом, головка стегнової кістки, Pipkin, кульшовий суглоб, діагностика, лікування, остеосинтез. Результати. Класифікація за Pipkin дозволяє систематизувати підходи до лікування пацієнтів та за умов вірного її використання зменшити відсоток ускладнень і покращити функціональні результати. Комп'ютерна томографія є важливою процедурою під час діагностики переломів головки стегнової кістки, які поєднуються з вивихом стегна, щоб якнайшвидше вправити вивих. Особливості кровопостачання та ризиків формування асептичного некрозу враховані в класифікації за Pipkin і чинять вплив на тактику лікування, як і тип перелому. Так за типу I цієї класифікації можливі як консервативний спосіб, так і оперативний; II — фіксація гвинтами: прихованими компресійними, самокомпресуючими без головки, а також біорезорбтивними; III — невідкладна хірургія, переважно відкрите вправлення з первинним ендопротезуванням; IV — якщо характер перелому дозволяє — відкрита репозиція й остеосинтез. У післяопераційному догляді важливим є раннє функціональне лікування, 6–12 тижнів часткового навантаження, уникання високих ступенів, згинання стегна більше 45°–50°. Висновки. Правильно обрана тактика лікування під час первинного надходження дозволяє скоротити терміни та покращити результати лікування. Ключові слова. Перелом, головка стегнової кістки, класифікація за Pipkin, кульшовий суглоб, діагностика, лікування, остеосинтез.

Keywords. Fracture, femoral head, Pipkin classification, hip joint, diagnosis, treatment, osteosynthesis

Introduction

Fractures of the femoral head are quite rare in medical practice but are often combined with hip dislocation. For the first time, a fracture of the femoral head was described by J. Birkett in 1869 [1]. Most often, this injury occurs in high-energy trauma, such as motor vehicle or motorcycle accidents, falls from a height, etc. [2].

According to meta-analyses, today most of such fractures are treated surgically (90.8 %) with the advantage of anatomical reconstruction in 76.7 % of cases. Posterior access for surgery is the most common (52.5 %). In 70.5 % of cases, excellent or good results were achieved with surgical intervention according to the Thompson-Epstein criteria. The highest level of indicators was observed in the case of minimally invasive osteosynthesis and surgical intraoperative dislocation of the hip. The main late complications are aseptic necrosis (10.8 %), post-traumatic osteoarthritis (16.2 %) and heterotopic ossification (20.8 %). Total hip arthroplasty was necessary in 6.9 % of cases [3].

Biomechanics of fracture

The vast majority of femoral head fractures are accompanied by posterior dislocations of the hip [4, 5]. Occasionally, fractures of this location may be the result of anterior dislocation of the hip [6] or isolated trauma without concomitant dislocation. The position of the hip (flexion, abduction or adduction and rotation) in combination with the magnitude and direction of the forces applied during the injury determine the nature and severity of the fracture. For some time, it was believed that the femoral head fracture is a typical avulsive fracture, caused by the tearing action of the central ligament of he femoral head. However, further studies have shown that the femoral head fragment is not always connected to the hip joint by the indicated ligament [7], and other studies have shown that only a small bone-cartilage fragment can be torn off by this mechanism. It has been found that the morphology of the fracture depends on the mechanism of injury and the position of the limb at the time of the traumatic factor.

The exact morphology of the fracture in a posterior hip dislocation depends on its position at the time of injury: if it is flexed less than 60° and adducted, a Pipkin type I injury occurs (the medial part of the femoral head is pressed against the strong part of the posterior wall of the acetabulum). Abduction position with the same flexion is likely to result in a Pipkin type II injury. If the hip is flexed more than 60°, the femoral head is pressed against the thinner part of the posterior wall of the acetabulum, which is likely to cause its fracture and damage to the cartilage or cortical depression of the femoral head [8]. A Pipkin type III fracture usually occurs when there is prolonged exposure to various forces: the first impact causes the femoral head to dislocate from the joint and causes it to fracture by a shearing mechanism. Prolonged adduction then causes a fracture of the femoral neck due to contact with the posterior edge of the acetabulum, which acts as a fulcrum [9].

Diagnosis of a femoral head fracture

The history of the injury plays an important role in the diagnosis (most often it is a high-energy injury such as a road accident, a fall from a height, etc. [2]). Despite its variability, the clinical presentation is of great importance. Fractures with posterior hip dislocation are usually accompanied by flexion, adduction and internal rotation of the hip, creating the impression of a general shortening of the limb. In the case of fractures with anterior dislocation, the thigh is usually abducted and rotated outwards. The first and basic examination involves a classic radiograph of the pelvis in direct projection, which in most cases allows diagnosing dislocation and the presence of a fracture of the bones in the hip joint. In case of additional diagnostic difficulties, in the presence of an incompetent hip dislocation and for patients with polytrauma, it is important to perform computed tomography (CT) of the hip joint area. In general, it can be used to determine the size, number and localization of fracture fragments, as well as associated injuries. Magnetic resonance imaging (MRI) is mainly used to detect the integrity of the cartilage and vessels of the femoral head and in the long term of treatment. In particular, when assessing the occurrence of early forms of avascular necrosis.

Pipkin classification

In order to systematize and organize femoral head fractures according to treatment tactics, several classifications have been created, one of them is Pipkin (Fig. 1, [10]), which takes into account the localization of the femoral head fracture, the presence of a femoral neck fracture and pelvic bones. It was introduced in 1957 [11]: type I injuries are injuries in which the fracture line passes caudal to the *fovea capitis femoris*, while in type II fractures the line ends cranially to it. This helps to distinguish between fractures outside (type I) and inside (type II) of the load-bearing part of the femoral head. In type III injuries, a femoral head fracture of any type is associated with a femoral neck fracture. In type IV, a head fracture due to a fracture of the acetabular wall.

Treatment

Management of femoral head dislocation

The first step in treatment is to reduce hip dislocation. It has been proven that the time from injury to

the moment of reduction is important in the long-term rehabilitation perspective [12]. According to various sources, reduction is desirable within 3–6 hours from the moment of injury [13], according to the results of modern studies, this time correlates with the frequency of subsequent aseptic necrosis of the femoral head, which can vary from 4.8 to 52.9 % of cases [14]. There is a wide variety of hip reduction techniques, but they are based on separate mechanisms for anterior and posterior dislocations. Management of anterior hip dislocation occurs on axial traction of the extended lower limb along the axis. For reduction of posterior dislocation, the knee and hip joints are flexed to 90° and traction is performed along the axis of the femur. These procedures should be performed under sufficient analgesia and muscle relaxation, which will facilitate the intervention and prevent additional trauma. After this, a CT scan should be performed to determine further treatment tactics. The morphology of the fracture and the satisfaction of the reduction will have an impact. It should be noted separately that closed reduction is contraindicated in patients with a concomitant fracture of the femoral neck.

Conservative treatment

According to research, conservative treatment with skeletal traction demonstrates unsatisfactory functional results [15]. Such therapy is allowed for Pipkin type I fractures, in the case of anatomical reduction, stability of the hip joint and satisfactory congruence of the articular surfaces [16]. Given that the fragment is outside the load-bearing zone of the joint, secondary displacements or its aseptic necrosis are possible, which should not lead to significant functional impairment [17]. Previously, similar criteria were applied to Pipkin type II fractures, but more modern studies have revealed a high frequency of unsatisfactory closed reduction and significant risks of secondary displacement of fragments (the fragment of the head is part of the load-bearing surface of the joint). It should be noted separately that usually in Pipkin type II femoral head fractures, its fragments are typically of significant size, and therefore such an injury is accompanied by instability of the hip joint. In addition, the presence of a fracture in the load-bearing area of the joint often leads to secondary displacement of fragments, instability of the hip joint and post-traumatic osteoarthritis, which significantly worsens the functional results of treatment [18]. Also, the development of aseptic necrosis of the fragment causes pronounced functional impairment and requires surgical intervention. For some time, removal of the head fragment was considered as a treatment option, but modern studies prove that the best result is achieved in the case of osteosynthesis [19]. Satisfactory reduction and fixation of the fragments demonstrates excellent functional results in the long term [20]. Under the conditions of choosing a conservative treatment strategy, the patient moves on crutches without loading the injured lower limb for at least 6 weeks with staged radiological control.

Surgical treatment

During surgical intervention, the primary issue is the choice of surgical access to the site of injury. It is necessary to consider the topographic anatomy of the area, in particular the peculiarities of the blood supply to the femoral head. The most important are the terminal branches of the medial artery, which runs around the femur. Given the peculiarities of its location, the Smith-Peterson anterior approach remains common (Fig. 2, [21]), which allows achieving satisfactory visualization of fragments in Pipkin type I and II fractures without the risk of critical disruption of the blood supply [22, 23].

Visualization is performed by radial dissection of the capsule and extension, abduction, and external

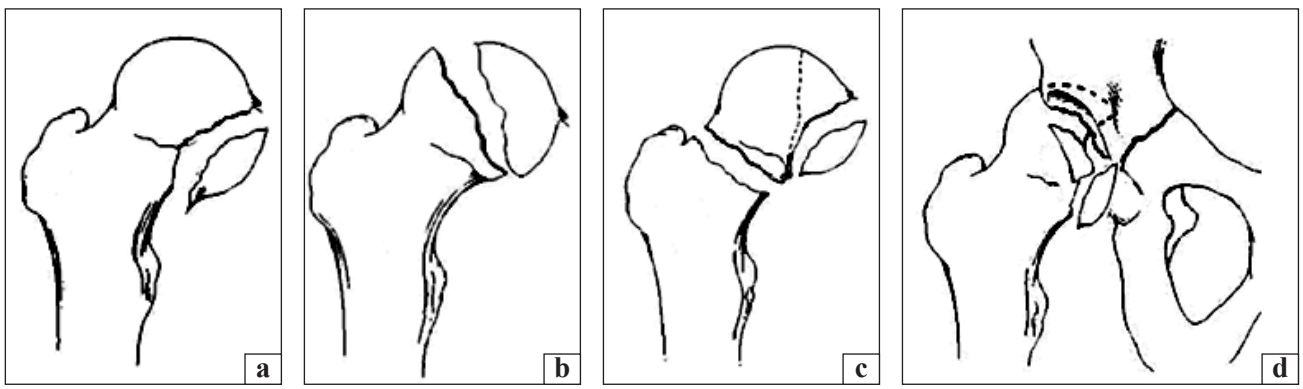

Fig. 1. Pipkin classification: Type I — femoral head fracture below the central fossa (a), type II — fracture extending above the central fossa (b), type III — any femoral head fracture with concomitant femoral neck fracture (c), type IV — any femoral head fracture with concomitant acetabular fracture (d) [10]

rotation of the hip. The Watson-Jones anterolateral approach is accompanied by less soft tissue trauma and allows visualization of the femoral neck (relevant for Pipkin type III fractures) but is less convenient for working with a fractured head and more difficult if the surgical approach needs to be expanded.

Recent meta-analyses indicate that in terms of complications, heterotopic ossification is more common for the anterior approach, and other postoperative complications (including aseptic necrosis of the femoral head) and functional outcome are not affected by the surgical approach [24].

Posterior approaches are the option of choice in case of incompetent hip dislocations (soft tissues located posterior to the hip joint, such as the piriformis tendon, sometimes lead to interposition) and Pipkin type IV fractures. The optimal approach in this case is the Kocher-Langebeck approach. However, visualization of the fracture fragments of the femoral head is unsatisfactory during this approach. A combination of posterior approach, greater trochanter osteotomy, and Ganz surgical dislocation of the hip is a feasible option (Fig. 3, [25]). This maneuver is used to leave the external obturator muscle intact and preserve the blood supply to the head through the medial artery, around the femur. It has been proven that such surgical access to the head is safer and is not accompanied by the risk of its avascular necrosis [25]. Thus, surgical dislocation of the hip provides visualization and access to clinically significant anatomy of the femoral head compared to the Smith-Peterson approach (with or without separation of the rectus muscle) and the Gaither approach. Visualization and anatomical access influence the ability to achieve anatomical reduction during open reduction with open reduction internal fixation (ORIF) of the femoral head.

Therefore, surgical hip dislocation may have important clinical advantages, including the ability to access complex injuries in Pipkin type IV fractures, such as acetabulum injuries [26]. The highest rate of major complications is associated with the anterior approach (77%), and the lowest with surgical hip dislocation (37.8%) [3].

Basic principles of choosing a method of treatment for fractures of the femoral head according to the Pipkin I classification

If conservative treatment for Pipkin type I fractures is rejected, the choice arises between open reduction with subsequent osteosynthesis and removal of the fragment. It has been proven that osteosynthesis is accompanied by a certain percentage of nonunions or aseptic necrosis. Conservative treatment in the presence of displacement will lead to the formation of post-traumatic osteoarthritis [27]. Removal of a fragment (which is less than 1/3 of the volume of the femoral head) in Pipkin type I fractures does not cause functional disorders, since it is not a load-bearing part of the hip joint [28]. If it is larger than 1/3 of the femur, it can result in instability of the hip joint, then surgical treatment is preferable, such as open reduction and osteosynthesis.

Pipkin II

In Pipkin type II fractures, the fragment is part of the load-bearing surface of the hip joint. Its removal will lead to a redistribution of the load on the femoral head and the rapid development of osteoarthritis [29]. The surgical approach and fixation method are selected according to the size and localization of the fragment at the surgeon's discretion. In the case of a large size, extra-articular insertion of a tightening screw is possible, but the following screws are most often used: compression [30], compression headless [31], bioresorbable [32]. Unfortunately, given the low incidence of Pipkin type II fractures, there are currently no studies on the results of treatment with these implants, the advantages and disadvantages of individual types of osteosynthesis. In extreme cases, if high-quality osteosynthesis is not possible and removal of the fragment is impractical, primary joint arthroplasty should be considered, which will ensure early rehabilitation and avoid the risk of fatal complications and secondary prosthetic repair.

Pipkin III

Pipkin type III fracture is a rare injury that requires a careful approach to choosing treatment tactics. Due to the high incidence of aseptic necrosis of the femoral head, it is difficult to achieve satisfactory functional results with the use of open reduction and osteosynthesis, so the possibility of primary hip arthroplasty may be considered [33]. However, for young patients, given the future need for revision prosthetic repair, due to the satisfactory blood supply to the proximal femur and good regenerative capabilities of the body, open reduction and osteosynthesis of the femoral head may be recommended, provided that the patient is fully informed about the high level of complications associated with this procedure.

In the case of joint-preserving surgery, the need for fixation of the femoral head depends on the size of the fragments and their position after reduction. Primary hip arthroplasty may be an option for the elderly and for highly displaced femoral neck fractures [33].

Pipkin IV

Pipkin type IV fractures are associated with poor functional outcomes for patients of all ages. Current

data suggest that the risk of post-traumatic osteoarthritis is greater than 85 %, and the proportion of total hip arthroplasty within the first two years after injury is 50 % [34].

Given this, each patient with such an injury should be considered primarily from the perspective of joint preservation and functional outcomes. In cases of uncertain prognosis, primary total hip arthroplasty should be preferred, allowing for early rehabilitation and a rapid return to daily life. If a decision is made to preserve the joint, it is recommended to carry out open reduction and osteosynthesis of the acetabular fossa and femoral head. Indications for osteosynthesis/resection of the femoral head fragment do not differ from those given in Pipkin type I and II fractures (Table).

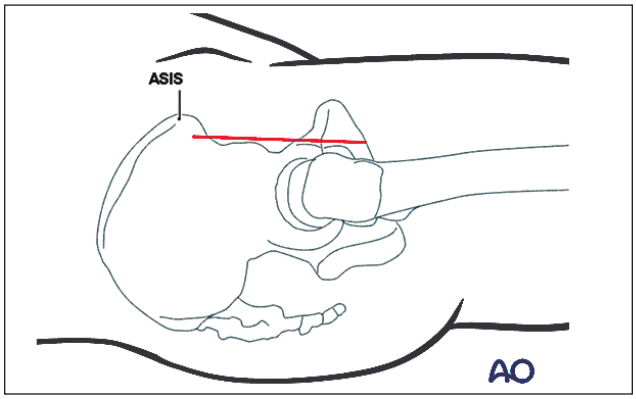

Fig. 2. Smith-Peterson approach — skin incision 2 cm lateral to the anterior superior iliac spine (ASIS) 8–10 cm distally [21]

Postoperative care

In the postoperative period, under conditions of stable fixation, in the first 6 weeks, therapeutic physical exercises (TPE) and walking on crutches with a dosed (no more than 20%) load on the lower limb are recommended. A motorized splint may be useful to reproduce passive movements in the hip joint. In case of posterior dislocation of the hip, it is worth avoiding its flexion more than 80° (excessive load on the damaged posterior part of the acetabular lip can lead to repeated dislocation). In satisfactory findings following radiological control and CT after 6 weeks, the load can be increased by adding axial exercise to TPE. Walking with full range of motion is allowed no earlier than 3 months after surgery.

Complications

The average rate of complications after treatment of Pipkin fractures is 44 % [35]. The most common of these is sciatic nerve damage (almost 20 %). The most injured fibers are the peroneal nerve, which

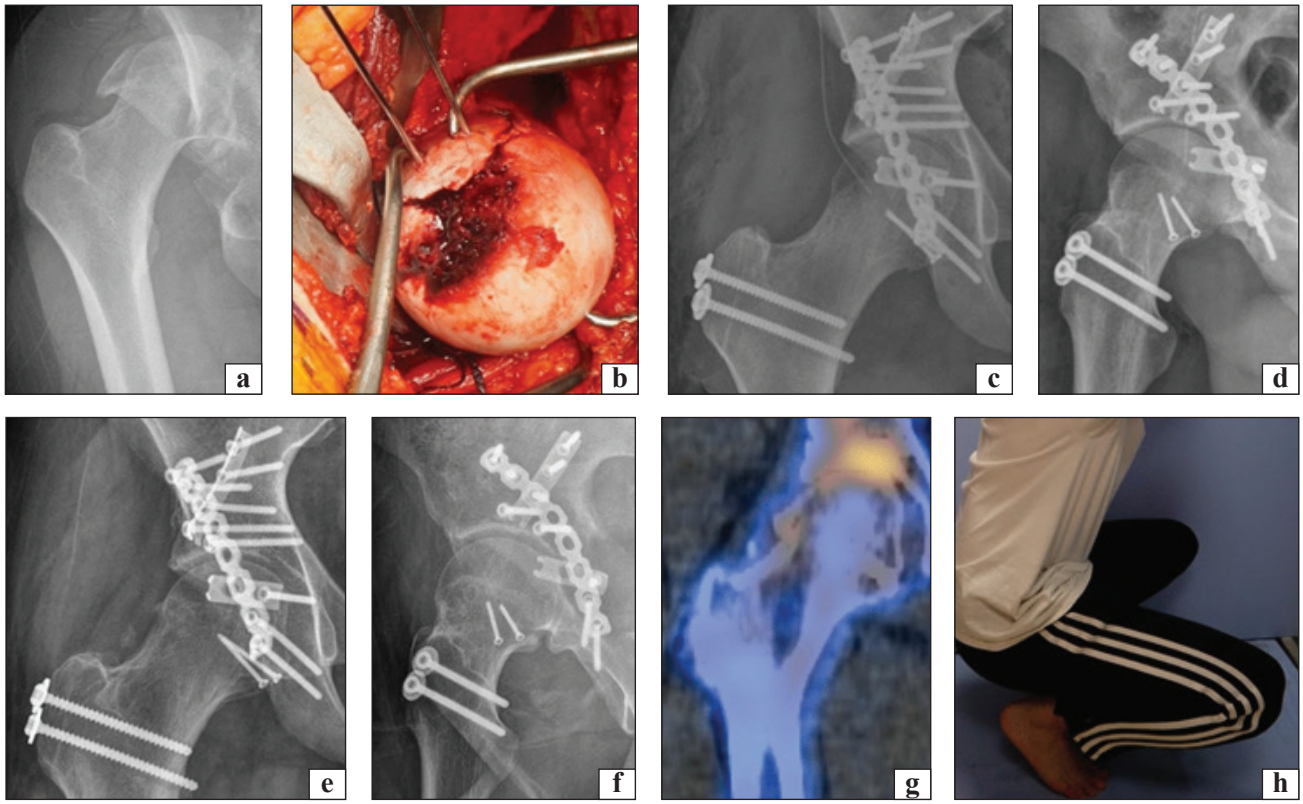

Fig. 3. Pipkin type IV femoral head fracture (a), surgical dislocation of the hip (b), stable fixation and congruence achieved (c, d), consolidation 8 months after surgery (e, f), single-photon emission CT (blood flow preserved) (g), function satisfactory (h) [25]

Table

Surgical treatment tactics and choice of operative access (details in the text)

Pipkin	Surgical access	Treatment
I	Predominantly anterior (Smith-Peterson)	Conservative*; fragment removal
II	Predominantly anterior (Smith-Peterson), posterior (Kocher-Langebeck) with surgical Ganz hip dislocation	Conservative*; open reduction and metal osteosynthesis
III	Predominantly anterolateral (Watson-Jones)	Primary arthroplasty; open reduction and metal osteosynthesis
IV	Posterior with surgical Ganz hip dislocation; two approaches (anterior and posterior)	Conservative*; open reduction and metal osteosynthesis

*Note.** — provided the anatomical location of the fragment, joint stability, and congruence of the articular surfaces.

is most sensitive to ischemia. In 2/3 of cases, no macroscopic signs of damage to the sciatic nerve are detected in patients with clinical symptoms of sciatic neuropathy [36]. Only early reduction of the dislocation allows to reduce the time of ischemia and improve the prognosis for recovery. In addition, in Pipkin fractures, aseptic necrosis of the femoral head (12 %), heterotopic ossification (16.8–25 %), post-traumatic osteoarthritis (16–20 %), and infectious complications (3.2 %) are observed [37, 35]. A unique complication of surgical hip dislocation was nonunion of the trochanteric flip osteotomy and trochanteric bursitis, which occurred at a frequency of 3.4 and 3.8 %, respectively [35]. Aseptic necrosis mostly occurs within 2 years after surgery. Its signs are not easy to see on radiographs, the first reliable signs can be detected on MRI. There are several important predictors of the development of aseptic necrosis of the femoral head [38], but prolonged primary disruption of its blood supply (uncorrected hip dislocation) is the main one [39]. Unsuccessful attempts at reduction lead to cartilage damage and subsequent complications. Another important complication is heterotopic ossification. The exact cause is difficult to establish, but risk factors include concomitant damage to surrounding muscles, wide intraoperative access, and significant intraoperative trauma. Some authors have reported a higher incidence of heterotopic ossification with anterior approaches [40]. To prevent this, nonsteroidal anti-inflammatory drugs have been suggested. The most common oral regimens are 50 mg diclofenac twice or 25 mg three times daily for 3 weeks after surgery. This has been shown to effectively reduce the risk of severe heterotopic ossification [41]. Post-traumatic osteoarthritis is a very common complication after hip dislocations with or without associated fractures.

Its development is associated with the severity of the primary injury, the extent of direct damage to the articular cartilage [42] and the postoperative congruence of the articular surface [43]. Accordingly, the risk of developing osteoarthritis is different for all types of fractures: while some degree of osteoarthrosis is observed in almost all patients with Pipkin III fractures or ventral dislocations, this complication is detected in only 50 % of cases with Pipkin I and II fractures.

Conclusions

Analyzing the review findings, it can be concluded that injuries of the femoral head with hip dislocation most often occur in young patients (mean age — 40 years) and their main mechanism is a traffic accident (> 80 %). This fracture occurs by a shearing mechanism, its nature depends on the position of the hip at the time of injury.

It should be noted that early closed reduction improves the prognosis (lower risk of aseptic necrosis and sciatic nerve neuropathy < 6 h). Immediate open reduction is the priority if closed reduction is unsuccessful, and CT is recommended after it.

In the case of femoral head fractures with hip dislocation, the Pipkin classification is used, which allows systematizing the approach to choosing treatment tactics.

It should be noted that conservative methods provide satisfactory results only in the Pipkin type I fractures, with displacement < 2 mm, a stable hip joint and the absence of displaced fragments.

If closed reduction is successful, surgical intervention is recommended in the later stages of primary care (7–10 days after injury). The decision to remove fragments or fix them is made if residual displacement of fragments is ≥ 2 mm; if the fragment forms the load-bearing surface of the hip joint; if there is a restriction of movements or interposition.

The treatment tactics depend on the type of fracture according to the Pipkin classification:

– type I — non-operative/removal of fragments;

– type II — fixation with screws: hidden compression, self-compression without a head, as well as bioresorbable pins and screws;

– type III — emergency surgery, preference is given to open reduction with primary endoprosthesis;

– type IV — if the nature of the fracture allows, open reduction and osteosynthesis are used.

In postoperative care, early functional treatment is important, 6–12 weeks of partial weight-bearing, avoidance of high steps, hip flexion > 45°–50°.

Common complications are nerve damage (20 % of sciatic nerve injury in conditions of posterior dislocations), avascular necrosis of the femoral head, heterotopic ossification and osteoarthritis.

Conflict of interest. The authors declare the absence of a conflict of interest.

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FRACTURES OF THE FEMORAL HEAD (CLINICAL LECTURE)

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