

Current Management of Femoral Neck Fractures (Literature Review)

Zazirnyi I.M.¹✉, Kostrub O.O.²

Summary. Femoral neck fractures are a commonly encountered injury in orthopedic practice and result in significant morbidity and mortality. It is essential that surgeons are able to recognize specific fracture patterns and patient characteristics that indicate the use of particular implants and methods to effectively manage these injuries. The use of the Garden and Pauwels classification systems has remained the practical mainstay of femoral neck fracture characterization that help choosing appropriate treatment. Operative options include in situ fixation, closed or open reduction and internal fixation, hemiarthroplasty, and total hip arthroplasty. Recent reports demonstrate diversity among orthopedic surgeons in regard to the optimal treatment of femoral neck fractures and changing trends in their management.

Key words: femur; neck; fracture; review; trauma.

Introduction

More than 250,000 hip fractures occur annually in the United States and are evenly divided between femoral neck and intertrochanteric fractures [1]. This number is projected to double by the year 2050 [2]. Seventy-five percent of hip fractures occur in women [3]. The incidence in younger patients is very low and is associated mainly with high-energy trauma. The majority occur in the elderly (average age of 72 years) as a result of low-energy falls [4]. Risk factors include female sex, white race, increasing age, poor health, tobacco and alcohol use, previous fracture, fall history, and low estrogen level.

Mechanism of Injury

Low-energy trauma is most common in older patients and can involve either direct or indirect mechanisms. Direct mechanisms include a fall onto the greater trochanter or forced external rotation of the lower extremity, which impinges the femoral neck onto the posterior lip of the acetabulum. Indirect mechanisms result when muscle forces overwhelm the strength of the femoral neck. High-energy trauma accounts for most femoral neck fractures in younger individuals, such as motor vehicle accident or fall from a significant height. Cyclical loading-stress fractures are seen in athletes, military recruits, and ballet dancers. Insufficiency fractures occur in patients with osteoporosis and osteopenia.

Clinical Evaluation

Patients with displaced femoral neck fractures typically complain of groin and thigh pain and are non-

ambulatory, with shortening and external rotation of the lower extremity. However, patients who sustain an impacted or stress fracture of the femoral neck may lack deformity and may be able to bear weight. Patients involved in high-energy trauma should be subjected to standard Advanced Trauma Life Support (ATLS) protocols. Pain is usually evident on attempted range of hip motion, with pain on axial compression and with tenderness to palpation of the groin. An accurate history is important in the low-energy fracture that usually occurs in older individuals. Obtaining a history of loss of consciousness, prior syncopal episodes, medical history, chest pain, prior hip pain (pathologic fracture), and preinjury ambulatory status is important and critical in determining optimal treatment and disposition. All patients should undergo a thorough secondary survey to evaluate for associated injuries.

Radiographic Evaluation

Radiographic evaluation of a suspected hip fracture should include an anteroposterior view of the pelvis and an anteroposterior and a cross-table lateral view of the involved proximal femur. A frog lateral is contraindicated as it may cause displacement of an impacted or non-displaced femoral neck fracture. A physician-assisted internal rotation view of the injured hip can be helpful with further clarifying the fracture pattern and determining treatment plans as it eliminates the normal femoral neck anteversion. A thin-slice computed tomography scan can help to detect non-displaced femoral neck fractures, particularly in the face of a high-energy femoral shaft fracture [5]. Magnetic resonance imaging is currently the imaging study of choice in delineating non-displaced or occult fractures that are not apparent on plain radiographs [6].

✉ Zazirnyi I. M., zazirnyi@ukr.net

Kostrub O.O., akostrub@ukr.net

¹Clinical Hospital "Feofaniya" of the Agency of State Affairs, Kyiv

²SI "Institute of Traumatology and Orthopedics of NAMS of Ukraine", Kyiv

Classification

The Garden classification of femoral neck fractures is the one most commonly used in the literature. In this classification, femoral neck fractures are divided into 4 types based on the degree of displacement of the fracture fragments. A type I fracture is an incomplete or valgus-impacted fracture. A type II fracture is a complete fracture without displacement of the fracture fragments. A type III fracture is a complete fracture with partial displacement of fracture fragments. A type IV fracture is a complete fracture with total displacement of the fracture fragments, allowing the femoral head to rotate back to an anatomic position. In practice, however, it is difficult to differentiate the 4 types of fractures, and therefore, it may be more accurate to classify femoral neck fractures as non-displaced (Garden I and II) or displaced (Garden III and IV).

The Pauwel classification is based on the angle of fracture from the horizontal [11]: type I: 30 degrees, type II: 30–70 degrees, and type III: >70 degrees. Increasing shear forces with increasing angle leads to more fracture instability.

The OTA Classification of Femoral Neck Fractures is mainly used for research purposes. Because of poor intraobserver and interobserver reliability in using the various classifications, femoral neck fractures are commonly described as either non-displaced or displaced. Non-displaced fractures include impacted valgus and non-displaced femoral neck fractures. This is a much better prognostic situation. Displaced fractures are characterized by any detectable fracture displacement [7].

Treatment

The treatment of choice for most femoral neck fractures is operative to allow early patient mobilization, decrease the risk for complications, and improve patient outcomes. Non-operative management should be considered only in patients who are seriously ill and present excessive surgical risk. In the majority of patients, operative management is indicated; the choice of a specific treatment option is based on the stability and orientation of the fracture and patient factors such as age, function, and bone quality. In general, surgery should be performed on an urgent or emergent basis to minimize the risk for perioperative complications, improve patient comfort, and decrease the length of hospitalization [8]. The American Academy of Orthopaedic Surgeons (AAOS) has recently published evidence-based guidelines for the perioperative and intraoperative management of elderly patients who have sustained a hip fracture [9].

Nondisplaced/Impacted Fractures

Operative management of impacted and non-displaced femoral neck fractures (Garden I and II) usually involves *in situ* fixation with either multiple cancellous lag screws (Fig. 1) or a sliding hip screw (SHS) (Fig. 2). The primary goal of internal fixation is to prevent displace-

ment of a stable fracture pattern [10]. Compared with an SHS, multiple cancellous lag screws offer the advantage of a relatively minimally invasive technique, shorter operative time, and sufficient fixation for most stable fracture patterns. Typically, 3 cannulated cancellous screws (6.5, 7.0, or 7.3 mm) are placed in a parallel inverted triangle configuration (inferior, posterosuperior, and anterosuperior) with situation of the screws adjacent to the inferior (calcar) and posterior cortices (Fig. 1). The inferior screw resists inferior displacement of the femoral head, whereas the posterior screw resists posterior displacement. The starting point for the inferior screw should be at or above the lesser trochanter to avoid generating a stress riser in the subtrochanteric region. The screw threads should lie sole within the femoral head to generate a lag effect and end within 5 mm of the subchondral bone of the femoral head. Comparison of different screw configurations and altering screw number has demonstrated higher mechanical stability with the parallel inverted triangle pattern of screw placement in most fracture models [11]. In cases with a more significant posterior comminution, the use of a fourth screw along the posterior cortex may improve stability. In osteoporotic bone, adding a washer can aid in preventing screw penetration through the lateral cortex and may increase the maximal insertion torque of the lag screw, improving screw purchase in the femoral head [12].

Gjertsen et al. [13] reported an 89% implant survival rate with the use of cannulated screws for stabilization of non-displaced femoral neck fractures at 1-year follow-up in a group of 4468 patients. Kain et al. [14] published a revision surgery rate of 10% after cannulated screw fixation in a cohort of elderly patients (average age of 80 years) who sustained a Garden I or II femoral neck fractures at an average follow-up of 11 months (range, 0–5 years). Osteonecrosis, nonunion, loss of fixation, and subtrochanteric fracture were reported as the main reasons for revision; the authors recommended consideration of hemiarthroplasty (HA) as a feasible alternative for managing certain elderly patients.

Lapidus et al. [15] attempted to discriminate which patients with Garden I or II fractures may be at higher risk for fracture healing complications and subsequent revision but found no relation to age, gender, American Society of Anesthesiologists (ASA) classification, cognitive function, time to surgery, or posterior tilt in 382 hips with 5 years of follow-up. Conversely, Parker et al. [16] prospectively looked at 565 nondisplaced intracapsular hip fractures and found that the incidence for fracture healing complication was higher in older and female patients.

An SHS is also a proven option for managing non-displaced and impacted femoral neck fractures and are preferable over cancellous lag screws in cases where the fracture is oriented more vertically (Pauwels III) or in the basicervical region [17]. However, it has been reported by

Bray [18] that patients treated with an SHS have higher rates of osteonecrosis than multiple cancellous lag screws, possibly related to the insertion torque generated by the large-diameter lag screw resulting in rotational malalignment. An antirotation screw or wire can be used to prevent this complication and then either removed or leaved in place after the large-diameter lag screw has been inserted (Fig. 2) [19]. Similar to the use of an SHS for stabilization of intertrochanteric fractures, the tip–apex distance should be under 25 mm to prevent the likelihood of lag screw cutout [20].

In a review of 5274 nondisplaced and displaced femoral neck fractures, Parker et al. [21] found no difference in complication rates and outcomes between the use of cannulated screws or an SHS but did note increased blood loss and operative time with SHS implants. Stiasny et al. [17] compared cancellous lag screws with SHS implants for stabilization of Garden type I and II fractures and reported a revision rate of 15% using cannulated screws and an overall 50% higher likelihood of revision. The primary reason cited for revision was subtrochanteric soft-tissue irritation by prominent cancellous screws that resulted from progressive femoral neck shortening. The same study also reported better patient outcomes and no cases with loss of reduction when an SHS implant was used.

A new implant with multiple small-diameter sliding cancellous screws, which lock to a side plate, has shown promising potential for managing femoral neck fractures in Europe [48]. This implant is a hybrid between cancellous lag screws and an SHS, providing rotational stability, controlled collapse of the femoral neck, and prevention of screw toggling within the femoral neck. Early results have shown similar functional results with lower amount of femoral neck shortening than an SHS implant [22] and lower nonunion and revision rates compared with cancellous lag screws [23]. However, more clinical and mechanical evidence is necessary to advocate regular use of this type of implant to stabilize femoral neck fractures.

Although historically a shortened and healed femoral neck fracture was an acceptable clinical result, recent studies focusing on femoral neck shortening and outcomes have reported a positive association between increasing amounts of shortening and lower quality of life measures and higher revision rates [24]. Length-stable implants (fully threaded cancellous screws, divergent cancellous screws, and proximal femoral locking plates) and augmentation with a locked plate on the anterior–inferior aspect of the femoral neck have been proposed as solutions for minimizing the amount of femoral neck shortening to potentially improve postoperative outcomes, lower revision rates, and provide sufficient mechanical stability (Fig. 3) [25]. However, one study about the use of a length-stable proximal femoral locking plate to stabilize femoral neck fractures reported an unacceptably high failure rate (36.8%) and recommended avoid-

ing the use of this implant for managing femoral neck fractures [26]. The authors hypothesized that the stiffness of the implant precludes micromotion at the fracture site, which in turn transfers applied mechanical loads through the implant, resulting in fatigue failure of the plate or failure at the bone–screw interface.

A unique type of nondisplaced femoral neck fracture is a stress fracture. These fractures can occur in younger active patients or elderly osteoporotic patients and can be located on the compression or tension side of the femoral neck. These fractures are classified as fatigue and insufficiency fractures that result from mechanically malaligned cyclic loading across the femoral neck, and in osteoporotic patients, impaired bone quality [49]. It is essential to identify these fractures early to prevent fracture displacement.

Management is dependent on fracture location. In general, non-displaced stress fractures of the femoral neck localized on the compression side may be treated non-operatively with protected weight bearing and close observation for 6–8 weeks. In elderly patients with insufficiency fractures, a thorough endocrine workup should be performed to detect and treat any underlying metabolic bone pathology. Younger patients should be educated on appropriate training activities. Non-displaced fractures on the tension side of the femoral neck are at increased risk for fracture displacement and require internal fixation. Endocrine workup and activity modification should be instituted in the respective populations, similar to compression-sided fractures. Operative fixation is similar to internal fixation treatment of traumatic non-displaced and impacted fractures.

Displaced Fractures

Operative options for displaced (unstable) femoral neck fractures (Garden III and IV) include closed reduction and internal fixation (CRIF), open reduction and internal fixation (ORIF), HA, and total hip arthroplasty (THA). Selection of the appropriate implant for a particular patient requires individualized assessment of patient-related (eg, activity level, life expectancy, medical comorbidities) and fracture-related (eg, location, orientation, comminution) factors. It is important to note that the indications for particular treatment modalities are very heterogeneous among orthopedic surgeons, although there has been a recent push toward establishing algorithms and hospital care pathways.

Closed or Open Reduction and Internal Fixation

For young adults and some active older individuals, the treatment of choice is either CRIF or ORIF with cancellous lag screws or an SHS. CRIF may also be suitable for severely infirmed or nonambulatory patients who are unfit to undergo a major surgical procedure such as arthroplasty. If CRIF or ORIF is selected as the operative management method, it is paramount for a surgeon to

realize that the accuracy of anatomic reduction is critical; malreduction is a strong indicator for fracture healing complications, lower functional recovery, and subsequent reoperation [56-60].

The acceptable reduction criteria for displaced femoral neck fractures is a neck-shaft angle between 130 and 150 degrees and 0 and 15 degrees of anteversion [27]. Up to 15 degrees of valgus angulation is acceptable, as it may increase stability especially in cases with significant posterior comminution. Conversely, varus angulation, inferior offset, and retroversion are not acceptable and must be corrected, as these factors significantly increase the potential for nonunion, loss of reduction, and osteonecrosis [27]. Although closed reduction maneuvers may be successful in certain cases to achieve acceptable reduction, there should be no hesitancy to proceed open reduction using an anterior (Smith-Peterson) or anterolateral (Watson-Jones) approach to visualize the fracture and attain anatomic alignment if necessary [28].

The Smith-Peterson approach uses the interval between the *sartorius* and *tensor fascia latae* muscles; it provides excellent exposure of the anterior femoral neck including the subcapital region but requires an additional surgical approach to place internal fixation. The Watson-Jones approach uses the interval between the *tensor fascia latae* and *gluteus medius* muscles and can be used to insert internal fixation but provides limited exposure of the subcapital region. It is best used to open reduction of more lateral femoral neck fractures. If the fracture is not exposed, hematoma decompression performed by capsular release to relieve pressure on the femoral head vasculature has been advocated to decrease the risk for osteonecrosis. However, this practice is not completely supported in the current literature; a number of studies have found no difference in patient outcomes whether a capsular release is performed. Once anatomic reduction is achieved, the techniques and principles for internal fixation of displaced fractures using cancellous lag screws (Fig. 1) or an SHS (Fig. 2) are similar to that described for nondisplaced fractures [28].

Displaced Pauwel type I and most type II fractures may be effectively managed with 3 parallel cancellous lag screws inserted in an inverted triangular configuration, entering at or above the level of the lesser trochanter [11]. For Pauwel type III, basicervical, and highly comminuted unstable fracture patterns, an SHS offers greater mechanical stability to resist the increased shear forces and should be used in place of cancellous screws [29]. The use of an antirotational screw or pin to prevent malreduction during SHS cephalic screw insertion should be considered (Fig. 2); one should try to achieve a tip-apex distance of 25 mm to minimize potential lag screw cutout [19]. A recent meta-analysis comparing CRIF with ORIF of displaced femoral neck fractures has found a significantly higher rate of osteonecrosis with CRIF but no difference in fracture union [30].

Bedi et al. [27] investigated the outcomes of internal fixation in 51 younger individuals (range, 15–50 years) who sustained a displaced femoral neck fracture and reported a 27% rate of osteonecrosis and a 9.8% rate of nonunion. In patients who had a good to excellent reduction, the osteonecrosis rate was 24% and nonunion rate was 4%. In contrast, 4 of 5 patients (80%) who had a fair to poor primary reduction developed osteonecrosis, nonunion, or both. Based on this and other studies, approximately one-third of femoral neck fractures treated with internal fixation require subsequent operative intervention [31].

An international multicenter randomized control study known as the fixation using alternative implants for the treatment of hip fractures (FAITH) trial has been established to compare cancellous lag screws versus SHS in the management of femoral neck fractures, with the main objective to analyze revision rates at 24 months [76]. The FAITH trial will further focus on assessing health-related quality of life, functional outcome, health state services, fracture healing, mortality, and adverse fracture-related complications in patients with both non-displaced and displaced femoral neck fractures. As the results of this randomized control trial emerge, there will hopefully be more definitive evidence indicating appropriate internal fixation methods for specific fracture patterns and patient characteristics.

Arthroplasty

Arthroplasty (HemiArthroplasty (HA) and total hip arthroplasty (THA)) is the treatment of choice for most older individuals who sustain a displaced femoral neck fracture [32].

HA has been established as an effective management option resulting in excellent pain relief, early mobilization, and good long-term return to function in the sedentary elderly (Fig. 4). As patients are living longer with healthier and active lives, THA has been gaining popularity as an appropriate treatment option in elderly patients and those with preexisting symptomatic osteoarthritis (Fig. 5). It is recognized that acute arthroplasty, used for the management of hip fractures, carries higher risks than the one used for elective arthroplasty procedures. Parvizi et al. [33] reported a 2.4% 30-day mortality rate in femoral neck fracture patients treated with arthroplasty (HA or THA) and noted it to be approximately 10 times higher than the rate after elective hip arthroplasty.

Available HA implants have a number of different options including cemented and uncemented (press-fit) stems, unipolar and bipolar heads, and fixed-neck and modular-neck designs. Cemented femoral stems remain the standard of care with good long-term results [34].

There is a valid concern regarding the occurrence of intraoperative sudden death due to cardiopulmonary compromise that may occur during cementing [33]. However, recognition of this serious complication has led to modifying cementing techniques, which have resulted in a 3-fold

decrease in intraoperative mortality rates. Alternatively, uncemented (press-fit) stems obviate the need for cement and potential for cement-associated cardiopulmonary complications. Uncemented stems are gaining greater acceptance as viable “first-choice” arthroplasty implants for the treatment of femoral neck fractures, with many studies reporting equivalent or better functional results when compared with cemented stems and shorter operative time, lower blood loss, and no difference in complication or reoperation rates [35]. There is evidence, however, that uncemented stems are at an elevated risk for intraoperative and postoperative periprosthetic fracture; furthermore, some studies report increased pain and poorer functional outcomes with the use of uncemented stems compared with cemented stems for the treatment of femoral neck fractures in the elderly [36]. With these conflicting bodies of evidence, there continues to be a debate “to use or not to use” the cement. In our experience, cemented stems become increasingly appropriate as bone quality diminishes, and uncemented stems are best indicated in patients who are at higher risk for cardiovascular and pulmonary complications.

A direct anterior (Smith-Peterson), posterior (Moore), lateral (Hardinge), or anterolateral (Watson-Jones) approach may be used to perform hip arthroplasty, and selection of one approach over another is generally surgeon specific [37]. Although the majority of studies report similar outcomes and complication rates between operative approaches, there may be higher dislocation rates by using the posterior approach. In addition, some evidence indicates that the direct anterior approach improves early postoperative mobilization, pain, and patient satisfaction [37]. It is important to recognize that when compared with HA, total hip replacement necessitates a more extensive exposure for implantation with higher blood loss and increased potential for perioperative complications.

The most commonly used femoral stems are fixed-neck angle implant designs. Modular-neck femoral stems are also available, although there has been concern regarding failure of these designs [38]. Potential issues with modular neck and head designs are the possibility of trunnionosis [39] and component dissociation at the head-neck and neck-stem interfaces. Although these complications are rarely encountered, they may be considered in cases with new onset hip pain or dysfunction after arthroplasty. With respect to HA modular head design, there remains controversy between unipolar and bipolar heads. Although a number of investigators have found no differences between unipolar and bipolar designs [40], some authors report an increased rate of acetabular erosion, higher mortality and dislocation rates, and diminished functional results with unipolar HA [41]. Conversely, Leonardsson et al. [42] reported higher dislocation rates with bipolar implants. One difference between the 2 head types is the possible higher cost of bipolar implants. They recommended reducing costs using unipolar HA for the treatment of femoral neck fractures in

the elderly, as bipolar implants showed no advantage over unipolar heads in multiple studies.

There has been increasing interest in the use of THA for the treatment of active elderly patients who have sustained a displaced femoral neck fracture (Fig. 5). The goal of treatment is to return the patient to his/her previous level of function and provide cost-effective management. In properly selected patients, this is best accomplished through the use of THA. A study evaluating changing treatment patterns for the management of femoral neck fractures in recent graduates of orthopedic training programs reported that the use of THA as a primary treatment option had increased from 0.7% in 1999 to 7.7% in 2011 [32]. The same study showed that significantly more patients younger than 75 years were managed using THA in 2011 (13.1%) than in 1999 (1.4%).

Comparison of THA to HA and ORIF has shown no difference in 30-day mortality rates but potentially a higher rate of respiratory complications with THA [112]. Improvements in patient-based outcomes and function have been reported with THA compared with HA and internal fixation [44]. Studies have also shown lower reoperation rates and better pain relief with THA but a higher dislocation rate when compared with HA [114-118]. Although THA prostheses are more expensive, the overall cost may be less when taking into account longer implant survival, lower reoperation rate, and improved functional results [45].

Multiple investigators have reported that patients treated with THA after displaced femoral neck fracture have a longer interval to revision surgery or death and improved functional outcomes compared with HA and internal fixation [44].

Heetveld et al. [31] recognized the potential benefits of THA over other management options for the treatment of femoral neck fractures but emphasized that larger trials are necessary to verify these findings especially in younger patient groups.

Hedback et al. [46] reported better quality of life and hip function over a 4-year follow-up period in patients with femoral neck fracture treated with THA in comparison with those treated with HA. Tidermark et al. [47] described their experience with THA versus internal fixation in elderly patients (mean age, 80 years) at 12 and 24 months of follow-up and found a 36% hip complication rate in the internal fixation group in contrast to 4% in the THA group. The authors also noted a 42% versus 4% revision rate for internal fixation (2 cannulated screws) and THA, respectively, as well as improved hip function, less pain, and better mobility. In regard to THA implant survivorship in patients managed for femoral neck fractures, Lee et al. [127] found that 94% implants were retained at 10 years of follow-up. It should be noted that in all of these studies, patients who were treated with THA were independent ambulators before femoral neck fracture with no significant cognitive deficits.

Conclusion

CRIF or ORIF is indicated for displaced femoral neck fractures in younger individuals, some active elderly, and those patients who are medically unfit and might not tolerate a more extensive arthroplasty option. Patients and their families should be counseled on the high risk for fixation failure and need for revision surgery.

HA is a good option for lower demand ambulatory older individuals. The decision to use a unipolar versus bipolar head, surgical approach, and need to cement or press-fit the stem should be based on multiple factors including patient bone quality, implant cost, and surgeon prior experience.

THA is a good option for the active elderly and those with preexisting acetabular disease.

References

- National hospital discharge survey (NHDS), National Center for Health Statistics. Available at: http://205.207.175.93/hdi/ReportFolders/ReportFolders.aspx?IF_ActivePath=P,18External. Accessed December 31, 2014.
- Gullberg B, Johnell O, Kanis JA. World-wide projections for hip fracture. *Osteoporos Int*. 1997; 7: 407–413. DOI: 10.1007/pl00004148.
- Jordan KM, Cooper C. Epidemiology of osteoporosis. *Best Pract Res Clin Rheumatol*. 2002; 16: 795–806. DOI: 10.1053/berh.2002.0264.
- Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int*. 2006; 17:1726–1733. DOI: 10.1007/s00198-006-0172-4.
- Heikal S, Riou P, Jones L. The use of computed tomography in identifying radiologically occult hip fractures in the elderly. *Ann R Coll Surg Engl*. 2014; 96:234–237. DOI: 10.1308/003588414x13824511650533.
- Hakkarinen DK, Banh KV, Hendey GW. Magnetic resonance imaging identifies occult hip fractures missed by 64-slice computed tomography. *J Emerg Med*. 2012; 43:303–307. DOI: 10.1016/j.jemermed.2012.01.037.
- Gaspar D, Crnkovic T, Durovic D, et al. AO group, AO subgroup, Garden and Pauwels classification systems of femoral neck fractures: are they reliable and reproducible? *Med Glas (Zenica)*. 2012;9:243–247.
- Kim JW, Byun SE, Chang JS. The clinical outcomes of early internal fixation for undisplaced femoral neck fractures and early full weight-bearing in elderly patients. *Arch Orthop Trauma Surg*. 2014; 134: 941–946. DOI: 10.1007/s00402-014-2003-y.
- AAOS evidence-based guidelines for management of hip fractures in the elderly, adopted by the American Academy of Orthopaedic Surgeons Board of Directors September 5, 2014. Available at: <http://www.aaos.org/Research/guidelines/HipFxGuideline.pdf>. Accessed December 31, 2014.
- Bjorgul K, Reikeras O. Outcome of undisplaced and moderately displaced femoral neck fractures. *Acta Orthop*. 2007; 78: 498–504. DOI: 10.1080/17453670710014149.
- Papanastassiou ID, Mavrogenis AF, Kokkalis ZT, et al. Fixation of femoral neck fractures using divergent versus parallel cannulated screws. *J Long Term Eff Med Implants*. 2011; 21: 63–69. DOI: 10.1615/jlongtermeffmedimplants.v21.i1.50.
- Bishop JA, Behn AW, Castillo TN. The biomechanical significance of washer use with screw fixation. *J Orthop Trauma*. 2014; 28:114–117. DOI: 10.1097/bot.0b013e31829f9805.
- Gjertsen JE, Fevang JM, Matre K, et al. Clinical outcome after undisplaced femoral neck fractures. *Acta Orthop*. 2011; 82:268–274. DOI: 10.3109/17453674.2011.588857.
- Kain MS, Marcantonio AJ, Iorio R. Revision surgery occurs frequently after percutaneous fixation of stable femoral neck fractures in elderly patients. *Clin Orthop Relat Res*. 2014; 472:4010–4014. DOI: 10.1007/s11999-014-3957-3.
- Lapidus LJ, Charalampidis A, Rundgren J, et al. Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. *J Orthop Trauma*. 2013; 27:386–390; discussion 90–91. DOI: 10.1097/bot.0b013e318281da6e.
- Parker MJ, Raghavan R, Gurusamy K. Incidence of fracture-healing complications after femoral neck fractures. *Clin Orthop Relat Res*. 2007; 458:175–179. DOI: 10.1097/bla.0b013e3180325a42.
- Stiasny J, Dragan S, Kulej M, et al. Comparison analysis of the operative treatment results of the femoral neck fractures using side-plate and compression screw and cannulated AO screws. *Ortop Traumatol Rehabil*. 2008;10:350–361.
- Bray TJ. Femoral neck fracture fixation. Clinical decision making. *Clin Orthop Relat Res*. 1997; 339:20–31. DOI: 10.1097/00003086-199706000-00004.
- Saglam N, Kucukdurmaz F, Kivilcim H, et al. Biomechanical comparison of antirotator compression hip screw and cannulated screw fixations in the femoral neck fractures. *Acta Orthop Traumatol Turc*. 2014; 48:196–201. DOI: 10.3944/aott.2014.3159.
- Pervez H, Parker MJ, Vowler S. Prediction of fixation failure after sliding hip screw fixation. *Injury*. 2004; 35: 994–998. DOI: 10.1016/j.injury.2003.10.028.
- Parker M, Cawley S, Palial V. Internal fixation of intracapsular fractures of the hip using a dynamic locking plate: two-year follow-up of 320 patients. *Bone Joint J*. 2013;95-B(10):1402–1405. DOI: 10.1302/0301-620x.95b10.31511.
- Eschler A, Brandt S, Gierer P, et al. Angular stable multiple screw fixation (Targon FN) versus standard SHS for the fixation of femoral neck fractures. *Injury*. 2014; 45 (suppl 1):S76–S80. DOI: 10.1016/j.injury.2013.10.026.
- Thein R, Herman A, Kedem P, et al. Osteosynthesis of unstable intra-capsular femoral neck fracture by dynamic locking plate or screw fixation: early results. *J Orthop Trauma*. 2014; 28: 70–76. DOI: 10.1097/bot.0b013e3182a225fa.
- Zielinski SM, Keijsers NL, Praet SF, et al. Femoral neck shortening after internal fixation of a femoral neck fracture. *Orthopedics*. 2013; 36: e849–e858.
- Kunapuli SC, Schramski MJ, Lee AS, et al. Biomechanical analysis of augmented plate fixation for the treatment of vertical shear femoral neck fractures. *J Orthop Trauma*. 2014 [epub ahead of print].
- Berkes MB, Little MT, Lazaro LE, et al. Catastrophic failure after open reduction internal fixation of femoral neck fractures with a novel locking plate implant. *J Orthop Trauma*. 2012; 26: e170–e176. DOI: 10.1097/bot.0b013e31823b4cd1.
- Bedi A, Karunakar MA, Caron T, et al. Accuracy of reduction of ipsilateral femoral neck and shaft fractures—an analysis of various internal fixation strategies. *J Orthop Trauma*. 2009; 23: 249–253. DOI: 10.1097/bot.0b013e3181a03675.
- Ly TV, Swiontkowski MF. Treatment of femoral neck fractures in young adults. *J Bone Joint Surg Am*. 2008; 90: 2254–2266.
- Collinge CA, Mir H, Reddix R. Fracture morphology of high shear angle “vertical” femoral neck fractures in young adult patients. *J Orthop Trauma*. 2014; 28:270–275. DOI: 10.1097/bot.0000000000000014.

29. Wang W, Wei J, Xu Z, et al. Open reduction and closed reduction internal fixation in treatment of femoral neck fractures: a meta-analysis. *BMC Musculoskelet Disord.* 2014; 15:167. DOI: 10.1186/1471-2474-15-167.
30. Heetveld MJ, Rogmark C, Frihagen F, et al. Internal fixation versus arthroplasty for displaced femoral neck fractures: what is the evidence? *J Orthop Trauma.* 2009; 23: 395–402. DOI: 10.1097/bot.0b013e318176147d.
31. Miller BJ, Callaghan JJ, Cram P, et al. Changing trends in the treatment of femoral neck fractures: a review of the American board of orthopaedic surgery database. *J Bone Joint Surg Am.* 2014; 96: e149.
32. Parvizi J, Ereth MH, Lewallen DG. Thirty-day mortality following hip arthroplasty for acute fracture. *J Bone Joint Surg Am.* 2004; 86-A(9): 1983–1988.
33. Viberg B, Overgaard S, Lauritsen J, et al. Lower reoperation rate for cemented hemiarthroplasty than for uncemented hemiarthroplasty and internal fixation following femoral neck fracture: 12-to 19-year follow-up of patients aged 75 years or more. *Acta Orthop.* 2013; 84: 254–259. DOI: 10.3109/17453674.2013.792033.
34. Bell KR, Clement ND, Jenkins PJ, et al. A comparison of the use of uncemented hydroxyapatite-coated bipolar and cemented femoral stems in the treatment of femoral neck fractures: a case-control study. *Bone Joint J.* 2014; 96-B (3): 299–305. DOI: 10.1302/0301-620x.96b3.32271.
35. Langslet E, Frihagen F, Opland V, et al. Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures: 5-year follow-up of a randomized trial. *Clin Orthop Relat Res.* 2014; 472:1291–1299. DOI: 10.1007/s11999-013-3308-9.
36. Rogmark C, Fenstad AM, Leonardsson O, et al. Posterior approach and uncemented stems increases the risk of reoperation after hemiarthroplasties in elderly hip fracture patients. *Acta Orthop.* 2014; 85:18–25. DOI: 10.3109/17453674.2014.885356.
37. Krishnan H, Krishnan SP, Blunn G, et al. Modular neck femoral stems. *Bone Joint J.* 2013; 95-B(8):1011–1021. DOI: 10.1302/0301-620x.95b8.31525.
38. Shulman RM, Zywiell MG, Gandhi R, et al. Trunnionosis: the latest culprit in adverse reactions to metal debris following hip arthroplasty. *Skeletal Radiol.* 2014 [epub ahead of print]. DOI: 10.1007/s00256-014-1978-3.
39. Liu Y, Tao X, Wang P, et al. Meta-analysis of randomised controlled trials comparing unipolar with bipolar hemiarthroplasty for displaced femoral-neck fractures. *Int Orthop.* 2014;38:1691–1696. DOI: 10.1007/s00264-014-2355-5.
40. Kanto K, Sihvonen R, Eskelinen A, et al. Uni-and bipolar hemiarthroplasty with a modern cemented femoral component provides elderly patients with displaced femoral neck fractures with equal functional outcome and survivorship at medium-term follow-up. *Arch Orthop Trauma Surg.* 2014; 134:1251–1259.
41. Leonardsson O, Karrholm J, Akesson K, et al. Higher risk of reoperation for bipolar and uncemented hemiarthroplasty. *Acta Orthop.* 2012; 83:459–466.
42. Fisher MA, Matthei JD, Obirize A, et al. Open reduction internal fixation versus hemiarthroplasty versus total hip arthroplasty in the elderly: a review of the National Surgical Quality Improvement Program database. *J Surg Res.* 2013; 181:193–198. DOI: 10.1016/j.jss.2012.07.004.
43. Burgers PT, Van Geene AR, Van den Bekerom MP, et al. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis and systematic review of randomized trials. *Int Orthop.* 2012; 36:1549–1560. DOI: 10.1007/s00264-012-1569-7.
44. Carroll C, Stevenson M, Scope A, et al. Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: a systematic review and cost-effectiveness analysis. *Health Technol Assess.* 2011;15: 1–74.
45. Hedbeck CJ, Enocson A, Lapidus G, et al. Comparison of bipolar hemiarthroplasty with total hip arthroplasty for displaced femoral neck fractures: a concise four-year follow-up of a randomized trial. *J Bone Joint Surg Am.* 2011;93:445–450. DOI: 10.2106/jbjs.j.00474.
- Tidermark J, Zethraeus N, Svensson O, et al. Quality of life related to fracture displacement among elderly patients with femoral neck fractures treated with internal fixation. 2002. *J Orthop Trauma.* 2003; 17 (8 suppl): S17–S21. DOI: 10.1097/00005131-200309001-00005.
48. Augat P, Bliven E, Eng M, Hackl S. Biomechanics of Femoral Neck Fractures and Implications for Fixation. *J Orthop Trauma* 2019;33:S27–S32. DOI: 10.1097/bot.0000000000001365.
49. Medda S, Snoap N, Carroll E. Treatment of Young Femoral Neck Fractures. *J Orthop Trauma* 2019;33:S1–S6. DOI: 10.1097/bot.0000000000001369.

Сучасне лікування переломів шийки стегнової кістки (Огляд літератури)

Зазірний І.М.¹, Коструб О.О.²

¹Клінічна лікарня “Феофанія” Державного управління справами, м. Київ

²ДУ “Інститут травматології та ортопедії НАМН України”, м. Київ

Резюме. Переломи шийки стегнової кістки часто зустрічаються в ортопедо-травматологічній практиці і призводять до значної інвалідності та смертності. Важливо, щоб ортопеди-травматологи могли розпізнати конкретні структури переломів та характеристики пацієнта, які вказують на використання конкретних імплантатів та методів ефективного лікування цих травм. Використання систем класифікації Garden та Pauwels залишається практичною основою характеристики переломів шийки стегнової кістки, що допомагає обрати відповідне лікування. Операційні варіанти включають фіксацію *in situ*, закрите або відкрите вправлення та внутрішню фіксацію, геміартропластику та тотальну артропластику стегна. Останні публікації демонструють різноманітність варіантів щодо оптимального лікування переломів шийки стегнової кістки, які використовують хірурги-ортопеди, та зміни тенденцій лікування.

Ключові слова: стегнова кістка; шийка; перелом; огляд; травма.

Современное лечение переломов шейки бедренной кости (Обзор литературы)

Зазирный И.М.¹, Коструб А.А.²

¹Клиническая больница "Феофания" Государственного управления делами, г. Киев

²ГУ "Институт травматологии и ортопедии НАМН Украины", г. Киев

Резюме. Переломы шейки бедренной кости часто встречаются в ортопедо-травматологической практике и приводят к значительной инвалидности и смертности. Важно, чтобы ортопеды-травматологи могли распознать конкретные структуры переломов и характеристики пациента, которые указывают на использование конкретных имплантатов и методов эффективного лечения этих травм. Использование систем классификации Garden и Pauwels остается практической основой характеристики переломов шейки бедренной кости, что помогает выбрать соответствующее лечение. Операционные варианты включают фиксацию *in situ*, закрытое или открытое вправление и внутреннюю фиксацию, гемиаартропластику и тотальную артропластику бедра. Последние публикации показывают разнообразие относительно оптимального лечения переломов шейки бедренной кости, которые используют хирурги-ортопеды, и изменения тенденций лечения.

Ключевые слова: бедренная кость; шейка; перелом; обзор; травма.