FEMORAL NECK FRACTURES IN YOUNG PATIENTS

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Summary
Femoral neck fractures in young adults are uncommon. They usually occur as a result of high-energy trauma and patients often have associated injuries. Osteonecrosis of the femoral head and nonunion are the two most common and challenging complications. The key factors in treating femoral neck fractures should include early diagnosis, early surgery, anatomic reduction, capsular decompression and stable internal fixation.
Key words: femoral neck, anatomical reduction, management, complications

Rezumat. Fracturi de col femoral la pacienţii tineri
Fracturile de col femoral la pacienţii tineri sunt neobişnuite, sunt cauzate de un traumatism de energie înaltă şi pacienţi deseori au diferite leziuni asociate. Complicaţii cele mai severe şi des întâlnite sunt osteonecroza capului femoral şi fractura neconsolidată. Factori+cheie în tratamentul fracturilor de col femoral trebuie să fie diagnosticul precoce, intervenţia chirurgicală efectuată la timp, reducerea anatomică, decompresia capsulei şi fixarea internă stabilă.
Cuvinte-cheie: col femoral, reducere anatomică, management, complicaţii

Резюме. Переломы шейки бедра у молодых пациентов
Переломы шейки бедра у молодых пациентов встречаются нечасто. Обычно эти переломы являются результатом высокоэнергетической травмы, и такие пациенты имеют много сочетанных повреждений. Остеонекроз головки бедра и несрастающийся перелом являются самыми частыми и сложными осложнениями. Основные ключевые пункты в лечении таких переломов – это ранняя диагностика и хирургическое лечение, анатомическая репозиция, декомпрессия капсулы и стабильная внутренняя фиксация.
Ключевые слова: шейка бедра, анатомическая репозиция, лечение, осложнения

Introduction

Stress fractures of the femoral neck are uncommon, but they may have serious consequences. Femoral neck fractures comprise 5-10% of all stress fractures. Intracapsular femoral neck fractures are commonly seen in the elderly population after a trivial fall. However, femoral neck fractures in adults younger than age 50 years are uncommon and often the result of high-energy trauma. They account for only 2-3% of all femoral neck fractures [1, 2].

To evaluate and treat femoral neck fractures in young adults, it is important to understand and contrast the differences between elderly and young adult patients. Characteristic differences are seen with respect to the osseous and vascular anatomy, the mechanism of injury, associated injuries, fracture pattern and the goals of treatment. Femoral neck fractures in young adults are associated with higher incidences of femoral head osteonecrosis [2,3] and nonunion [4]. The rate of osteonecrosis reported in the literature ranges from 12-86% in young patients after femoral neck fracture [3, 4, 5]. This devastating complication may lead to collapse of the femoral head and subsequent osteoarthritis. Reoperation and salvage procedures such as osteotomy have high failure rates and arthroplasty procedures are not ideal given the young age and higher levels of activity. While achieving an anatomic reduction and stable internal fixation are imperative, other treatment variables, such as time to surgery, the role of capsulotomy and the fixation methods remain debatable. Knowledge of these treatment options and potential complications

are beneficial in understanding and managing femoral neck fractures in young adults.

It is important to remember that blood supply of the femoral head comes from three main sources; the medial femoral circumflex artery (MFCA), lateral femoral circumflex artery (LFCA) and the obturator artery. In the adult, the obturator artery provides little and variable amount of blood supply to the femoral head via the ligamentous teres. The LFCA gives rise to the inferior metaphyseal artery by way of the ascending branch and provides the majority of the infero-anterior femoral head. The largest contributor to the femoral head, especially the superolateral aspect of the femoral head is the MFCA. The lateral epiphyseal artery complex comes from the MFCA and courses along the posterosuperior aspect of the femoral neck before supplying the femoral head. These terminal branches supplying the femoral head are intracapsular. Thus, disruption or distortion due to fracture displacement of terminal branches to the femoral head plays a significant role in the development of osteonecrosis [5]. Variables that have been hypothesized in contributing to femoral head osteonecrosis include vascular damage from the initial femoral neck fracture [3, 4], the quality of reduction or fixation of the fracture (restoring flow to the distorted arteries) [2] and the elevated intracapsular pressure [4].

In young adults, the mechanism of injury is often high-energy trauma, such as motor vehicle accident or fall from height. Fractures that occur in this normal bone density population require substantial axial load with the hip in an abducted position. The clinical evaluation of these patients requires a thorough trauma workup because they frequently have other associated injuries [4]. Despite this, diagnosis and treatment of femoral neck fractures in young adults should only be superseded by other life and limb-threatening injuries. The clinical presentation of patient with femoral neck fracture will show a shortened, flexed and externally rotated leg. Radiographic evaluation should include antero-posterior (AP) pelvis, AP and lateral plain radiographs of the entire femur. Although uncommon, ipsilateral femoral neck and shaft fractures can occur in 2-6% of all femoral shaft fractures [6]. These concomitant injuries can be challenging to reduce and the best methods of fixation are debatable.

The fracture pattern seen in young adults will be different from the elderly patients. The poor bone quality and fall from a standing height leads to a low-energy injury and results in a femoral neck or intertrochanteric hip fracture; the femoral neck fracture seen in elderly patients will often be subcapital. It is common to see a transverse fracture pattern with impaction at the fracture site. The fracture pattern seen in young adults will be significantly different because of their better bone quality and higher energy mechanism. The axially loaded mechanism onto an abducted hip will often result in a basicervical or more distal neck fracture; the fracture pattern has a tendency to be more vertically oriented and thus is biomechanically more unstable [7, 8, 9]. These characteristics have important implications in terms of obtaining and maintaining stable fixation to allow healing to occur.

Despite known limitations, femoral neck fractures in elderly patients are frequently described using the Garden classification [10]. In this age group, treatment can be recommended based on describing the fracture as nondisplaced (Grade I, II) or displaced (Grade III, IV). The Garden classification is not as useful for describing femoral neck fractures in young adults. Pauwels' classification [7] (**Figure 1**) might be more descriptive and useful because it is based on fracture pattern and is concerned for achieving a stable fixation in femoral neck fracture in the young population. Pauwels' classification is based on the angle of femoral neck fracture relative to the horizontal axis. This biomechanical model implied that Type I femoral neck fracture will have more instrinsic stability because of the compressive forces that predominate. On the other end of the spectrum, Type III femoral neck fractures are more unstable and seen in young adults more frequently. The fracture pattern is more vertically oriented, resulting in increased shear force, varus moment and instability. Type III fracture patterns have been shown to be more difficult to achieve fixation and have higher risk of fixation failure, malunion, nonunion and osteonecrosis [7, 8, 9, 10].

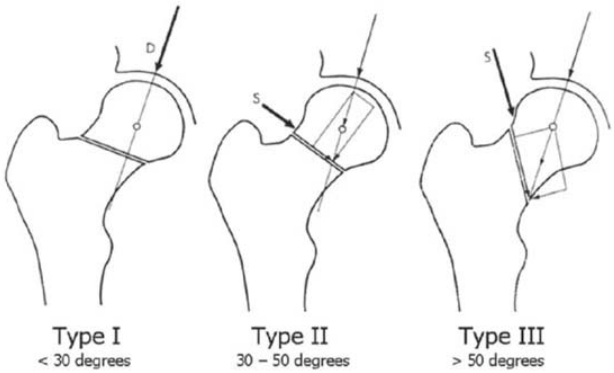

Figure 1. *Pauwels' classification [7].*

Management. The goals of treatment depend on the patient age and are different for the elderly versus the young adults. In the elderly patient, the goals are mobility with weight bearing as tolerated and minimizing complications seen with prolonged bed-rest.

Multiple surgical options are considered; reduction and internal fixation, hemiarthroplasty or total hip arthroplasty. Considerations include the patient's physiological age, level of activity, medical comorbidities and the degree of bone density.

In the young adult there is really only one treatment option and that is to do an open reduction and internal fixation of the femoral neck fracture. The main goals are to preserve the femoral head, avoid osteonecrosis and avoid nonunion. Arthroplasty procedures are not ideal given the younger age and high functional levels. Anatomic reduction and stable internal fixation is paramount for a good outcome. Fixation methods differ, but this is a less controversial topic.

There is good agreement that after life and limb-threatening injuries have been addressed if the patient is hemodynamically stable, surgical fixation of the femoral neck should proceed expeditiously. The injured limb should be left shortened and externally rotated while waiting for surgery. Temporary reduction of the femoral neck fracture by extension and internally rotating the limb should be avoided. It was shown [10] that the intracapsular pressure changes with hip position in femoral neck fracture. Intracapsular pressure is highest when the hip is in extension with internal rotation and decreases significantly when the hip is in flexion with external rotation.

Closed reduction can be attempted by flexing the hip to 45 degrees with slight abduction. This is followed by extending and internally rotating the leg while applying longitudinal traction. Anatomic reduction should be visualized on the fluoroscopic imaging before considering percutaneous fixation. There should be a low threshold to proceed with an open reduction and internal fixation if there is any question about the reduction. We recommend that surgery should be done with the patient in supine position, on a radiolucent table and the leg draped free. This positioning will allow you or other surgical teams to address associated injuries, ease of imaging and good visualization for reducing the femoral neck fracture.

Surgery is accomplished through the Watson-Jones approach (**Figure 2**). A straight lateral incision is made over the lateral proximal femur. The incision is curved anteriorly in the proximal portion toward the gluteal pillar of the ilium. The interval is between the tensor fascia and gluteus medius. The tensor fascia is retracted anteriorly and the gluteus medius is retracted posteriorly. The pericapsular fat needs to be swept off to visualize the anterior hip capsule. One can elevate a little bit of the vastus lateralis off the greater trochanteric ridge for further visualization. A T-capsulotomy, with release of the capsule of the intertrochanteric ridge, is performed in line with the femoral neck. This allows for decompression of the hematoma and direct visualization of the femoral neck fracture. The edges of the capsule can be tagged with nonabsorbable suture for retraction. Inserting a small, pointed Hohmann retractor extracapsularly onto the anterior part of the acetabular rim can help in better visualization.

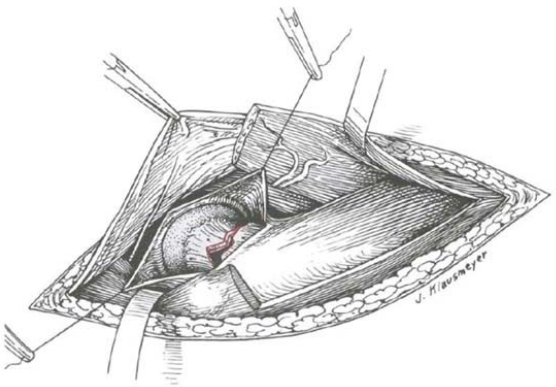

Figure 2. *The Watson-Jones anterolateral exposure to the hip for open reduction of femoral neck fractures [1]*

For the reduction, a bone-hook or a 5 mm Schanz pin can be used on the distal segment of the fracture. The bone-hook can be placed onto the greater trochanter for lateral traction and the leg can be manipulated into external rotation of leg. This will disimpact the fracture and facilitate reduction with an internal rotation maneuver. The alternative is placing an anterior to posterior Schanz pin several centimeters distal to the fracture site and using this to manipulate the fragments. For the proximal segment, 2-0 mm K-wires can be placed into the femoral head and used as joysticks to lift the proximal fragment anteriorly and reduce the fracture. Once the femoral neck fracture is anatomically reduced by direct visualization of the anterior cortex and by flourscopic imaging, then a Weber clamp or 2-0 mm K-wires can provisionally hold the reduction.

Definitive fixation can be accomplished with three cannulated or noncannulated cancellous screws (**Figure 3**). Closure is performed with reapproximating the capsule loosely, followed by layered closure with interrupted absorbable sutures and nylon or staples for the skin. A drain should be placed before the fascial closure.

Postoperative regimen should include postoperative antibiotics for 24 h, deep venous thrombosis prophylaxis with low molecular weight heparin or coumadin for four to six weeks (depending on patient mobility) and physical therapy consultation.

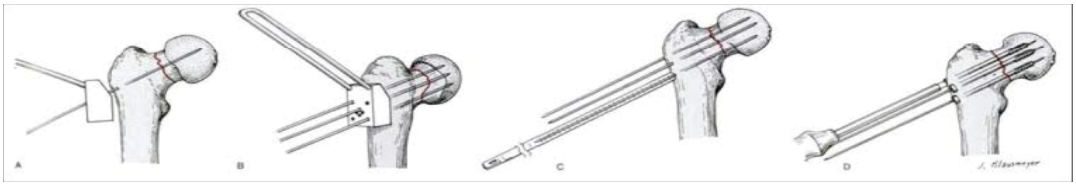

Figure 3. *Internal fixation of a femoral neck fracture with cannulated screws*

The toe-touch weight-bearing with crutches or a walker were allowed for at least eight weeks. Increased weight bearing can be allowed based on the healing seen on routine monthly radiographic follow-ups. If there is evidence of healing at eight weeks, patients are allowed to begin partial weight bearing (up to 50% of body weight) with crutches or walker. Full weight bearing is allowed at 12 weeks. Patients are instructed to wean off the crutches when they are able to ambulate without a significant limp.

Multiple clinical and biomechanical studies have evaluated the type and number of implants (cancellous screws) for treatment of femoral neck fractures [10,11]. The limitations of these studies are that all of these studies are based on osteoporotic bone models. However, the basic biomechanical principle should still be able to be applied to young adults with good bone density. For most femoral neck fractures, the recommended fixation technique is with multiple cancellous lag screws. The use of a fourth screw has not been shown to have a significant increase in mechanical advantage in most femoral neck fractures. However, in femoral neck fractures with posterior comminution, a fourth screw would be beneficial [11].

The sliding hip screw (SHS) is an alternative to consider [9]. Basicervical femoral neck fractures with comminution is a fracture pattern where SHS will provide more stable fixation than three cancellous screws. It was performed a biomechanical study [11] to evaluate three different fixation techniques for treatment of basicervical femoral neck fracture. The authors recommended the use of SHS over the use of multiple cancellous screws. Moreover, they found that a derotation screw located superior to the SHS did not add any increase in fixation after the SHS is placed. However, others recommend still using a derotational screw or a second Kirschner wire to prevent rotation of the femoral head during insertion of the compression screw because of the good bone density in a young adults [1].

Another fracture pattern that would be amenable to SHS is the more vertically oriented femoral neck fracture (Pauwels' Type III). The dominant shear force that is seen with this high-angle fracture pattern lends itself to a higher rate of failure and nonunion [7, 8, 12]. The deformities often seen are varus angulation and inferior translation of the proximal femoral neck/head fragment. Several biomechanical studies [9, 10] have evaluated different implants for managing Pauwels› Type III femoral neck fractures. Bonnaire and Weber [9] looked at four different methods of fixation (SHS with derotational screw, SHS without derotational screw, cancellous screws and a 130 degrees angled blade plate) for Pauwels› Type III cadaveric femoral neck fractures. They concluded that the SHS with the derotational screw is the best implant for this fracture pattern. Routinely using these large compression hip screws does raise concerns about the large amount of bone removed if later reconstruction is required for nonunion, the possibility of damaging the femoral head blood supply if imperfectly placed and their inability to control rotation well without an additional derotational screw [12].

The role of concomitant valgus osteotomy and internal fixation of fresh femoral neck fractures have been reported in the literature [13]. A valgus osteotomy converts the shear force to compressive forces at the fracture site. This increases the stability of the implant and allows for faster healing. For established femoral neck nonunion, there is good literature to support the method of performing a valgus producing osteotomy as a salvage procedure [14, 15, 16]. More recently Magu et al. [13], reported their outcome on 50 adult patients with osteoporosis who underwent a primary valgus intertrochanteric osteotomy for displaced femoral neck fracture. The interval between injury and surgery ranged from three to 30 days (no mean reported). They concluded that this is a dependable procedure for fresh fractures of femoral neck with osteoporosis.

Ly [1] prefers to treat Pauwels' Type III fracture by open reduction and internal fixation with three cannulated screws. Obtaining anatomic reduction and adequate fixation remains the key to successful treatment of femoral neck fractures in young adults, as with any other fractures. Failure is often a result of not achieving these principles. This is best accomplished through an open approach to visualize the fracture, anatomically reduce the fracture and compress it with three parallel and optimal placements of the screws.

Muscle pedicle bone grafting has been reported in the literature as an addition to open reduction and internal fixation of femoral neck fractures [17]. The use of a quadratus femoris muscle pedicle graft provides blood supply to the femoral head, structural bone graft to buttress the posterior femoral neck comminution and enhance stability. The reported rate of nonunion was 10% and of femoral head osteonecrosis was 5%. Usually muscle pedicle bone grafting is not used in acute femoral neck fractures. This adjunctive procedure requires the patient to be placed in a prone position. Often, this is not possible because of multiple injuries and requirement of immediate spine clearance. Other concerns include the extensive dissection required and risk of injuring the medial femoral circumflex artery.

Capsulotomy in femoral neck fractures remains a controversial issue and the practice varies by trauma program, region and country. Clinical studies [18]–show that decompressing the intracapsular hematoma via capsulotomy or aspiration reduces the intracapsular pressures. This decrease in the intracapsular pressure results in improved blood flow to the femoral head and may reduce femoral head ischemia. Most of these studies are small series, single-center and uncontrolled.

The randomized controlled trials with sufficient sample size to draw a definitive conclusion on whether or not capsulotomy should be performed are lacking (**Table 1**).

The conclusion here on the role of capsulotomy is that until there is conclusive data (i.e. prospective and controlled), Ly et al. [1] recommend performing a capsulotomy. It is easy to perform, adds minimal time and risks to the procedure. Most important it may help that small subset of patients who will develop osteonecrosis of the femoral head. The pooled evidence would indicate that intracapsular pressure plays a role in approximately 15% of patients.

The *timing of surgery* for femoral neck fractures remains a controversial topic. The data available is inconclusive on whether this fracture should be operated emergently, urgently or can wait until the next day. Advocates of early surgery suggest that the main advantages of prompt reduction of displaced femoral neck fractures are unkinking the vessels and performing an intracapsular decompression to remove the offending agent of increased intracapsular pressure. This will improve and restore blood flow to the femoral head, thus minimizing the risk of femoral head osteonecrosis [18]. Swiontkowski et al. [1] had previously recommended that treatment of femoral neck fracture should be performed emergently within 8 h after injury. Other studies have also confirmed that early surgery (within 6-12 h) can decrease the rate of femoral head osteonecrosis [2, 19, 20].

Table 1

Summary of literature on femoral neck fractures in young adults [1]

Authors	Year	No. of patients	Osteonecrosis	Capsulotomy
Protzman	1976	22	19	Not reported
Kofoed	1982	17	7	0
Swiontkowski	1984	27	5	17
Tooke	1985	32	6	Not reported
Visuri	1988	12	5	2
Sbih	1989	121	32	Not reported
Gerber	1993	54	5	47
Robinson	1995	46	8	0
Gautam	1998	25	3	25
Jam	2002	38	6	1 (aspiration)
Lee	2003	42	10	3
Upadhyay	2004	48 (CRIF)	7	0
		44 (ORIF)	8	44
Haidukewych	2004	73	17	22
Total		601	138 (23%)	

Jain et al. [21] retrospectively reviewed and compared early (< 12 h) and delayed (>12 h) fixation of subcapital hip fracture in 38 patients 60 years of age or less. Radiographic evidence of osteonecrosis developed in 16% of the patients and they were all in the delayed fixation group. Only one out of thirty eight patients had aspiration of the intracapsular hematoma. Age, fracture displacement and method of fracture fixation did not influence the development of osteonecrosis. Using the SF-36 and the WOMAC, they did not find a difference in the functional results between the patients who developed osteonecrosis and the patients who did not have osteonecrosis. They concluded that delayed treatment had an increased rate of osteonecrosis, but did not affect the functional outcome.

On the contrary several studies have reported no differences in the rate of osteonecrosis with delayed surgery greater than 24 h. Haidukewych et al. [3] retrospectively reviewed 83 femoral neck fractures in patients between the ages of 15-50 years. Osteonecrosis occurred in 23%. They reported that 13 of 53 (25%) femoral neck fractures that were treated within 24 h of diagnosis developed osteonecrosis. Four of 20 (20%) fractures that were internally fixed after 24 h of diagnosis developed osteonecrosis; with the small sample size, the difference was not significant.

There are multiple articles that have specifically evaluated the influence of time to reduction and fixation on the outcome. Once again until the results of randomized trials are available, it is recommended that surgery should be done on a urgent basis. This implies that the ORIF of the femoral neck should be performed as soon as the patient is considered stable and cleared to undergo anesthesia. Urgent operation allows early reduction, capsular decompression, restoration of the anatomy and restoration of femoral head vascularity by unkinking the vessels.

Complications. The two most challenging complications of femoral neck fractures in the young adult to deal with are femoral head osteonecrosis and nonunion. Osteonecrosis in a young patient is a devastating complication because of the limited options as compared to elderly patients with osteonecrosis of the femoral head. Osteonecrosis in the elderly is less likely to be symptomatic because of their lower functional demands and level of activity. Fortunately, total hip replacement is a good option and has consistent good results for the elderly patient with symptomatic osteonecrosis. However, there is no good alternative treatment in the young patient with symptomatic osteonecrosis. Younger age and higher function demands make prosthetic replacement fraught with high complications and should be a last resort. Reconstructive options to preserve the hip include osteotomy to unload the segmental area of femoral head collapse, femoral head core decompression, free vascularized bone grafting, hemi-resurfacing of the femoral head and hip arthrodesis [22, 23]. However, the best method for treating this difficult complication of osteonecrosis is prevention. This entails doing everything possible under the surgeon's control to minimize further vascular injury to the femoral head. This includes prompt reduction, intracapsular decompression, anatomic reduction, stable fixation and close monitoring postoperatively for osteonecrosis.

Nonunion is another complication of femoral neck fractures which is difficult to deal with. The rate of nonunion is between 10 and 30% [1]. Fortunately, there are good surgical options available for this problem. The treatment that has consistent good results is valgus osteotomy [14, 15, 16]. The goal of treatment is to create an environment that allows for healing. This means converting the shear force to compressive forces at the fracture site. This is done by performing a valgus-producing intertrochanteric osteotomy. This results in changing the more vertical femoral fracture line to horizontal and thus allowing for compression.

Conclusions

Femoral neck fractures in young adults are uncommon. They usually occur as a result of high-energy trauma and patients often have associated injuries. Osteonecrosis of the femoral head and nonunion are the two most common and challenging complications. Initial fracture displacement and disruption of the femoral head blood flow are contributing factors that are out of the surgeon's control. However, there are multiple other factors that can minimize and prevent these complications. The key factors in treating femoral neck fractures should include early diagnosis, early surgery, anatomic reduction, capsular decompression and stable internal fixation.

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