Femoral Neck Fractures in the Physiologically Young

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Expert Commentary
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Femoral neck fractures are associated with a high degree of morbidity in patients of any age, but urgent attention is given to fractures in the young patient due to complications such as femoral head osseous necrosis, fracture nonunion, or post traumatic hip arthritis. Anatomic open reduction with stable internal fixation is necessary. Controversies surrounding the timing of surgery, need for capsulotomy, and type of fixation construct are reviewed, and surgical considerations are discussed.

Femoral neck fractures cause a significant degree of morbidity regardless of the patient's age. Although the anatomical fracture zone is similar, intra-capsular hip fractures in physiologically young patients vary from those in older or clinically frail patients by the mechanism of injury, surgical timing and intervention, and clinical outcomes. In more senior patients, perioperative medical complications cause morbidity. Hip fractures in elder patients are often harbingers of other significant non-orthopaedic medical problems. In younger and active patients, the risk of developing femoral head osseous necrosis, fracture nonunion, or post traumatic hip arthritis dictates the urgent attention given to this fracture[1]. In addition, femoral neck fractures are usually the result of a high energy injury mechanism in younger patients and, therefore often associated with additional injuries complicating the prioritization of care[2].

Controversy still exists around the timing of treatment and the optimal strategy for surgical fixation of femoral neck fractures for young patients. The primary concern is the preservation or restoration of the critical blood supply to the femoral head through the neck area and the effects that increased intra-capsular pressure or prolonged fracture displacement may have on the eventual clinical result[3].

Anatomy

The blood supply to the femoral head is from the medial and lateral femoral circumflex arteries with a small contribution from the obturator vessels via the ligamentum teres. Specifically, the lateral epiphyseal artery and its terminal branches arise from the medial circumflex artery and supply the superolateral aspect of the femoral head[4]. Fracture displacement and increased intra-capsular pressure can disrupt these terminal branches and the blood supply to femoral head. The lateral epiphyseal system is most affected by the degree of fracture displacement[5]. Restoration of anatomic alignment may improve flow through the lateral epiphyseal system by "unkinking" these vessels. Previous series report an osteonecrosis rate from 12% to 86%. Knowledge and preservation of the blood supply to the proximal femur including the femoral head is quite critical if improved results are to be achieved after femoral neck fractures[6].

Classification

The Garden and Pauwels classification schemes are most frequently used to describe fractures of the femoral neck. The Garden classification is often simplified to describe fractures as nondisplaced (Types I and II) or displaced (Type III and IV)[7]. The Pauwels classification may be more useful for femoral neck fractures in young adults by describing the orientation of the fracture line relative to the horizontal plane. Type I fractures have a fracture line less than 30 degrees from horizontal; type II fractures have a fracture line between 30 and 50 degrees, and type III fractures are greater than 50 degrees[8]. Type III fractures are noted more frequent in young individuals because they are often associated with a high energy mechanism of injury, are the least mechanically stable because of their vertical orientation, and therefore are associated with the greatest number of complications postoperatively. The tenuous blood supply to the femoral head may be disrupted with greater fracture displacement and lead to higher rates of osteonecrosis[9].

Fixation

The most common fixation technique described for open reduction and internal fixation of femoral neck fractures is lag screw fixation using three screws in an inverted (apex distal) triangular fashion. Studies have shown that two screws do not provide adequate fixation. Similarly, while a fourth screw does not add significant stability, it can be used when there is significant comminution, especially inferior-posteriorly. In basicervial fractures, a sliding hip screw construct supplemented by an additional parallel lag screw proximally is used to achieve stable fixation.

The position of the fixation screws is of utmost importance in achieving stable fixation. The most inferior screw should be placed along the

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medial aspect of femoral neck. The other two screws should be placed parallel to the first, just posterior and superior to it, forming the inverted triangle. The addition of a fourth screw has not shown to improve the mechanical advantage of this fixation technique, but again, some authors advocate its use when there is inferior-posterior comminution[10]. Achieving stable fixation with more screws, or screws in different configurations, must take into account the blood supply to the femoral head so that a stable construct does not fail due to osteonecrosis. Therefore, each fracture must be addressed individually.

Other implant options, particularly useful in Pauwels type III fractures, include the angled blade plate and the dynamic condylar screw. These devices have been studied and compared to cannulated screw fixation and compression hip screw fixation with inconclusive results. Liporace et al looked specifically at Pauwels type III fractures and found a trend towards less fixation failure with a fixed angle device (dynamic hip screw, cephalomedullary nail, or dynamic condylar screw) as compared to cannulated screws[11]. Aminian et al compared four fixation constructs in simulated Pauwels type III femoral neck fractures in fresh frozen cadaveric specimens. Their study showed superior strength of the proximal femoral locking plate (PFLP) as compared to the dynamic hip screw, dynamic condylar screw, and 7.3mm cannulated screw constructs. The authors did mention that although the PFLP was the stiffest construct, the implant does not allow compression at the fracture site and may therefore affect healing in vivo[12].

There have been reports of valgus osteotomies performed on acute femoral neck fractures in patients with osteoporosis but this has not been described in the younger patient and remains a salvage-type procedure[13]. Although there is less risk of varus angulation because the forces at the fracture site are converted from shear to compression, the goal is still anatomic fracture reduction and fixation in the young patient.

Timing of Surgery

There is no consensus regarding how quickly a femoral neck fracture in a young individual must be reduced and fixed. As in any fracture, healing is dependent upon restoration of anatomic alignment, preservation of blood supply to both the bone and the surrounding tissues, and stable fixation. Because the blood supply to the femoral head may be compromised by displacement or increased intra-capsular pressures, some advocate early fixation of these fractures (within 6 to 12 hours). This allows early decompression of the capsule, reduction of the femoral neck fracture and thereby the critical local vessels, and fracture stabilization; all of which may decrease the rates of femoral head osteonecrosis.

Jain et al retrospectively compared fixation of femoral neck fractures within 12 hours to delayed fixation (after 12 hours). None of the femoral neck fractures fixed within 12 hours developed osteonecrosis; however, 16% of the delayed group had radiographic evidence of osteonecrosis. Jain noted that functional outcome was not affected in the patients with osteonecrosis[14]. Haidukewych et al reported on his series of 73 femoral neck fractures in young patients and found that the rate of osteonecrosis was not statistically different between those treated within 24 hours from the time of diagnosis (24%) and those treated more than 24 hours from the time of diagnosis (20%)[15].

Surgical Considerations

Multiple studies have shown that intracapsular pressure after femoral neck fracture is lowest when the hip is flexed and externally rotated. Therefore, extension and internal rotation should be avoided prior to the time of decompression of the capsule. Because of this, most clinicians avoid skeletal or skin traction for these injuries. Without traction immobilization, protection of the injured area from further injury due to instability is difficult. Fracture instability also causes pain.

Closed reduction techniques have been described for femoral neck fractures prior to stabilization with implants. Leadbetter described in 1932 his technique for closed reduction of fractures of the neck of the femur[16]. Since then, the reduction maneuver most widely used involves traction, internal rotation and abduction of the ipsilateral limb while the patient is secured on a fracture table[17]. Any reduction maneuver should take into consideration the vulnerable capsular vessels and at no point should sudden forceful reduction maneuvers take place nor should excessive traction be placed on the limb[18]. If the reduction maneuver is unsuccessful the first time, multiple attempts should not be undertaken[19]. Upadhyay et al.prospectively compared closed versus open reduction and internal fixation of femoral neck fractures in young patients and found no difference between the two groups with regard to rate of osteonecrosis and union. The factors they identified as increasing the risk of osteonecrosis were accuracy of fracture reduction, posterior comminution, and poor surgical stabilization[20].

The most common techniques for closed reduction include restoration of axial length with the fracture in an externally rotated, disimpacted position. Once the correct length has been achieved, internal rotation of the femur reduces the fracture gap and adduction compresses at the fracture line[21].

Open reduction and direct fracture fixation often occurs through either the Watson-Jones or Smith-Petersen exposure on either a fracture or radiolucent table[22]. The Smith-Peterson exposure has received recent attention since it provides improved direct exposure and thereby reduction of the anterior-medial-lateral cortex of the femoral neck.[23] Surgical implants can be placed through both the anterior and lateral exposures.

Capsulotomy

Capsulotomy and/or aspiration of the hip joint following femoral neck fracture have been shown to reduce intra-articular pressure, which, when elevated, may decrease blood flow to the femoral head and increase the risk of osteonecrosis[24]. The practice of relieving the intra-capsular pressure following fracture is not based on prospective controlled studies or Level I evidence. Rather, it is smaller studies, anecdotal evidence, and surgeon's experience which guide this practice.

Studies have shown that decompression of the capsule does lead to an increase in perfusion pressure and a decrease in intraosseous pressure within the femoral head[25]. Bone scintigraphy has also shown increased blood flow to the femoral head following aspiration of fracture hematoma surrounding the femoral neck[26]. Therefore, since performing a capsulotomy or needle decompression at the time of fracture fixation has a very low rate of morbidity, most surgeons advocate intracapsular decompression.

Future Directions

Femoral neck fractures in young patients are much less common than in the elderly population. Because of this, randomized prospective studies assessing the important factors that could predict outcome in femoral neck fractures are difficult to perform. Clearly, with the evidence that is available now, further research about this injury to standardize care and minimize complications needs to be performed.

One recent advancement that may help future studies is the use of advanced imaging techniques following fracture fixation. Kaushik et al described the use of dynamic MRI as early as 48 hours after fixation to assess femoral head vascularity and to predict outcome[27].

Use of pharmaceutical compounds that have an anabolic or anti-catabolic effect on bone have been investigated for their use in fracture healing both in animal and human subjects. Although their use may be more beneficial in patients with decreased bone mineral density, their role in younger patients is still evolving. Compounds such as bisphosphonates, parathyroid hormone (PTH), and inhibitors of receptor activator of NF-kappaB have shown promise and may play a more prominent role in osseous healing in both the young and old fracture patient[28].

In severe fractures where there is significant comminution, the use of bone graft substitutes or coated implants may have a role in fracture fixation to improve rates of union. There have not been any studies to evaluate these technologies in the young femoral neck fracture patient, so their increased cost may outweigh any benefit. Hydroxyapatite granules, calcium phosphate bone cements, and hydroxyapatite coated screws have all been proposed as possibly having benefit in fracture fixation[29].

Conclusion

Accurate open reduction along with stable internal fixation remains the treatment of choice for femoral neck fractures in the young patient. While there is still controversy regarding the timing of surgery, type of fixation construct, and performing a capsulotomy, there is no question that restoration of anatomic alignment and adherence to stable fixation techniques is essential. Recent literature shows a trend towards fixation of these fractures as soon as possible, release of the capsule, and consideration of fixed angle devices over the traditional cannulated screw construct. With the rising incidence and interest in femoral neck fractures, further research is warranted.

Ask the Expert

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What are your thoughts on timing of surgery (within 6, 12, 24 hours) in femoral neck fractures in the physiologically young?

Femoral neck fracture surgical timing, especially in the young patient, is dependant on numerous factors but should match the patient's overall clinical condition. Early and accurate reduction along with stable fixation should optimize the restoration of femoral head bloodflow via the neck area and therefore the clinical result. Many patients have intracapsular blood accumulations that are often under significant pressure. Such tense intracapsular bleeding has been shown in animal models to similarly interrupt head flow.We proceed to surgery as safely and expeditiously as we can for these patients. It seems anecdotally that I'm always doing this surgery sometime around 1 to 2am usually!!

Do you routinely aspirate or release the capsule in the setting of a femoral neck fracture?

I don't recommend nor perform aspirations for such injuries. Aspirations have been shown to provide short-term benefit at best, and it's not simple to predictably and effectively relieve the capsular blood using a needle. Since I usually do open reduction, the capsulotomy is a routine portion of the surgical exposure. I use the scalpel carefully to make the capsular incision in order to avoid potential thermal injury to the head cartilage from an electrocautery. I use an "oblique T-shaped" capsulotomy with the caudal limb paralleling the normal neck orientation and the perpendicular limbs paralleling the anterior acetabular wall while sparing the anterior acetabular labrum. It's common to note capsular blood under significant pressure as the initial incision is made through the anterior capsule. After fixation, I carefully repair the capsular incisional limbs paralleling the labrum and wall, but do not close the caudal portion of the capsulotomy.

What is the role of the PFLP or fixed angle device in femoral neck fractures in physiologically young patients?

The PFLPs are still somewhat "new" and therefore are being sorted out by clinicians. They certainly will be warranted if they provide more durable fixation, despite their additional costs. The PFLPs do limit the "art" of individualized or tailored fixation since the implant's design and location on the femur direct the screws predictably through the locking holes. The surgeon has restricted creative abilities with such an implant. The PFLP implant design determines the screw locations into the femoral head once it's applied to the lateral proximal femoral cortex. This implant may be best for those proximal femoral "pertrochanteric" fractures that have a neck component.

The angled blade plate is an excellent device and has been shown to provide quite durable fixation when applied properly…similar to "firm cupped hands supporting the rotten tomato". Unfortunately, the ABP's technical application demands have frightened away most clinicians over time. Rather than learn how to use it, most surgeons seek something similar yet simpler. The ABP details should be familiar to all clinicians seeking to provide quality fracture care.

A major stumbling block to progress may be the sustained legacy of closed reduction and percutaneous fixation regardless of closed reduction result. It seems that few educators actually are teaching young surgeons how to perform an accurate open reduction and stable internal fixation for a femoral neck fracture. When one surveys a large group of North American senior orthopedic residents still in their final phases of formal education or residency, few if any report ever seeing (much less performing) open reduction for a patient with a femoral neck fracture. Most, if not all, will describe their experience using some form of closed reduction technique, accepting the radiographic fluoroscopic result despite its appearance, and then proceeding to some form of geometrically challenged screw fixation…and always they describe "cannulated" screw fixation. Few, if any, seem to know how to insert standard large fragment screws into the proximal femur, unless they are cannulated. It's a sad de-evolution.

Do you have any pearls on techniques for closed reduction of femoral neck fractures before operative fixation?

I only know that I'm not very good at this technique. I've tried it a lot and still do try, but can never seem to achieve quality reduction. In several instances, I've temporarily wired percutaneously what we all thought was an "acceptable" manipulative closed reduction result, and then immediately performed an open exposure, opened the capsule, released the hematoma, noted the poor reduction, then removed the wires, and re-reduced it accurately under direct vision each time. I've learned that my closed reduction skills are poor.

Are provisional or supplemental fixation techniques (e.g. recon or 1/3 tubular plate) a part of your approach to these fractures?

Clamps are almost always needed to maintain the open reduction temporarily, so I use clamps. I also use Kirschner wires a lot and locate them remote from the areas of anticipated definitive fixation. It's always best to know what your definitive implants will be and where exactly you plan to apply them before placing wires and clamps. Surface implants such as contoured malleable plates applied to the anterior neck are not usually necessary. They may also cause anterior hip impingement with flexion later. Rarely, I will use them instead of a clamp if I can't make the clamp fit because the patient is obese or in another similar frustrating clinical scenario…but these surface implants are rarely needed.

The fixation construct is important. Most surgeons are focused on the number and location of screws or other devices based on biomechanical studies. I prefer to preserve the cranial-posterior neck quadrant since this region houses the vital femoral head blood supply conduits. It makes no sense to me to insert drills or screws into this area if we as surgeons are working dutifully and urgently without regard for the hour of day or night to release the capsular pressure, then reduce and stabilize the fracture in order to restore or preserve head flow through this area of injury. We should absolutely protect this area from surgical harm as well. Many argue that the neck cross sectional anatomy makes it difficult to locate two individual caudal screws…I don't agree with that excuse. It also makes sense to position the screws to resist the predictable failure pattern of varus-apex anterior collapse. So logically, two caudal fixation screws positioned to abut the endosteal cortical bone both anteriorly and posteriorly should optimally resist varus collapse while the cranial-anterior and caudal anterior screws resist apex anterior deformity.

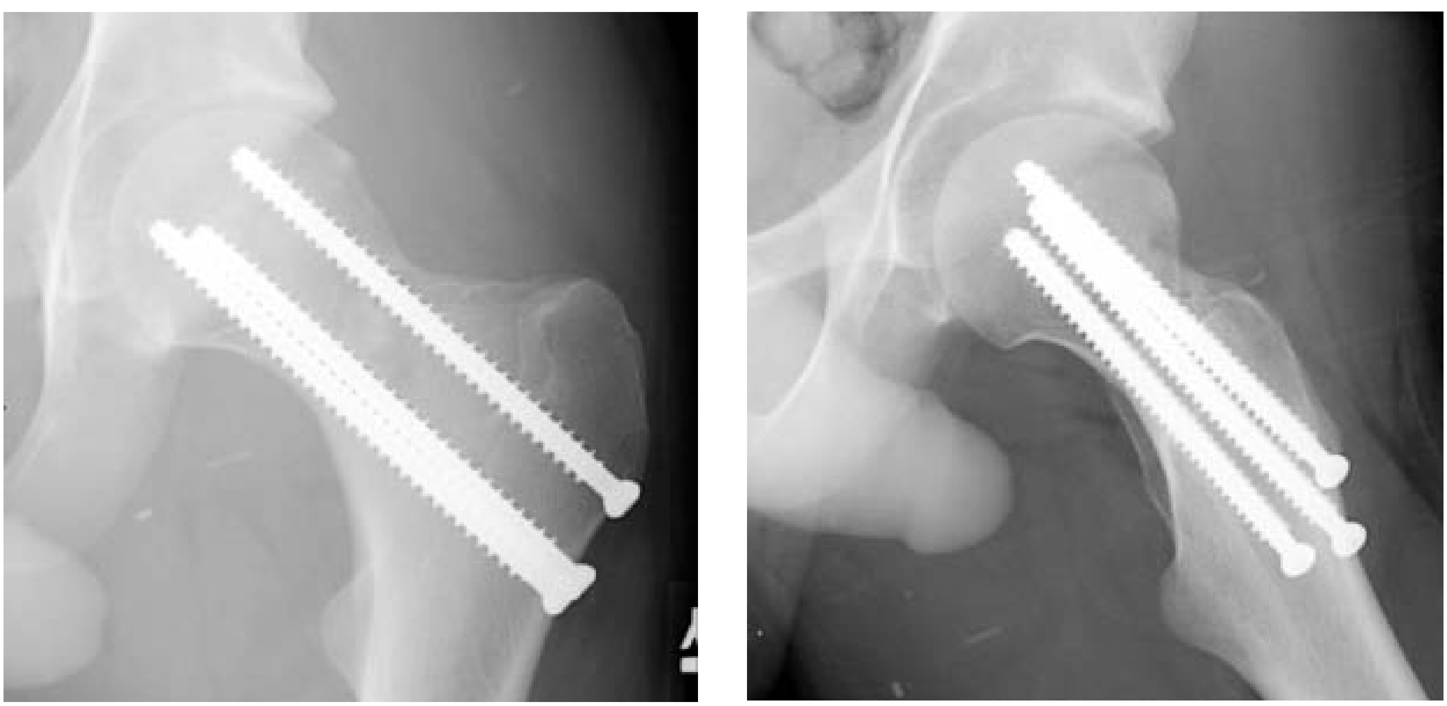
How do you approach a femoral neck fracture that presents with significant bone loss or comminution at the fracture site?

There is usually not bone loss but rather impaction or comminution. For young active patients, I still use open reduction and internal fixation, but pack the defect with ipsilateral iliac crest autologous bone graft. Most are structural cortical defects, so I tailor the patient's tricortical iliac crest bone to fit the defect. The graft is positioned so the cortical bone perimeter functions as the structural support for the neck defect.

Patient Example from Dr. Routt at Harborview Medical Center

Figure 1. This intraoperative image demonstrates a cranial anterior neck impaction defect in a 19 year old male patient after initial open reduction.

Figure 2. Ipsilateral tricortical iliac crest donor graft was tailored to fit the defect, packed into place, and then stabilized along with the neck fracture. The screws are positioned with two caudally and one cranially-anteriorly avoiding the cranial-posterior neck's vascular zone.



A **B**

Figure 3. Figure 3: Six months after injury, AP (A) and lateral (B) radiographs demonstrate fracture healing. His hip motion was symmetrical on exam and he had no gait abnormalities. He denied symptoms related to his hip and had returned to his prior activities.

References

1. **Protzman RR, Burkhalter WE.** Femoral-neck fractures in young adults. *J Bone Joint Surg Am.* 1976 Jul;58(5):689–95.
2. **Dedrick DK, Mackenzie JR, Burney RE.** Complications of femoral neck fracture in young adults. *J Trauma.* 1986 Oct;26(10):932–7.
3. **Ly TV, Swiontkowski MF.** Treatment of femoral neck fractures in young adults. *J Bone Joint Surg Am.* 2008 Oct;90(10):2254–66.
4. **Trueta J, Harrison MH.** The normal vascular anatomy of the femoral head in adult man. *J Bone Joint Surg Br.* 1953 Aug;35-B(3):442–61.
5. **Catto M.** A histological study of avascular necrosis of the femoral head after transcervical fracture. *J Bone Joint Surg Br.* 1965 Nov;47(4):749–76.
6. **Swiontkowski MF, Winquist RA, Hansen ST Jr.** Fractures of the femoral neck in patients between the ages of twelve and forty-nine years. *J Bone Joint Surg Am.* 1984 Jul;66(6):837–46.
7. **Frandsen PA, Andersen E, Madsen F, et al.** Garden's classification of femoral neck fractures. An assessment of inter-observer variation. *J Bone Joint Surg Br.* 1988 Aug;70(4):588–90.
8. **Bartonícek J.** Pauwels' classification of femoral neck fractures: correct interpretation of the original. *J Orthop Trauma.* 2001 Jun-Jul;15(5):358–60.
9. **Swiontkowski MF.** Intracapsular fractures of the hip. *J Bone Joint Surg Am.* 1994;76:129–38.
10. **Blair, B, Koval KJ, Kummer F, et al.** Basicervical fractures of the proximal femur: A biomechanical study of 3 internal fixation techniques. *Clin Orthop Relat Res* 1994;306: 256–63.
11. **Liporace F, Gaines R, Collinge C, et al.** Results of internal fixation of Pauwels type-3 vertical femoral neck fractures. *J Bone Joint Surg Am.* 2008 Aug;90(8):1654–9.
12. **Aminian A, Gao F, Fedoriw WW, et al.** Vertically oriented femoral neck fractures: mechanical analysis of four fixation techniques. *J Orthop Trauma.* 2007 Sep;21(8):544–8.
13. **Magu NK, Singh R, Mittal R, et al.** Osteosynthesis and primary valgus intertrochanteric osteotomy in displaced intracapsular fracture neck of femur with osteoporosis in adults. *Injury* 2005;36:110–22.
14. **Jain, R, Koo M, Kreder HJ, et al.** Comparison of early and delayed fixation of subcapital hip fractures in patients sixty years of age or less. *J Bone Joint Surg Am.* 2002 Sep;84-A(9):1605–12.
15. **Haidukewych GJ, Rothwell WS, Jacofsky DJ, et al.** Operative treatment of femoral neck fractures in patients between the ages of fifteen and fifty years. *J Bone Joint Surg Am.* 2004 Aug;86-A(8):1711–6.
16. **Leadbetter GW.** Closed Reduction of Fractures of the Neck of the Femur. *J Bone Joint Surg Am.*, Jan 1938; 20:108–113.
17. **Parker MJ, Pryor GA, Thorngren KG.** *Handbook of Hip Fracture Surgery.* Oxford, Butterworth Heinemann 1997.
18. **Bosch U, Schreiber T, Krettek C.** Reduction and fixation of displaced intracapsular fractures of the proximal femur. *Clin Orthop Relat Res.* 2002 Jun;(399):59-71.
19. **Garden RS.** Malreduction and avascular necrosis in subcapital fractures of the femur. *Clin Orthop* 114:259–264, 1976.
20. **Upadhyay A, Jain P, Mishra P, et al.** Delayed internal fixation of fractures of the neck of the femur in young adults. A prospective, randomised study comparing closed and open reduction. *J Bone Joint Surg Br.* 2004 Sep;86(7):1035-40.
21. **Probe R, Ward R.** Internal fixation of femoral neck fractures. *J Am Acad Orthop Surg.* 2006 Sep;14(9):565-71.
22. **Swiontkowski MF.** Femoral neck fractures: open reduction internal fixation. In: Wiss DA, editor. Master techniques in orthopaedic surgery: fractures. Philadelphia: Lippincott-Raven; 1998. 213-21.
23. **Molnar R, Routt M.** Open reduction of intracapsular hip fractures using a modified Smith-Petersen surgical exposure. *J Orthop Trauma.* 2007;21:490-4.
24. **Harper WM, Barnes MR, Gregg PJ.** Femoral head blood flow in femoral neck fractures. An analysis using intra-osseous pressure measurement. *J Bone Joint Surg Br.* 1991 Jan;73(1):73-5.
25. **Bonnaire F, Schaefer DJ, Kuner EH.** Hemarthrosis and hip joint pressure in femoral neck fractures. *Clin Orthop Relat Res.* 1998 Aug;(353):148-55.
26. **Stromqvist B, Nilsson LT, Egund N, et al.** Intracapsular pressures in undisplaced fractures of the femoral neck. *J Bone Joint Surg Br.* 1988;70:192-4.
27. **Kaushik A, Sankaran B, Varghese M.** Prognostic value of dynamic MRI in assessing post-traumatic femoral head vascularity. *Skeletal Radiol.* 2009 Jun;38(6):565-9.
28. **Kakar S, Little D, Einhorn TA.** Can we improve fixation and outcomes in the treatment of femoral neck fractures? The use of pharmaceuticals. *J Orthop Trauma.* 2009 Jul;23(6):413-21.
29. **Moroni A, Larsson S, Hoang Kim A, et al.** Can we improve fixation and outcomes? Use of bone substitutes. *J Orthop Trauma.* 2009 Jul;23(6):422-5.