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FEMORAL NECK FRACTURES, EPIDEMIOLOGY, ANATOMICAL DESCRIPTION, MECHANISM OF ACTION, CLASSIFICATION, CLINICAL EVALUATION, IMAGING EVALUATION, TREATMENT AND COMPLICATIONS

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ABSTRACT

Introduction: *Femoral neck fractures (FNF) are frequent and devastating injuries in orthopedics and traumatology. It usually has several therapeutic options depending on the type of fracture and the comorbidities of the affected individual, among the conservative treatment alternatives are bed rest with or without traction and among the surgical alternatives are internal fixation.*

Objective: *to detail the current information related to femoral neck fractures, epidemiology, anatomical description, mechanism of action, classification, clinical evaluation, imaging evaluation, treatment and complications.*

Methodology: *a total of 40 articles were analyzed in this review, including review and original articles, as well as clinical cases, of which 31 bibliographies were used because the other articles were not relevant to this study. The sources of information were PubMed, Google Scholar and Cochrane; the terms used to search for information in Spanish, Portuguese and English were: fractures, femur, femoral neck, prosthesis, trauma.*

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Results: *80% are generated in women, and the incidence doubles every 5 to 6 years in women over 30 years of age. It presents bimodal incidence. The risk factors are female sex, white race, advanced age, poor health, smoking, alcohol consumption, previous fractures, history of falls and low estrogen concentrations. Magnetic resonance imaging (MRI) is the test of choice for the diagnosis of undisplaced or occult fractures not observable on plain radiographs. Up to 40% of impacted or nondisplaced fractures will displace if they do not undergo internal fixation. Secondary displacement is 5% following internal fixation. Pseudarthrosis may complicate up to 5% of non-displaced fractures and up to 25% of displaced fractures; furthermore, osteonecrosis complicates up to 10% of non-displaced fractures and up to 30% of displaced fractures.*

Conclusions: *femoral neck fractures present a high incidence, the mechanism of action mostly presented in young people is high energy trauma, in the elderly the most common mechanism is low energy falls. Patients with displaced femoral neck fractures are unable to walk and show shortening and external rotation of the lower limb. Anteroposterior projections of the pelvis are indicated, as well as anteroposterior and cross lateral projections of the affected proximal femur. The goals of treatment are to relieve the patient's pain, restore hip function and have rapid mobilization through anatomical reduction and internal fixation or by prosthetic replacement. Conservative treatment of fractures is recommended in individuals at extreme surgical risk; it can also be considered in individuals with dementia, who do not maintain the ability to walk and have little symptomatology due to hip pain. Among the most important complications are pseudarthrosis and osteonecrosis. Surgery to treat nondisplaced femoral neck fractures is associated with a higher number of consolidation and associated with less avascular necrosis compared to conservative treatment.*

KEY WORDS: *fractures, femoral neck, trauma, prosthesis.*

INTRODUCTION

Femoral neck fractures (FNF) are frequent and devastating injuries in orthopedics and traumatology. Studies showed in 1990 approximately 1.3 million hip fractures worldwide, predicting an increase between 7.3 and 21.3 million by the year 2050. The Garden classification is frequently used, which gives an approach in the treatment since it can be a conservative or surgical treatment. Studies show good results with conservative treatment; however, surgical treatment presents optimal results, but it must be kept in mind that all surgery is associated with some risk(1-9).

Low bone mass and low traumatic fractures in aging continue to be of concern. Some osteoporotic hip fractures can be prevented using pharmacological treatments, with various anti-catabolic and anabolic agents that have so far shown results in promoting bone mass and decreasing the risk of osteoporotic hip fracture(10-12) .

The ideal in fractures of the proximal femur is surgical treatment within the first 24 hours, after this time the risk of perioperative complications such as pulmonary embolism, deep vein thrombosis, pneumonia, pressure ulcers and urinary tract infections increases. After 48 hours, the mortality rate increases significantly. Patients operated on within the first 48 hours have approximately a 20% lower risk of death within the next year, primarily individuals with comorbidities favor early surgery(9,13,14).

METHODOLOGY

A total of 40 articles were analyzed in this review, including review and original articles, as well as cases and clinical trials, of which 31 bibliographies were used because the information collected was not important enough to be included in this study. The sources of information were Cochrane, PubMed and Google Scholar; the terms used to search for information in Spanish, Portuguese and English were: fractures, femur, femoral neck, prosthesis, trauma.

The choice of bibliography exposes elements related to femoral neck fractures; in addition to this factor, epidemiology, anatomical description, mechanism of action, classification, clinical evaluation, imaging evaluation, treatment and complications.

DEVELOPMENT

EPIDEMIOLOGY

The incidence doubles every 5 to 6 years in women over 30 years of age. It presents bimodal incidence. The risk factors are female sex, white race, advanced age, poor health, smoking, alcohol consumption, previous fractures, history of falls and low estrogen concentrations. In young people it is mainly associated with high-energy trauma. Most of these fractures occur in the elderly, with a mean age of 72 years, as a result of low-energy falls(15,16).

Hip fractures make up less than 20% of osteoporotic fractures, yet they are the most devastating in terms of morbidity and mortality. More than 50% of individuals who suffer a hip fracture do not regain mobility within the first year after fracture. 1 in 5 women and 1 in 3 men die in the same period as a result of complications(12,17-19).

ANATOMY

In the hip, the femoral head is almost spherical and articulates with the hollow sphere of the facies lunata of the acetabulum. The surface of the articular cavity represents 50% of the area of the femoral head(9).

The cervicodiaphyseal angle has an approximate value of 130° ± 7° and the approximate femoral anteversion is 10° ± 7°. The femoral neck has a small periosteal layer; because of that the bony callus is made by endosteal proliferation. The capsule connects in the anterior portion at the intertrochanteric line. In the posterior portion, the capsule is ligated 1 cm to 1.5 cm above the intertrochanteric line. Three ligaments are inserted here, the ischiofemoral, the iliofemoral or Bigelow's Y ligament and the pubofemoral. It is important to recognize a structure called calcar femoris which is practically a vertically oriented sheet that goes from the posteromedial portion of the femoral diaphysis to the greater trochanter.

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Some forces that exert through the hip joint are remarkable as the elevation of the leg in extension representing 1.5 times the body weight, the monopodal position representing 2.5, the bipedal position representing 0.5 and the running representing 5.0.

In the internal anatomy we have that the direction of the trabeculae is parallel to the direction of the compressive forces, these follow the internal load lines. The vertically oriented bony trabecular arrangement is due to body weight loading through the femoral head, and the horizontal trabeculae are due to the action of the abductor muscles. These two trabecular systems interlock at right angles(15,16).

Bone healing depends on the blood supply to the femoral head, which may be cut off by fracture dislocation or increased intracapsular pressure, and the cellular coverage of the femoral head, which degenerates over time, restricting the entry of osteoprogenitor cells following a femoral neck fracture. In adult individuals, approximately 20% of the femoral neck surface is covered by cellular periosteum. The main blood supply to the femoral head comes from the superior, anterior and inferior retinacular arteries coming from the deep branch of the medial circumflex femoral artery and the arteries of the round ligament. The formation of post-traumatic osteonecrosis of the femoral head is related to the rupture of the retinacular arteries because they are the main blood supply(9,20,21).

Figure 1. Femoral Neck Fracture.

Source: The Authors.

MECHANISM OF INJURY

Fractures of the femoral neck can be caused by high and low energy trauma.

Low energy trauma is more common in the elderly and can be direct as in a fall on the greater trochanter or a forced external rotation applied to the lower limb. They can also be indirect due to muscle traction that exceeds the resistance of the femoral neck. High-energy trauma is more common in young people and is caused by traffic accidents or falls from a great height.

Stress fractures are more common in athletes, conscripts and ballet dancers(15,16).

CLINICAL EVALUATION

Individuals with displaced femoral neck fractures are unable to ambulate, in addition to showing shortening and external rotation of the affected lower limb. Those with stress or impacted fractures may present more subtle findings, such as pain on palpation over the anterior capsule, pain on axial compression, lack of deformity, in addition to being able to walk with the lower limb. In the physical examination, pain is generated when performing hip mobilization, axial compression and palpation over the groin. In low energy fractures, which usually occur in elderly individuals, it is crucial to make a thorough anamnesis. In order to decide the best treatment, it is imperative to ask about the history of alteration or loss of consciousness, previous syncope, clinical history, chest pain, previous hip pain and ambulation capacity before the fracture. In all affected individuals, a complete secondary examination should be performed to discover associated alterations(15,16).

IMAGE EVALUATION

Anteroposterior projections of the pelvis are indicated, as well as anteroposterior and lateral cross views of the affected proximal femur. Radiography with the injured hip in internal rotation can

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be used to define the fracture pattern and treatment. Computed tomography (CT) may be used in the polytraumatized individual. Abdominal and pelvic slices can aid in the diagnosis of nondisplaced femoral neck fractures. Magnetic resonance imaging (MRI) is the test of choice for the diagnosis of nondisplaced or occult fractures not visible on plain radiographs. Scintigraphy or CT is saved for individuals who have contraindications to MRI(15,16).

Figure 2. Pelvis X-Ray showing a Femoral Neck Fracture to the left.

Source: The Authors.

Figure 3. Radiographs of the Proximal Femur, with presence of fracture.

Source: The Authors.

CLASSIFICATION

There are three common classifications for femoral neck fractures: the Garden classification, the Pauwels classification and the AO classification.

Pauwel's classification: based on the angle between the fracture line and the horizontal, biomechanical forces that add pressure on the fracture line.

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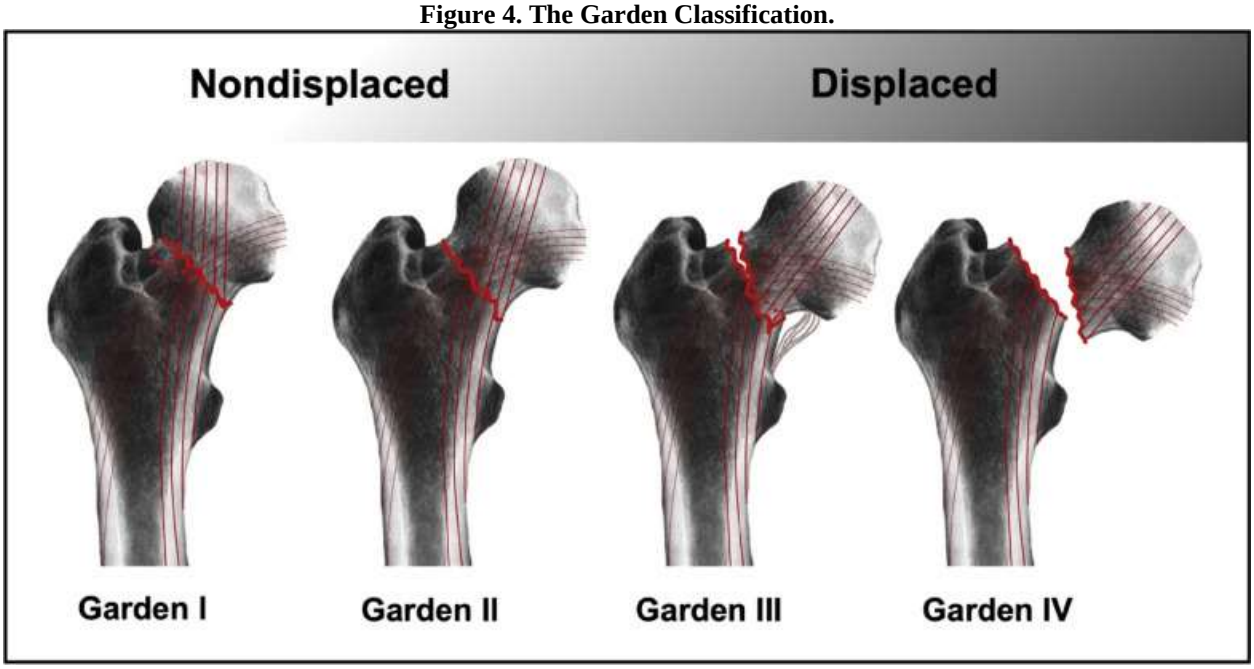
- Type I: 30°.
- Type II: 30° to 70°.
- Type III: > 70°.

The shear force is greater according to the increase of the angle, which generates greater fracture instability.

Garden's classification: is based on the level of valgus displacement. The displacement of the fracture is interrelated with the interruption of the vascular supply, therefore, it is associated with the risk of necrosis of the femoral head.

- Type I: Incomplete fracture-impacted in valgus.
- Type II: Complete fracture not displaced in the anteroposterior and lateral projections.
- Type III: Complete with partial displacement; the trabecular pattern of the femoral head is not aligned with that of the acetabulum.
- Type IV: Completely displaced; the trabecular pattern of the head is oriented parallel to the acetabulum.

Figure 4. The Garden Classification.



Source: Fischer H, Maleitzke T, Eder C, Ahmad S, Stöckle U, Braun KF. Management of proximal femur fractures in the elderly: current concepts and treatment options(9).

The AO classification combines fracture level, degree of displacement and fracture line angle.

In addition, according to their anatomical location, they can be subcapital, transcervical and basicervical, and are also usually described as non-displaced and displaced(9,15,16,22).

TREATMENT

The goals of treatment are to relieve the patient's pain, restore hip function and have rapid mobilization through anatomic reduction and internal fixation or by prosthetic replacement(15).

Adequate algic management should be performed. This is an important factor in the prevention of delirium. In perioperative pain in elderly patients, NSAIDs are not recommended, however, other medications such as paracetamol are indicated unless contraindicated. The next stage in pain control is intravenous or oral opioids accompanied by routine constipation prophylaxis(9,14,23).

If non-NSAIDs and opioids are not sufficient, femoral nerve blocks can be tried. Some studies report moderate-quality evidence for decreasing the risk of pneumonia, decreasing time to first mobilization, and decreasing the value of analgesics following single-injection blocks. High-quality evidence suggests that a regional block decreases pain within half an hour after block placement(9,24).

In patients with femoral fracture, routine laboratory tests are recommended such as:

- Complete blood count.
- Inflammatory markers such as CRP.
- INR
- Partial thromboplastin time.
- Basic metabolic profile.

Because affected individuals with femoral neck fractures are often prone to dehydration, venous hydration is likely to be needed. A flow rate of 100-200 ml/h for isotonic crystalloids is considered safe. However, volume status must be managed carefully, and because many elderly individuals have cardiac

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comorbidities, predisposing them to heart failure triggered by volume overload(9,14).

Conservative treatment of fractures is recommended in individuals at extreme surgical risk; it can also be considered in individuals with dementia, who do not maintain the ability to walk and have little symptomatology due to hip pain. Early mobilization from bed to chair is vital to reduce the risks and complications of prolonged bed rest, such as retention of respiratory secretions, venous stasis, decubitus ulcers and atelectasis.

Stress Fractures

Compression cortical stress fractures: minimal risk of displacement in the absence of other trauma; can walk with crutches until symptoms disappear. Surgery only if resistant pain.

Stress cortex overload fractures: high risk of secondary displacement; osteosynthesis with screws in situ is indicated.

Impacted Fractures and Undisplaced Fractures.

Up to about 40% of these fractures will displace if internal fixation is not performed. Secondary displacement is 5% following internal fixation. In situ fixation with three cancellous screws is recommended, except in osteoarthritis or severe rheumatoid arthritis, pathologic fractures, Paget's disease and other disorders; these individuals warrant a hip prosthesis(15,16).

Figure 5. Intraoperative of bipolar hip prosthesis.

Source: The Authors.

Displaced Fractures.

- Elderly: controversial management.
- High functional demands and good bone quality: total hip prosthesis of first choice, although reduction, open or closed and fixation can be considered, with a reoperation rate of 40%.
- Low demands and poor bone quality: hemiarthroplasty with a cemented unipolar partial prosthesis.
- With severe disease, dementia or bedridden: conservative treatment, if pain is intolerable, prosthetic replacement.

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- Young people with high energy lesion and normal bone: urgent reduction, closed or open, with internal fixation and capsulotomy. A fixed angle implant may be considered.

Rationale for Surgical Treatment

Femoral neck fractures can be treated by osteosynthesis, total hip arthroplasty or hemiarthroplasty. In individuals over 70 years of age with more than one comorbidity there is an elevated risk of approximately 83% of secondary fractures or dislocations when managed conservatively, demonstrating that the surgical procedure is the first line treatment for these individuals.

Early reduction of the fracture site is essential if possible because the risk of osteonecrosis may increase with time. Some reviews show that the quality of the reduction is the most notable predictor of fixation loss that the orthopedist can play a role in.

Fracture Reduction Maneuver

It is done by flexion of the hip with gentle traction and external rotation to disengage the fragments; subsequently, to obtain the reduction, the limb is slowly put in extension and internal rotation. Subsequently, it should be confirmed by anteroposterior and lateral radiographs.

To consider that the reduction is acceptable, an anatomical or valgus alignment should be evaluated in the anteroposterior projection, it should be evidenced that the hip maintains anteversion and does not show posterior translation of the fracture surfaces in the lateral projection. In addition, the level of posterior comminution should be evaluated.

Internal Fixation

The sliding screw-plate helps resistance to shear forces in fractures with a high Pauwel's angle; when this procedure is performed, a second screw or nail should be placed superiorly to maintain rotation at the insertion of the cephalic screw.

Multiple screw fixation is usually more accepted to stabilize the fracture; the screw thread should pass through the fracture site to provide compression. It should be performed with 3 parallel screws; placing more screws does not provide greater stability; on the contrary, it increases the risk of entering the joint. The screws must show an inverted triangle disposition, with one of them adjacent to the inferior part of the femoral neck and the other adjacent to the posterior part. It is advisable not to place the screws below the lesser trochanter in order to avoid stress accumulation and the risk of a subtrochanteric fracture.

Prosthesis

The hip prosthesis has some advantages over internal fixation, such as faster recovery, as well as early ambulation with full weight bearing, eliminates the possibility of osteonecrosis, pseudoarthrosis and fixation failure. However, it also has some disadvantages due to the fact that it is a more invasive technique, such as greater blood loss.

Monopolar Versus Bipolar Implants

The unipolar implant is cheaper. At the moment no results have been seen in which bipolar implants have greater advantages over unipolar implants, due to the fact that with time, bipolar implants can lose mobility in their internal articulation, becoming functionally unipolar implants.

Cemented Arthroplasty Compared to Uncemented.

Cemented arthroplasty presents a lower incidence of intraoperative fractures, however the rate of intraoperative hypotension and death during cement pressurization increases.

Primary Total Hip Arthroplasty.

Currently, the use of total hip prostheses has increased in the acute treatment of displaced fractures of the femoral neck. There is great scientific evidence that in hip arthroplasties, cemented implants generate less postoperative pain, which translates into better mobility. It is the standard treatment of choice in active patients due to better functionality and a lower reoperation rate. A cemented femoral stem leads to better fixation in osteoporotic bone. Several studies show better functional results compared to hemiarthroplasty and internal fixation, however total hip arthroplasty may be associated with a higher rate of dislocation. Finally, primary total hip arthroplasty eliminates the probability of acetabular erosions such as those seen in partial prostheses(9,15,16,25,26).

Hemiarthroplasty presents superiority when it comes to operation time and dislocation rate. Factors interconnected with the procedure, such as surgical approach, component positioning, soft tissue tension, orthopedic expertise and implant-related factors, play an important role in the risk of dislocation following total hip arthroplasty(9,26-29).

Systemic administration of tranexamic acid can decrease blood loss and transfusion rates and can be performed to control bleeding in anticoagulated individuals. However, there is still a lack of evidence on the optimal regimen, timing and dosage(9,30).

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Figure 6. Post-Surgical Bipolar Hip Prosthesis Fluoroscopy.

Source: The Authors

COMPLICATIONS

Affected individuals benefit from early mobilization because it reduces complication rates, as well as the risk of pneumonia, pressure ulcers, thromboembolism, and delirium.

Posterior pseudarthrosis of open reduction with internal fixation sometimes appears at around 12 months and shows as pain in the groin and gluteal region with hip extension or weight bearing. It complicates up to 5% of non-displaced fractures and up to 25% of displaced fractures. Older individuals with pseudarthrosis can be managed well with arthroplasty. Younger patients may benefit from a proximal femoral osteotomy. Some other techniques, such as cancellous bone grafting or pedicled muscle grafting, are no longer as commonly used.

Osteonecrosis following open reduction with internal fixation may show as pain in the groin, gluteal region or proximal thigh; it may be seen in up to 10% of non-displaced fractures and up to 30% of displaced fractures. Collapse is not perceived on radiographs in all cases. Treatment will be correlated with symptoms.

- ➢ Early without radiological changes: unloaded ambulation is performed. Central decompression may be used.
- ➢ Late with radiological changes: in older patients an arthroplasty can be performed, while in younger patients osteotomy, arthrodesis or arthroplasty can be performed.

Failure of fixation after open reduction with internal fixation is usually correlated with osteoporotic bone or technical drawbacks. Open reduction with internal fixation may be reattempted, or a prosthetic exchange may be attempted. Implants may protrude due to fracture collapse and screw displacement.

Dislocation can occur after the placement of a prosthesis, being more common in total hip prostheses compared to hemiarthroplasty, with an overall incidence of 1% to 2%(15,16,31).

CONCLUSIONS

Femoral neck fractures present a high incidence, the mechanism of action mostly presented in young people is high energy trauma, in the elderly the most common mechanism is low energy falls. Patients with displaced femoral neck fractures are unable to walk and show shortening and external rotation of the lower limb. Anteroposterior projections of the pelvis are indicated, as well as anteroposterior and cross lateral projections of the affected proximal femur. The goals of treatment are to relieve the patient's pain, restore hip function and have rapid mobilization through anatomical reduction and internal fixation or by prosthetic replacement. Conservative treatment of fractures is recommended

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in individuals at extreme surgical risk; it can also be considered in individuals with dementia, who do not maintain the ability to walk and have little symptomatology due to hip pain. Among the most important complications are pseudarthrosis and osteonecrosis. Surgery to treat non-displaced femoral neck fractures is associated with a higher number of consolidation and associated with less avascular necrosis compared to conservative treatment.

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Conflict of Interest Statement

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