

# Treatment of Femoral Neck Fractures in Young Adults

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## Abstract

*Femoral neck fractures in physiologically young adults, which often result from high-energy trauma, are less common than intracapsular femoral neck fractures in elderly patients. They are associated with higher incidences of femoral head osteonecrosis and nonunion. Understanding the multiple factors that play a significant role in preventing these complications will contribute to a good outcome.*

*Although achieving an anatomic reduction and stable internal fixation are imperative, other treatment variables, such as time to surgery, the role of capsulotomy, and the method of fixation remain debatable. Open reduction and internal fixation through a Watson-Jones exposure is the recommended approach. Definitive fixation can be accomplished with three cannulated or noncannulated cancellous screws. Capsulotomy in femoral neck fractures remains a controversial issue, and the practice varies by institution, region, and country. The timing of the open reduction and internal fixation is controversial. Until conclusive data are available through prospective, controlled studies, performing a capsulotomy followed by open reduction and internal fixation on an urgent basis is recommended. The goals of treating femoral neck fractures should include early diagnosis, early surgery, anatomic reduction, capsular decompression, and stable internal fixation.*

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Intracapsular femoral neck fractures are common in the elderly population after a simple fall.<sup>1</sup> However, femoral neck fractures in physiologically young adults are less common.<sup>2-4</sup> These younger patients are active, have minimal medical problems, and have good bone quality. Understanding the differences between elderly, frail patients and physiologically young and active patients facilitates treatment. Characteristic differences are seen in the osseous and vascular anatomy, the mechanism of injury, the associated

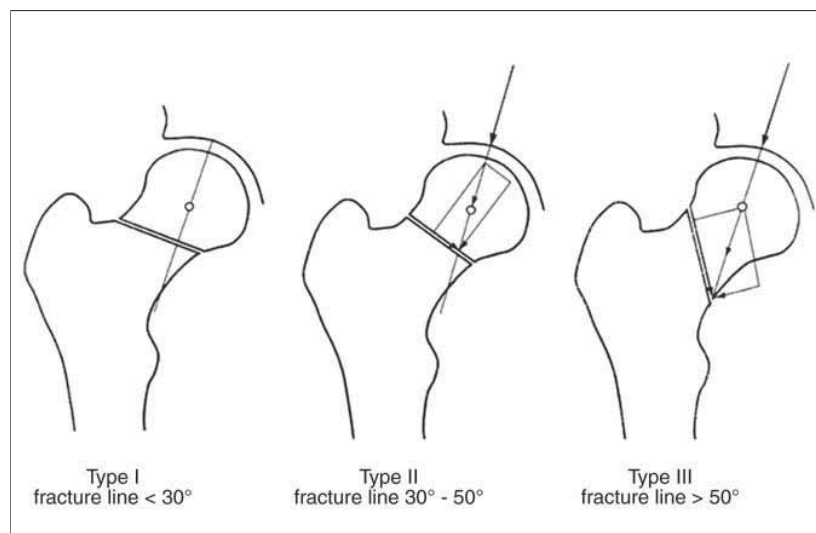
injuries, the fracture pattern, and the goals of treatment.

Femoral neck fractures in young adults are associated with higher incidences of femoral head osteonecrosis and nonunion.<sup>4-13</sup> The reported rate of osteonecrosis after a femoral neck fracture in young patients ranges from 12% to 86%.<sup>3,4,7-15</sup> This complication may lead to collapse of the femoral head and osteoarthritis. Salvage procedures, such as osteotomy, and other revisions have high failure rates, and arthroplasty procedures are not ideal, given the pa-

tient's young age and higher level of activity.<sup>16</sup> Although achievement of an anatomic reduction and stable internal fixation is imperative, the effects of other treatment variables, such as the time to surgery, the role of capsulotomy, and specific fixation methods, have been debated. Knowledge of these treatment options and potential complications aids in the understanding and management of femoral neck fractures in young adults.

## Anatomy

The femoral head blood supply comes from three main sources: the medial femoral circumflex artery, the lateral femoral circumflex artery, and the obturator artery.<sup>17-20</sup> In adults, the obturator artery provides little and variable amounts of the blood supply to the femoral head through the ligamentum teres. The lateral femoral circumflex artery gives rise to the inferior metaphyseal artery by way of the ascending branch and supplies most of the inferoanterior aspect of the femoral head. The largest contributor to the blood supply of the femoral head, especially its superolateral aspect, is the medial femoral circumflex artery.<sup>20</sup> The lateral epiphyseal artery complex originates from the medial femoral circumflex artery and courses along the posterosuperior



**Figure 1** Pauwels classification. (Adapted with permission from Bartoníček J: Pauwels' classification of femoral neck fractures: Correct interpretation of the original. *J Orthop Trauma* 2001;15:358-360.)

aspect of the femoral neck before supplying the femoral head. These terminal branches supplying the femoral head are intracapsular; thus, disruption or distortion of these terminal branches because of displacement of the femoral neck fracture plays a substantial role in the development of osteonecrosis.<sup>21-24</sup> Variables that have been hypothesized to contribute to femoral head osteonecrosis include vascular damage from the initial femoral neck fracture, the quality of the reduction or fixation of the fracture (whether flow has been restored to the distorted arteries), and elevated intracapsular pressure.<sup>4,6,7,10-12,24-33</sup>

### Diagnosis

Femoral neck fractures in elderly patients usually occur as a result of a fall from a standing height. Poor bone density, multiple medical problems, and a propensity to fall are major risk factors for a femoral neck fracture in these individuals. In

physiologically young adults, the mechanism of injury often involves high-energy trauma, such as a motor-vehicle collision or a fall from a height. A substantial axial load with the hip in an abducted position is required for the femoral neck to fracture in these young individuals.<sup>4,7</sup> The clinical evaluation of these patients should include a thorough trauma work-up, as they frequently have other injuries.<sup>5,7,14,34</sup> Diagnosis and treatment of femoral neck fractures in young adults should be done immediately after other life- and limb-threatening injuries have been managed. Patients with a femoral neck fracture have a shortened, flexed, and externally rotated lower extremity. Radiographic evaluation should include AP and lateral plain radiographs of the entire femur as well as an AP radiograph of the pelvis. Ipsilateral femoral neck fractures have been reported in association with 2% to 6% of all femoral shaft

fractures.<sup>35-41</sup> These concomitant ipsilateral injuries can be challenging to reduce, and the best methods of fixation are debatable.

The fracture pattern seen in young adults is different from that observed in elderly patients. An elderly patient with poor bone quality who has sustained a low-energy injury, such as in a fall from a standing height, usually sustains an intertrochanteric hip fracture or a femoral neck fracture, which is often subcapital. It is common to see a transverse fracture pattern with impaction at the fracture site. In young adults with better bone quality, the higher energy mechanisms of injury (usually an axially loaded, high-energy force applied to an abducted hip) result in a basicervical or more distal neck fracture. The fracture pattern has a tendency to be more vertically oriented and, thus, biomechanically more unstable.<sup>42-46</sup> These characteristics have important implications with regard to obtaining and maintaining stable fixation, both of which are necessary for healing to occur.

Despite its known limitations, the Garden classification is frequently used to describe femoral neck fractures in elderly patients.<sup>47,48</sup> In this age group, treatment is based on whether the fracture is nondisplaced (grade I or II) or displaced (grade III or IV). The Garden classification is not as useful for describing femoral neck fractures in young adults. The Pauwels classification is more descriptive of femoral neck fractures in young adults<sup>42</sup> (Figure 1). The fracture pattern can indicate the relative stability of the fracture and predict the difficulty of obtaining stable fixation. A femoral neck fracture line of less than 30° from the horizontal plane is Pauwels type I, one that has an angle

with the horizontal between 30° and 50° is Pauwels type II, and one that has an angle of more than 50° is Pauwels type III. The type I femoral neck fracture has more intrinsic stability than the others. Type III femoral neck fractures, which are the least stable, are seen in young adults more frequently than in elderly individuals. Type III fracture patterns are more difficult to treat and are associated with increased risks of fixation failure, malunion, nonunion, and osteonecrosis.<sup>42-46</sup>

### Principles of Management and Treatment Algorithm

Patients who are younger than 65 years generally are considered “young” and those older than 75 years are considered “elderly.” Patients between age 65 and 75 years are judged to be young or elderly on the basis of their physiologic age. Those who are active and have high functional demands, good bone quality, and minimal medical comorbidities are considered young, whereas those who have low functional demands (use an assistive device to walk), chronic illness, or poor bone quality are considered elderly.

For an elderly patient, the goals are to restore mobility with weight bearing as tolerated and to minimize the complications seen with prolonged bed rest. A hemiarthroplasty or total hip replacement often best accomplishes these goals. The patient’s age makes preservation of the femoral head of little importance.

For a physiologically young and active adult, the goals are to preserve the femoral head, avoid osteonecrosis, and achieve union. Avoiding an arthroplasty is ideal. It is generally agreed that anatomic reduction and stable internal fixation are paramount for a good outcome. Nevertheless,

other issues such as the use of closed or open reduction, the role of capsulotomy, and the time to surgery remain controversial. The specific method of fixation is a less controversial variable.

The fracture pattern alone determines the treatment of nondisplaced fractures. These should be treated with internal fixation.<sup>49,50</sup> Nonsurgical management of a nondisplaced femoral neck fracture is associated with higher complication rates and an increased risk of displacement.<sup>49</sup> The proper selection of patients for internal fixation can be more difficult when the fracture is displaced. The factors to consider when deciding whether to proceed with open reduction and internal fixation of a displaced femoral neck fracture are the patient’s chronologic and physiologic ages, the level of activity, bone quality, associated comorbidities, and the fracture pattern and characteristics. Although multiple treatment algorithms have been used and published, the best protocol remains debatable.<sup>51-56</sup>

### Surgical Approach

After the patient is medically optimized, surgical fixation of the femoral neck should proceed expeditiously. The injured limb should be left shortened and externally rotated while the patient awaits surgery. Several authors have shown that the intracapsular pressure changes with the hip position in patients with a femoral neck fracture.<sup>29,33,57</sup> Intracapsular pressure is highest when the hip is in extension with internal rotation, and it decreases substantially when the hip is in flexion with external rotation.

Once the patient is under anesthesia, closed reduction is attempted by flexing the hip to 45° with the hip slightly abducted and then extending and internally rotating the lower limb

while applying longitudinal traction. The quality of the reduction is judged on the basis of fluoroscopic imaging before the surgeon proceeds with percutaneous fixation. Only an anatomic reduction should be accepted; if it is not possible, open reduction and internal fixation should be used.<sup>51,58,59</sup> The authors’ preference is to have the patient supine on a radiolucent table with the leg draped free, but some surgeons prefer the patient to be in traction on a fracture table. The supine position provides optimal visualization for fracture reduction and facilitates fluoroscopic imaging. Furthermore, other orthopaedic or surgical teams can treat associated injuries with the patient supine.

A Watson-Jones approach is used<sup>60,61</sup> (Figure 2). A straight lateral incision is made over the proximal-lateral part of the femur. Proximally, the incision is curved anteriorly toward the gluteal pillar of the ilium. The tensor fasciae latae are retracted anteriorly while the gluteus medius is retracted posteriorly. The pericapsular fat is then swept off to visualize the anterior aspect of the hip capsule. The vastus lateralis can be elevated slightly off the greater trochanteric ridge for further visualization. A T-capsulotomy, with release of the capsule from the intertrochanteric ridge, is performed in line with the femoral neck. This allows decompression of the hematoma and direct visualization of the femoral neck fracture. The edges of the capsule can be tagged with a suture for retraction. Inserting a small, pointed Hohmann retractor outside the capsule onto the anterior part of the acetabular rim can aid in visualization.

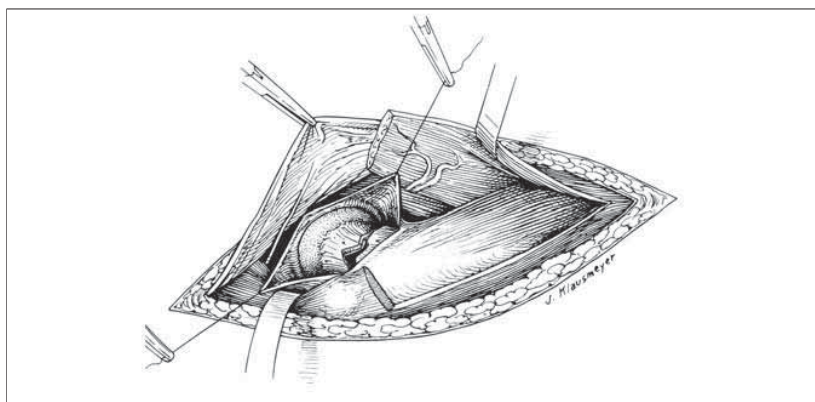
For the reduction, a bone hook or a 5-mm Schanz pin can be applied to the distal fracture segment. The bone

hook can be placed onto the greater trochanter for lateral traction, and the lower extremity can be manipulated and externally rotated. This will disimpact the fracture and facilitate reduction with an internal rotation maneuver. The alternative is to place a Schanz pin from anterior to posterior several centimeters distal to the fracture site to aid in manipulation of the distal fragment. For the proximal segment, 2.0-mm Kirschner wires can be

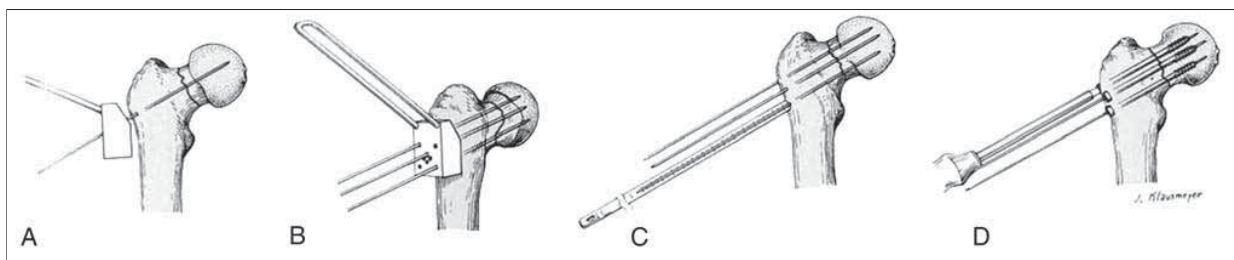
inserted into the femoral head, to function as joysticks to lift the proximal fragment anteriorly and reduce the fracture. Once the femoral neck fracture is anatomically reduced by direct visualization of the anterior cortex and the reduction is confirmed by fluoroscopic imaging, a Weber clamp or 2.0-mm Kirschner wires can provisionally hold the reduction. Definitive fixation can be obtained with three cannulated or noncannulated

cancellous screws (Figure 3). Closure is routine. Another approach, using a modified Smith-Petersen surgical exposure, has been described.<sup>62</sup> This allows direct access to and visualization of the femoral neck fracture, especially in the subcapital region. However, a separate incision is required for implant insertion.

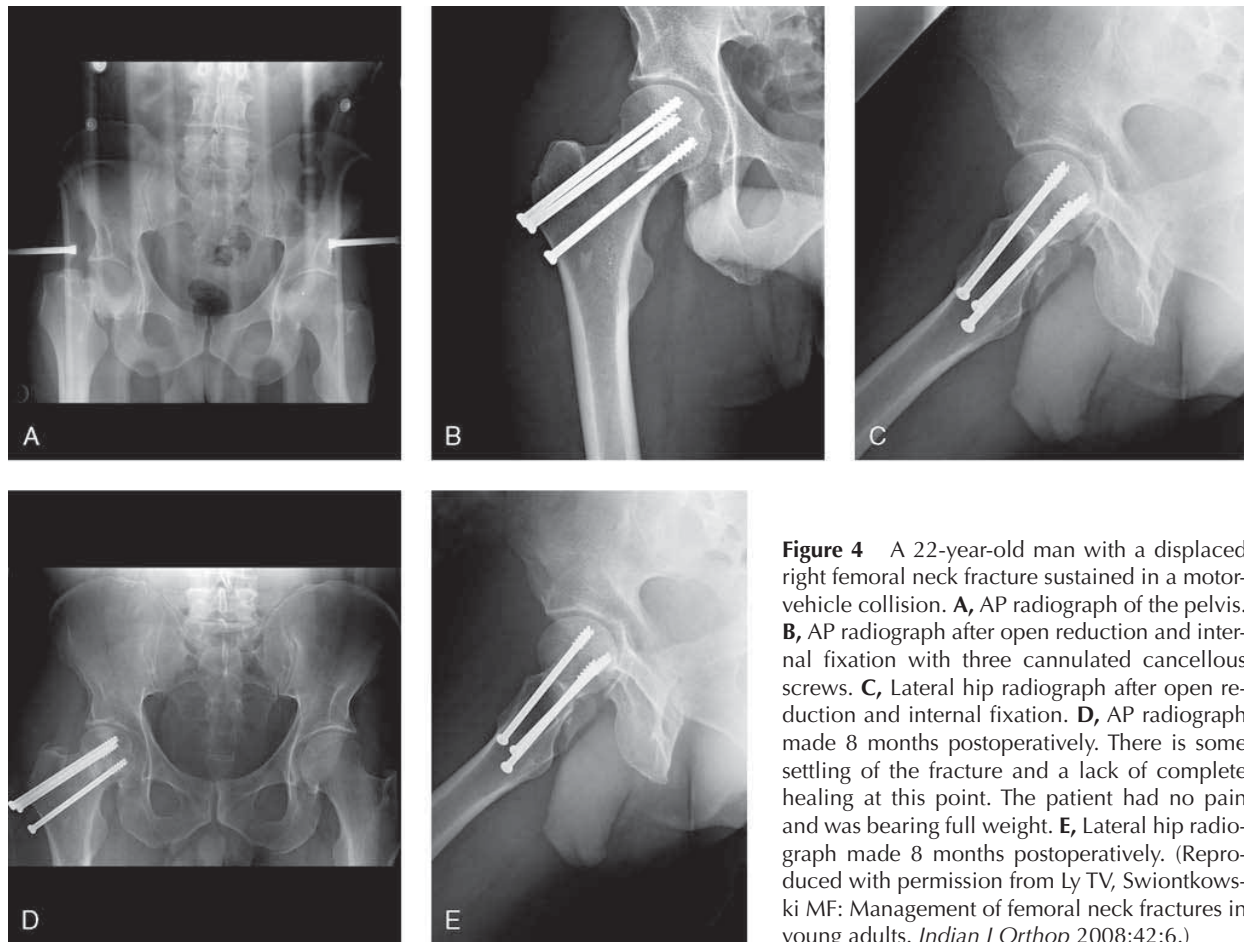
The chapter authors' postoperative regimen preference includes antibiotics for 24 hours; prophylaxis against deep venous thrombosis with low-molecular-weight heparin or warfarin for 4 to 6 weeks, depending on the patient's ambulatory status; and a physical therapy consultation. Patients are rapidly mobilized and are instructed to use toe-touch weight bearing with crutches or a walker for 12 weeks. Patients can progress to full weight bearing when they have the strength and balance to do so. They are instructed to wean off the crutch support when they are able to walk without a substantial limp. Monthly radiographs are made to assess healing and to identify any evidence of femoral head osteonecrosis. A reasonable clinical indicator that the femoral head is still viable is relative femoral head osteopenia on the injured side as com-



**Figure 2** The Watson-Jones anterolateral exposure of the hip for open reduction of femoral neck fractures. The interval between the tensor fasciae latae and the gluteus medius is exposed. A T-capsulotomy is performed to visualize the femoral neck fracture. (Reproduced with permission from Swiontkowski MF: Intracapsular hip fractures, in Browner BD, Jupiter JB, Levine AM, Trafton PG (eds): *Skeletal Trauma: Basic Science, Management, and Reconstruction*, ed 3. Philadelphia, PA, WB Saunders, 2003, p 1735.)



**Figure 3** Internal fixation of a femoral neck fracture with a cannulated screw system. **A** and **B**, Reduction is confirmed, and three parallel guidewires are placed with use of the guide and fluoroscopic control. **C**, The length of the wires is measured. **D**, Screws are inserted over the guidewires to the preselected depth. (Reproduced with permission from Swiontkowski MF: Intracapsular hip fractures, in Browner BD, Jupiter JB, Levine AM, Trafton PG (eds): *Skeletal Trauma: Basic Science, Management, and Reconstruction*, ed 3. Philadelphia, PA, WB Saunders, 2003, p 1737.)



**Figure 4** A 22-year-old man with a displaced right femoral neck fracture sustained in a motor-vehicle collision. **A**, AP radiograph of the pelvis. **B**, AP radiograph after open reduction and internal fixation with three cannulated cancellous screws. **C**, Lateral hip radiograph after open reduction and internal fixation. **D**, AP radiograph made 8 months postoperatively. There is some settling of the fracture and a lack of complete healing at this point. The patient had no pain and was bearing full weight. **E**, Lateral hip radiograph made 8 months postoperatively. (Reproduced with permission from Ly TV, Swiontkowski MF: Management of femoral neck fractures in young adults. *Indian J Orthop* 2008;42:6.)

pared with the normal side on an AP pelvic radiograph. A single photon emission computed tomography (SPECT) scan can be obtained to evaluate the likelihood of developing femoral head osteonecrosis. If the uptake is less than 90%, there is an increased chance of osteonecrosis developing.<sup>63</sup> MRI is not a good predictor of posttraumatic osteonecrosis.<sup>64,65</sup> Patients in whom femoral head osteonecrosis develops usually have persistent groin and trochanteric pain that does not resolve with time. If the patient does not have pain and has normal radiographic findings at 24 months, os-

teonecrosis is unlikely to develop. A femoral neck fracture is deemed to be healed when the patient is asymptomatic and the fracture line is fading. It is completely healed when the patient is asymptomatic and the fracture is no longer visible. If there is any question (due to persistent pain) about healing at 4 to 6 months postoperatively, a CT scan should be obtained to assess the fracture line.

### Fixation Methods

The type and number of cancellous screws necessary for effective treatment of femoral neck fractures have

been evaluated in multiple clinical and biomechanical studies.<sup>43-46,66-68</sup> A major limitation of these studies is that their conclusions are all based on osteoporotic bone models. However, the basic biomechanical principles should still apply to young adults with good bone density. Fixation with multiple cancellous lag screws is recommended for most femoral neck fractures (Figure 4). Three cancellous lag screws placed parallel to one another and perpendicular to the fracture line provide optimal compression at the fracture.<sup>68</sup> Pauwels type I and II fracture variants are most amenable to this

type of fixation. These three cancellous lag screws should be in an inverted triangle configuration (Figure 4, B) because there is less risk of a subtrochanteric fracture with this apex-distal screw orientation than there is with the apex-proximal orientation.<sup>69,70</sup> The most inferior screw should rest on the medial aspect of the distal femoral neck fragment to resist varus displacement. A fourth screw does not increase mechanical strength enough in most femoral neck fractures to justify its use, but if there is posterior comminution, a fourth screw is recommended.<sup>56,71</sup> Two cannulated screws are inadequate for the fixation of a displaced femoral neck fracture.<sup>70,72</sup>

Basicervical femoral neck fractures with comminution are a variant in which a sliding hip screw provides more stable fixation than three cancellous screws.<sup>44,45</sup> Blair and associates<sup>66</sup> recommended sliding hip screw fixation on the basis of their biomechanical cadaver study, in which they evaluated three different fixation techniques for the treatment of a basicervical femoral neck fracture. They found that a derotational screw located superior to the sliding hip screw does not enhance fixation. However, the chapter authors still use a derotational screw to prevent rotation of the femoral head during insertion of the compression screw.

The Pauwels type III fracture remains a difficult challenge. The dominant shear force with this high-angle fracture pattern lends itself to higher rates of failure and nonunion.<sup>42-46,73</sup> Open reduction and internal fixation with three cannulated screws is preferred for treating Pauwels type III fractures. Obtaining an anatomic reduction and adequate fixation remains the key to

successful treatment of femoral neck fractures in young adults, as it is in the treatment of any other fracture. Failure is often a result of not adequately achieving these goals, which are best accomplished through an open approach to visualize the fracture, anatomic reduction of the fracture, and achievement of fracture compression with three screws, optimally placed in parallel. The first screw should be placed inferiorly, along the calcar; the second should be placed posteriorly, along the neck; and the third should be placed superiorly, at the tensile surface of the fracture. Postoperatively, the patient is instructed to maintain strict toe-touch weight bearing for a total of 12 weeks and to advance to weight bearing thereafter. Other surgeons use a sliding hip screw for more vertically oriented femoral neck fractures (Pauwels type III). Baitner and associates<sup>44</sup> found that fixation with this device resulted in less inferior femoral head displacement, less shearing displacement, and a greater load to failure when compared with the findings following fixation with three cannulated cancellous screws. Bonnaire and Weber<sup>45</sup> evaluated four different methods of fixation of Pauwels type III femoral neck fractures in cadavers; these methods included a sliding hip screw with a derotational screw, a sliding hip screw without a derotational screw, cancellous screws, and a 130° angled blade-plate. They concluded that the sliding hip screw with the derotational screw is the best implant for this fracture pattern. Routine use of one of these large compression hip screws raises several concerns, including the amount of bone removed if subsequent reconstruction is required for the treatment of nonunion, the risk of disrupting the

blood supply to the femoral head if the hip screw is imperfectly placed, and its inability to adequately control rotation without insertion of an additional derotational screw.<sup>51,74</sup>

In a comparative study, Aminian and associates<sup>75</sup> examined the biomechanical stability of the fixed-angle proximal femoral locking plate, three 7.3-mm cannulated screws, the 135° dynamic hip screw, and the 95° dynamic condylar screw for fixation of Pauwels type III femoral neck fractures. Using cadaver femora, they found that the strongest construct was the proximal femoral locking plate, followed by the dynamic condylar screw, the dynamic hip screw, and three cannulated screws. The locking plate allows multiple fixed-angle points of fixation into the femoral head. However, proper anatomic reduction and compression of the fracture are necessary before fixation because this plate does not allow fracture compression. The reported clinical experience with the proximal femoral locking plate is insufficient to allow a recommendation for its routine use at this time.

### Role of Capsulotomy

The role of capsulotomy in the treatment of femoral neck fractures remains controversial, and the practice varies by trauma program, region, and country. There are both animal and clinical studies that suggest that capsulotomy is beneficial. Animal studies have shown that increased hip intracapsular pressure results in a tamponade effect and may reduce blood flow to the femoral head.<sup>24,28</sup> Clinical studies have shown that decompressing the intracapsular hematoma by means of a capsulotomy or aspiration reduces the intracapsular pressure.<sup>29-33</sup> This decrease in the intracapsular pres-

sure results in improved blood flow to the femoral head and may reduce femoral head ischemia.<sup>24,28,30,31,33</sup> Most of these studies have been of small series at single institutions and were uncontrolled.

Bonnaire and associates<sup>29</sup> reported that 75% of the patients with a femoral neck fracture in their study had increased intra-articular pressure. They believed that an increase in joint pressure was associated with reduced perfusion of the femoral head. Harper and associates<sup>30</sup> used a transducer to measure intraosseous pressure and quantify blood flow. They showed that aspiration of the hematoma led to a significant decrease in intraosseous pressure ( $P = 0.037$ ) and increase in the pulse perfusion pressure ( $P = 0.038$ ) within the femoral head. They suggested that an increase in femoral head blood flow is initiated by relief of the tamponade. Strömqvist and associates<sup>33</sup> and Holmberg and Dalen<sup>31</sup> used technetium-methylene diphosphonate (Tc-MDP) scintimetry to evaluate intracapsular pressure and its effect on femoral head circulation. Strömqvist and associates<sup>33</sup> showed an increase in uptake in the femoral head after aspiration of the hematoma at the site of a femoral neck fracture. Holmberg and Dalen<sup>31</sup> reported that four of nine patients had an intracapsular pressure of more than 80 mm Hg and an associated low scintimetric rate, which indicated decreased blood flow to the femoral head. These studies suggested that intracapsular distention of the hip may be one cause of femoral head osteonecrosis. Other studies, however, do not support the concept of increased intracapsular pressure as a major factor in the development of osteonecrosis.<sup>26,76</sup> Maruenda and associates<sup>27</sup> measured preoperative

**Table 1**  
Summary of Literature on Femoral Neck Fractures in Young Adults

Study	Year	Total Patients	Patients With Osteonecrosis	Patients With Capsulotomy
Protzman and Burkhalter <sup>4</sup>	1976	22	19	Not reported
Kofoed <sup>8</sup>	1982	17	7	0
Swiontkowski et al <sup>7</sup>	1984	27	5	17
Tooke and Favero <sup>14</sup>	1985	32	6	Not reported
Visuri et al <sup>11</sup>	1988	12	5	2
Shih and Wang <sup>9</sup>	1991	121	32	Not reported
Gerber et al <sup>81</sup>	1993	54	5	47
Robinson et al <sup>2</sup>	1995	46	8	0
Gautam et al <sup>15</sup>	1998	25	3	25
Jain et al <sup>79</sup>	2002	38	6	1 (aspiration)
Lee et al <sup>10</sup>	2003	42	10	3
Upadhyay et al <sup>13</sup>	2004			
Closed reduction and internal fixation		48	7	0
Open reduction and internal fixation		44	8	44
Haidukewych et al <sup>12</sup>	2004	73	17	22
Total		601	138 (23%)	

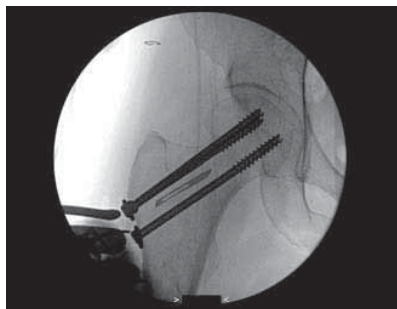
(Adapted with permission from Ly TV, Swiontkowski MF: Management of femoral neck fractures in young adults. *Indian J Orthop* 2008;42:8.)

intracapsular pressure in 34 patients and followed them for an average of 7 years after internal fixation of a femoral neck fracture. They found that five of six patients in whom femoral head osteonecrosis developed had an intracapsular pressure that was less than the diastolic blood pressure. They suggested that osteonecrosis may be a result of the vascular damage that occurred at the time of injury and not of the tamponade effect.

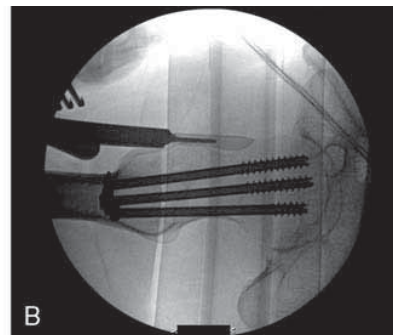
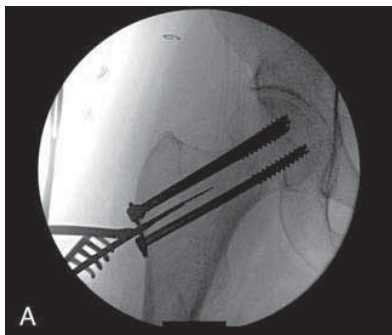
Other variables hypothesized to be related to osteonecrosis include the amount of initial fracture displacement,<sup>4,7,12</sup> disruption of the blood supply at the time of fracture,<sup>25,26</sup> the quality of the fracture reduction or postreduction malalignment,<sup>4,7,10,12,27</sup> the time be-

tween the fracture and the reduction,<sup>4,7,10,77,78</sup> the postoperative time to full weight bearing,<sup>27,79</sup> fracture nonunion,<sup>4,11,12</sup> loss of fracture reduction,<sup>10</sup> and an associated fracture of the ipsilateral femoral shaft.<sup>35,36,38-41,80</sup> There is no solid evidence indicating which factor, or combination of factors, places the patient at a greater risk for femoral head osteonecrosis.

There are too few femoral neck fractures in young patients to allow the performance of randomized, controlled trials of a sufficient sample size to evaluate the role of capsulotomy. Table 1 summarizes the available literature on femoral neck fractures in young adults, including the rate of femoral head osteonecrosis and its relationship to



**Figure 5** Intraoperative c-arm image of a No. 10 blade detached from the knife handle during a percutaneous capsulotomy.



**Figure 6** Intraoperative c-arm images. **A**, AP view of a percutaneous capsulotomy with a No. 10 blade. **B**, Lateral view of a percutaneous capsulotomy with a No. 10 blade.

capsulotomy.<sup>2,4,7-11,13-15,79,81</sup> Until there are conclusive data derived from prospective controlled trials, a capsulotomy is recommended. It is easy to perform and adds minimal time and risk to the procedure. Most importantly, it may help a small subset of patients in whom osteonecrosis of the femoral head would otherwise develop. The pooled evidence indicates that intracapsular pressure plays a role in approximately 15% of patients. There is no evidence of complications associated with an open anterior capsulotomy (with direct visualization of the capsule). The blade has detached from the knife handle during a percutaneous capsulotomy, but the blade was easily retrieved (Figure 5). For femoral neck fractures that are successfully reduced with closed means and are pinned, performing a percutaneous capsulotomy with a No. 10 blade is recommended (Figure 6). After making sure that the blade is fully seated on the knife handle, the surgeon should slide the blade over the anterior aspect of the trochanter and in line with the center of the femoral neck, as seen on the AP c-arm image. The capsulotomy

should be performed while the blade is viewed on the lateral view (with the surgeon making sure that the blade is right on top of the femoral neck both by feel and c-arm imaging). If a small incision (5 cm) has been made and the iliotibial band has been split for pin placement, a flash of hematoma should be seen to ooze out when the capsulotomy is complete.

### Time to Surgery

The timing of surgery for femoral neck fractures remains controversial, and the available data remain inconclusive. Advocates of early surgery suggest that the main advantages of prompt reduction of a displaced femoral neck fracture are uninking of the vessels and performance of an intracapsular decompression to remove the hematoma that increases intracapsular pressure.<sup>7,17,82</sup> This improves and restores blood flow to the femoral head, minimizing the risk of femoral head osteonecrosis.<sup>19,28,30,31,33</sup> Swiontkowski and associates<sup>7</sup> previously recommended that femoral neck fractures be treated within 8 hours after injury. Other studies

have suggested that early surgery (within 6 to 12 hours) can decrease the rate of femoral head osteonecrosis.<sup>10,77,78,81,83</sup>

Jain and associates<sup>79</sup> retrospectively reviewed and compared early fixation (within 12 hours) and delayed fixation (at more than 12 hours) of subcapital hip fractures in 38 patients who were age 60 years or younger (average age, 46.4 years). Radiographic evidence of osteonecrosis developed in 16% of the patients, all in the delayed-fixation group. Only 1 of the 38 patients had undergone aspiration of the intracapsular hematoma. Age, the degree of fracture displacement, and the method of fracture fixation did not influence the development of osteonecrosis. Using the Medical Outcomes Short Form-36 (SF-36) and the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index instruments, Jain and associates<sup>79</sup> did not find a difference in the functional results between the patients in whom osteonecrosis developed and those in whom it did not. They concluded that delayed treatment was associated with an increased rate of os-

teonecrosis but did not affect the functional outcome. The power of this comparison was low, and long-term follow-up is needed to evaluate more fully the late development of femoral head osteonecrosis and hip arthritis.

There are several studies that demonstrated no difference in the rate of osteonecrosis following surgery that was delayed for more than 24 hours. Haidukewych and associates<sup>12</sup> retrospectively reviewed a series of 73 femoral neck fractures in patients between the ages of 15 and 50 years. Osteonecrosis developed in 23% of the series as a whole, in 13 of 53 patients (25%) in whom the femoral neck fracture had been treated within 24 hours after the diagnosis, and in 4 of 20 patients (20%) who had been treated more than 24 hours after the diagnosis. Given the small sample size, the difference was not significant. Upadhyay and associates<sup>13</sup> performed a prospective, randomized study comparing open reduction and internal fixation with closed reduction and internal fixation in 102 young adults with a Garden grade III or IV femoral neck fracture. Of the 92 patients who were available for follow-up, 44 had been randomized to treatment with open reduction and internal fixation (a Watson-Jones approach with a T-shape incision in the capsule) and 48 to treatment with closed reduction and internal fixation. There was no significant difference in the osteonecrosis rate between the two groups (15% in the closed-reduction group and 18% in the open-reduction group) at 2 years postoperatively. Risk factors such as age, sex, time to surgery (less than or more than 48 hours), and posterior comminution did not appear to affect the development of osteonecro-

sis. Most patients in this series were treated more than 48 hours after the injury.

The multiple factors mentioned above make it difficult to come to a final conclusion regarding the timing of surgery. The influence of time to reduction and fixation on the outcome has been specifically evaluated in several articles, and until conclusive data are available, surgery on an urgent basis is recommended. This implies that open reduction and internal fixation of the femoral neck should be performed as soon as the patient is considered stable and cleared to undergo anesthesia. An urgent operation allows early reduction, capsular decompression, restoration of the anatomy, and restoration of femoral head vascularity by uninking the vessels.

### Outcomes of Internal Fixation

Preservation of the femoral head with internal fixation is desirable in younger and more active patients with a femoral neck fracture. A healed femoral neck fracture, without the development of osteonecrosis, leads to a good functional outcome.<sup>12,15,43,56,84-87</sup> The ability to achieve a good outcome by decreasing fixation failure and the rate of nonunion depends on several factors that the surgeon can control—namely, the quality of the reduction and obtaining a stable fixation.<sup>68,84,88,89</sup> Jain and associates<sup>79</sup> compared early and delayed fixation of subcapital hip fractures in patients who were age 60 years or younger. After a minimum of 2 years of follow-up, they did not find any significant difference between the early and delayed-fixation groups with regard to functional outcomes as assessed with the SF-36 and

WOMAC. There was also no significant difference in outcome between displaced and nondisplaced fractures. However, a study of a larger number of patients with longer follow-up is needed to determine, more accurately, if there is indeed a difference between the two groups. El-Abed and associates<sup>90</sup> reported the outcomes of hemiarthroplasty and dynamic hip screw fixation for the treatment of displaced subcapital hip fractures. Function was measured by a physician using the Matta functional hip score and by the patient using the SF-36. According to the Matta scoring system, 70% of the patients treated with internal fixation had a good or excellent result compared with 42% in the hemiarthroplasty group. There was a significant agreement ( $r = 0.64$ ) between the patients' perception (SF-36 score) and the physicians' perception (Matta functional hip score) of outcome.

### Summary

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

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