MEDICAL RECORDS-International Medical Journal

Research Article

Surgical Fixation with Cannulated Screws in the Adult Femoral Neck Fractures

Ismail Guzel[1], Oktay Belhan[2], Tarik Altunkilic[3]

[1]Turgut Özal University Faculty of Medicine, Department of Orthopedics and Traumatology, Malatya, Türkiye
[2]Fırat University Faculty of Medicine, Department of Orthopedics and Traumatology, Elazığ, Türkiye
[3]Turgut Özal University Faculty of Medicine, Department of Orthopedics and Traumatology, Malatya, Türkiye

Abstract

Aim: Femoral neck fractures are common injuries in orthopedic practice and result in significant morbidity and mortality. They are fractures in the intra-capsule area of the proximal femur. They usually occur in the elderly patient group. However, younger age groups could also experience femoral neck fractures as a result of high-energy traumas. The aim of the present study was to compare with the literature the outcomes in adult patients for whom surgical fixation was performed after femoral neck fracture using cannulated screws in our clinic.

Materials and Methods: The study included patients for whom surgical fixation was performed for femoral neck fractures using cannulated screws between August 2010 and August 2012. Fracture non-union, delayed union, avascular necrosis and arthrosis were evaluated in patients. Avascular necrosis evaluation was performed using Ficat and Arlet classification. Functional outcomes were evaluated using Harris hip score.

Results: The average follow-up period of our patients was 32 months (range: 24-48 months). Follow-ups indicated that 16 patients recovered without problems, walked with a double wand starting from about the third month with respect to the bone union status and full union was achieved in an average of six months. Non-union was observed in four patients. Ficat and Arlet avascular necrosis classification showed that four patients had avascular necrosis. The average time for these patients to be admitted to surgery was seven days. Five of our patients developed superficial wound infections. Antibiotic treatment and wound care were applied to our patients. When the patients were evaluated based on Harris hip score numerical rating chart, it was found that excellent outcomes were obtained in five patients, very good results in eight patients, good results in four patients, moderate results in two patients and poor results in one patient.

Conclusion: Femoral neck fractures are a common type of injury in orthopedic practice and they result in significant morbidity and mortality when treated inappropriately. In order to reduce the rate of bone non-union, avascular necrosis or other complications that could be observed in patients who underwent surgical fixation after femoral neck fractures, and appropriate and acceptable reduction of femoral neck fracture should be realized as soon as possible, and stable fixation should be achieved.

Keywords: Femoral neck fracture, internal fixation, garden classification, ficat and arlet classification, harris hip score

INTRODUCTION

Femoral neck fractures are common orthopedic injuries and associated with considerable morbidity and mortality. Femoral neck fractures, which make up majority of the fractures in the capsular area in femoral proximal, predominantly develop due to osteoporosis in older age. They can also occur in younger age groups as a result of high energy traumas (1-3). Femoral neck fractures constitute about half of the fractures in femur intracapsular area. Although they can occur at any age, as high as 97% of them are observed in patients over 50 years of age (4,5).

The main aim in the treatment for these fractures depends on pre-fracture mobilization status and osteoporosis level of the patient, the amount of displacement in the fracture, if any, and the time to the surgical operation. Femoral neck fractures are predominantly treated surgically. In the treatment of femoral neck fractures in young adults with a physiological age of less than 65, non-surgical treatment is not applied except for the presence of serious risk factors or life-threatening multiple traumas. However, conservative treatment can be considered in patients who do not have a displacement preventing surgical intervention, who have comorbid diseases, who are stable and who have valgus-impacted femoral neck fractures. In elderly patients, on the other hand, non-surgical treatment indication of displaced

CITATION
Guzel I, Belhan O, Altunkilic T. Surgical Fixation with Cannulated Screws in the Adult Femoral Neck Fractures. Med Records. 2023;5(1):96-102. DOI: 10.37990/medr.1174776

Received: 13.09.2022 **Accepted:** 21.11.2022 **Published:** 08.01.2023
Corresponding Author: Ismail Guzel, Turgut Özal University Faculty of Medicine, Department of Orthopedics and Traumatology, Malatya, Türkiye **E-mail**: dr.ismailguzel@gmail.com

femoral neck fractures is extremely rare (6).

Non-displaced or valgus-impacted femoral neck fractures should be surgically fixed before displacing take place, regardless of the age of the patient. Cannulated spongious screws, nails and sliding hip plaques can be used for surgical fixation. In surgical treatment of these fractures in many trauma centers abroad or in Turkey, fixation with three cannulated spongious screws are preferred, and adequate fixation and stabilization is achieved with this surgical treatment.

In the present study, we aimed to compare with literature the functional and clinical outcomes of adult inpatients who were surgically treated for hip fracture in our clinic using cannulated screws and internal fixation in surgical intervention.

MATERIAL AND METHOD

Functional and clinical results of adult patients surgically treated using canulated screws and internal fixation in our clinic for hip fracture between August 2010 and August 2012 were evaluated in comparison with the literature.

For the classification of fractures that occur after in-vehicle and pedestrian traffic accidents, high fall and firearm injury were considered fractures due to high-energy traumas while fractures after slipping in the bathroom or ice, stumbling while walking, simple falls at home or fractures of the patients who could not remember how the fracture occurred were considered low-energy trauma-related fractures. The classification of fractures was made according to Pauwels and Garden classification in adult patients.

Patients with multiple fractures, patients with associated chest, abdominal or head injuries, simultaneous systemic diseases such as chronic renal failure, rheumatoid arthritis, systemic lupus erythematosus and malignancy were excluded.

Clinical research ethics committee of Fırat University approved the study (Approval No: 17.12.2013/09-05).

Statistical Analyses

The IBM SPSS 19 software (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY) was used for statistical analyses. The continuous variables (age, length of stay, duration of surgery, etc.) were expressed as mean± standard errors. One-way analysis of variance (One-way ANOVA) was used to determine whether there was a difference between the relevant categorical variable groups for continuous variables. Categorized variables were expressed as percentages and numbers. To determine the relationship between categorized variables, the Chi-square test was used. The significance level was taken as 5 and 1%.

Clinic Evaluation

Clinical results and radiographs were evaluated at 1, 3, 6, 12, and 24 months postoperatively. Femur proximal anterior, posterior and side radiographies were taken for patients during the follow-ups and evaluated to see whether there was fracture union or delay in union, and to detect whether avascular necrosis and arthrosis developed. Avascular necrosis evaluation of the patients was performed based on Ficat and Arlet classification. Broker classification was used for the evaluation of ectopic ossification. Pain, function, deformity and mobility were evaluated using Harris hip score numerical rating chart (7,8). According to this chart, 86-100 points were considered excellent, 71-85 points very good, 61-70 points good, 41-60 points moderate, and 40 points or less poor.

Surgical Technique

Patients were operated upon receiving the approval from the Anesthesia and Reanimation department that they could be operated. Patients were taken to the surgical table in supine position. Then, general or regional anesthesia was applied by the anesthesia team. The fractured extremity was washed and painted with Povidone-iodine solution. The patient was covered with sterile green and the preparation was completed. First, a closed reduction was applied to fracture using the Leadbetter maneuver. In this maneuver, while the hip joint was at 90 degrees flexion, the femur was brought to internal rotation, and the external rotation deformity was corrected. Then, the shortness formed was corrected by straight traction along the thigh plane. While maintaining the internal rotation, the hip joint was first taken to abduction then to full extension at table level. Reduction control was achieved with scopy. If anatomic reduction was achieved after scopy, closed surgical intervention was continued. If the reduction was not sufficient, open reduction was indicated. Later, a skin incision was made starting from 3 cm posterior and distal of anterior superior spina iliaca to trochanter major, and from trochanter major to 5 cm distal. After passing under the skin, entrance was made between tensor fascia lata and gluteus medius, and at the distal, vastus lateralis muscle was cut off at the point of proximal end muscle insertion site. The superior gluteal nerve was preserved and the capsule was reached. The capsule was cut off and the fracture line was reached. After the fracture fixation, the incision was washed with serum physiological, bleeding control was applied, and the incision was sewn up.

RESULTS

Demographic data of patients are given in Table 1. Five of the patients with femoral neck fractures who were admitted to our clinic after high-energy trauma had additional accompanying fractures. Only one patient had additional fractures after low-energy trauma. The average age of these patients was 30.76 years, and the average age of patients without additional fractures was 53.83 years. There was a significant difference between these averages ($p<0.01$). High-energy traumas such as in-vehicle traffic accidents in two patients (33.3%), pedestrian traffic

accidents in two patients (33.3%) and falling from a height in one patient (16.6%) were involved in additional fractures while one patient with additional fractures (16.6%) had low-energy trauma. This patient developed a fracture at the radius distal end as a result of a simple domestic fall. Accompanying fractures had significant associations with the etiology of fracture ($p<0.01$). Accompanying fractures involved femur in two patients, humerus in one patient, radius distal tip in one patient, forearm double bone in one patient, ischium pubis arm in two patients and fibula in one patient. We had three patients with other organ injuries after the trauma. They were all injured by high-energy trauma. Car accident was the cause in two patients and falling from height in another. Other accompanying organ injuries included liver laceration, kidney laceration, femoral artery and saphenous vein injuries.

Fifteen of our admitted and examined patients (67.5%) had one or more comorbid diseases (such as chronic obstructive pulmonary disease, hypertension, diabetes mellitus, hyperthyroidism). The mean age of these patients was 54.1 years. Ten of them (66.7%) were female and 5 (33.3%) were male. Presence of comorbid disease was significantly associated with older age and female gender ($p<0.01$). In the patients with comorbid disease, the cause of fracture was low-energy trauma in eight patients (53.3%) and high-energy trauma in seven (46.7%). This association was significant ($p<0.01$).

The mean time for the patients to apply to our post-traumatic emergency department was 48 hours (range: 1 hour-24 days). Patients were operated within an average of two days. The earliest operation was performed four hours later while the latest was eight days later for a patient with comorbid diseases. The patient who underwent surgery after eight days had been transferred to the intensive care unit as a result of additional diseases and due to the fact that the operation was not allowed. Those with any existing systemic diseases were operated within an average of four days after applying to the emergency outpatient clinic. There was a significant difference between the patients with and without systemic disease for the time to surgery ($p<0.01$).

All patients who underwent surgical treatment were operated under regional or general anesthesia. Average operation time was 60 minutes, the shortest being 20 minutes and the longest 140 minutes. Blood transfusion was performed in postoperative period for five of our patients (20.8%) whom we treated with surgical intervention. These patients were the ones with additional fractures who were admitted to our clinic as a result of high-energy trauma.

In 5 of the 24 patients (20.8%) for whom we performed surgical treatment, superficial wound infection developed. All of these patients were those we applied open reduction. These patients responded to antibiotic and wound care treatment, and no additional treatment was required. While the superficial infection rate was 27.7% in the patients whose fractures were fixed with open reduction, this rate was 15% in those whose fractures were fixed with closed reduction. Of the 24 patients treated surgically, two (8.3%) developed deep infections. Both of these patients were the ones whose fractures were fixed with open reduction. In one of these patients, infection was detected in the third postoperative month. The infection was treated by removing the debridement and implants, and after the infection healed completely, the patient was given a total hip prothesis. The other patient developed an infection in the third week after surgery. The infection was treated with wound site debridement and washing. The mean duration of surgery was 133 minutes for patients with deep infection, which was significantly different compared to the duration of surgery for patients without deep infection ($p<0.01$).

Deep vein thrombosis developed in one patient (4.2%). This patient also had a femoral shaft fracture on the same side. This patient was treated with low molecular weight heparin, elevation and anti-thromboembolic socks. Pulmonary thromboembolism developed in two of the patients (8.4%) we treated surgically. One of them died of thromboembolism, and the other patient responded to treatment and recovered.

Decubitus wound developed in three patients (12.5%). The mean age of these patients was 62.4 years and there was a significant difference between the mean age of these patients and that of the patients who did not develop a pressure wound ($p<0.01$). The average time for these three patients to be admitted to surgery was six days. There was a significant relationship between the duration of the patients' admittance to surgery and the development of decubitus wounds ($p<0.01$). These three patients had accompanying systemic disease.

Union was observed in 4 of the 24 patients (16.7%) for whom fixation was performed for fracture treatment. The average age of these patients was 50 years, and one of them was male and three were female. The fracture type was Garden type 2 in two patients and Garden type 4 in two patients. All patients had inadequate fixation and reduction. One of the four patients who were observed to have bone union had open reduction, bone grafting and fixation for the non-union which was detected 1.5 years later during follow-up examinations. For another case, fixation with bone grafting was performed. We managed to achieve union in both fracture areas, but serious avascular necrosis occurred in our patients. Total hip prothesis was applied to two other patients who did not have union.

An average of 0.53 cm (1-3 cm) shortness was found in our patients who were examined and measured for shortness. An average of 1.4 cm of atrophy was detected in patients who were measured for atrophy 10 cm above the knee joint line.

A total of 20 patients who had complete follow-ups and whose files were sufficient were evaluated according to the Ficat and Arlet avascular necrosis classification. Avascular necrosis was observed in four patients (20%). One of these patients was evaluated as Ficat and Arlet Type 2, two as Ficat and Arlet Type 3 and another one as

Ficat and Arlet type 4. The average time for these patients to be admitted to operation was seven days. There was a significant relationship between the duration of the patients' admittance to surgery and the formation of avascular necrosis (p<0.01).

The 20 patients who had complete follow-ups and whose files were sufficient were evaluated with Harris hip score rating chart, and five patients (25%) had excellent outcomes, while eight had (40%) very good, four (20%) good, two (10%) moderate and one (5%) poor outcome.

Table 1. Demographic data	
Gender (Male/Female)	13 (52.2%) / 11 (45.8%)
Side (Right/Left/Bilateral)	10 (41.7%) / 12 (50%) / 2 (8.3%)
Age	49.21±17.6
Fracture etiology	
High energy trauma	45.8%
In-vehicle traffic accident	3 (12.5%) patients
Pedestrian traffic accident	1 (4.2%) patient
Falling from height	6 (25.0%) patients
Firearm injury	1 (4.2%) patient
Low energy trauma	54.2%
Fracture type	
Garden type-1	1 (4.2%) patient
Garden type-2	4 (16.6%) patients
Garden type-3	10 (41.6%) patients
Garden type-4	9 (37.6%) patients
Pauwels type-2	18 (75%) patients
Pauwels type-3	6 (25%) patients
Treatment modality	
Internal fixation with closed reduction	20 (76.9%) patients
Internal fixation with open reduction	6 (23.1%) patients
Harris hip score	
Excellent outcome	5 (25%) patients
Very good outcome	8 (40%) patients
Good outcome	4 (20%) patients
Moderate outcome	2 (10%) patients
Poor outcome	1 (5%) patient
Avascular necrosis (4 (20%) patients)	
Type 2	1 patient
Type 3	2 patients
Type 4	1 patient
Moderate outcome	2 (10%) patients
Poor outcome	1 (5%) patient

DISCUSSION

Fractures of the femoral neck are a common injury in orthopedic practice and result in significant morbidity and mortality as a result of inappropriate treatment. Appropriate and acceptable reduction and stable fixation of the femoral neck fracture should be achieved as soon as possible in order to reduce the rate of development of non-union, avascular necrosis or other complications seen in patients undergoing surgical fixation.

The 20-40% postoperative failure and revision rates has prompted orthopedic surgeons to investigate the factors that influence the failure of internal fixation. Gurusamy et al. (9) found that non-anatomical reduction was the most important factor for failure in femoral neck fracture. In this case, the quality of the reduction, fracture of calcar, small femoral head, varus angling over 30 degrees in femoral neck, the vertical status of the fracture line in relation to the ground plane and the fragmentation of the posterior cortex of the femoral neck are important factors. Slobogean et al. (10) showed that the only factor to be controlled by the orthopedic surgeon for a successful result is the quality of the reduction. Ozturkmen et al. (11) stated that the high failure rate was mainly due to the patients for whom adequate and stable reduction was not achieved. They stated that the surgical technique

was not applied appropriately in 35% of patients and that inappropriate and inadequate implants were used in 8.8% of patients. Han et al. (12) found that 14 (21%) of the 67 patients who underwent surgery with the diagnosis of femoral neck fracture developed reduction loss. The author reported that avascular necrosis developed as a complication in 42% of patients with reduced reduction loss, and that non-union was observed in the fracture in 28% of patients with reduction loss. Karslı et al. (13) evaluated the risk of developing avascular necrosis depending on the operation and anatomic reduction of the patients in their study. According to this study, no difference was found in the risk of developing avascular necrosis between the patient groups who underwent late surgery with poor reduction and who underwent early surgery and anatomically reduced. In the present study, we observed that the reduction was not anatomical in 7 of 26 hips (26.8%) and that there was no acceptable reduction in 3 hips (11%) based on Garden alignment index. Other patients had acceptable reduction. A total of nine patients (34%) were found to have technical defects or inadequate fixation. In these patients, lack of parallelism of the screws in relation to each other, positioning of the grooved part of the screw in the fracture line and inappropriate screw orientation in relation to femoral neck were some of the fixation problems. In addition, appropriate anatomical reduction was not achieved in seven of these patients. We are of the opinion that a proper reduction is essential for a perfect fixation. Both avascular necrosis and non-union were observed in 45% of our patients with inadequate and inappropriate fracture reduction and unstable fixation.

During the development of a femoral neck fracture, damage to the retinacular vessels responsible for supplying the femoral head region causes a high rate of non-union and avascular necrosis (14). Slobogean et al. (10) stated that the time factor played an important role in the results, that the blood supply to the femoral head was impaired in displaced fractures, and that operating the patient within six hours after trauma helped to reduce the rate of avascular necrosis. In addition, the author stated that intra-articular hematoma was an important factor affecting the blood supply to the head by increasing intra-articular pressure, and that while drainage of the hematoma and depressurization affected the outcome of non-displaced fractures, this was not taken into account in displaced fractures. It was shown that suitability of the reduction was an important factor for development of avascular necrosis in the surgical treatment of displaced femoral neck fractures. It was shown that in femoral neck fractures the rate of avascular necrosis could increase between 7 and 65% in cases where the neck angle is less than 155 degrees after reduction or greater than 180 degrees based on the Garden alignment index (15). All of our patients who developed avascular necrosis after surgical fixation had fixation failure or insufficient reduction. We think that the quality of fixation and fracture reduction may be important factors in the formation of avascular necrosis. Lee et al. (16) studied 116 adult patients diagnosed with femoral neck fracture and treated with cannulated screw fixation and reported that 17% of 12 patients with displaced fractures developed avascular necrosis while only 4% of 104 patients with non-displaced fractures developed avascular necrosis. In the present study, avascular necrosis was observed in four patients (20%). One of these patients was concluded as Ficat and Arlet Type 2, two patients as Ficat and Arlet Type 3 and the other patient as Ficat and Arlet type 4. The mean duration to surgery was seven days for our patients with avascular necrosis. While 25% of our cases had non-displaced fractures, 75% had displaced fractures.

Another important complication that may occur in patients who undergo surgical intervention due to hip fracture is the development of hematoma and infection. Studies in the literature revealed that infection development rate could vary between 2 and 20% in patients who undergo surgery (15). Lee et al. (16) reported that infection development rate was 6.3% in patients for whom drainage was used and 28% when drainage was not used. Petersen et al. (17) reported the development of deep wound infection in 1.4% of the patients and superficial infection in 0.3%. Kınık et al. (18) observed deep infection in 2.4% of patients who underwent surgery with a cannulated screw due to a fracture of the femoral neck. Rogmark et al. (19) observed superficial infections in 2.8% of patients when they applied internal fixation and reported no deep infections. In the present study, of the 24 patients who had surgical intervention, five (20.8%) developed superficial wound infection and two (8.3%) developed deep infection. These findings were consistent with the literature.

Deep vein thrombosis is one of the most serious complications that can be observed after fractures of the femoral neck. Previous thromboembolism attack, orthopedic operations, venous surgery and presence of varicose veins, malignancy, advanced age, congestive heart failure, immobilization, obesity, excessive blood loss and blood transfusion, oral contraceptive or hormone therapy use are factors contributing to the development of deep vein thrombosis. It mostly (80-90%) occurs in the fractured extremity. It develops in veins in legs and thighs, and extends towards proximal by 30%. Grosso et al. (20) reported that 2.2% of patients treated for hip fracture developed deep vein thrombosis and 1.1% developed pulmonary embolism. Kumar et al. (21), on the other hand, observed deep vein thrombosis in 3.5% of the patients and pulmonary embolism in 2%. It was reported in the literature that the patients who underwent surgical treatment after a femoral neck fracture had a deep vein thrombosis rate of 58% and fatal pulmonary embolism rate of 7.5%. Deep vein thrombosis developed in one of our patients (4.2%) while pulmonary thromboembolism developed in two patients (8.4%). One patient died whereas the other responded to treatment and recovered. The incidence of deep vein thrombosis and pulmonary embolism in our cases was consistent with the literature.

Although developments in the follow-up and treatment

of femoral neck fractures and improvements in implant quality have considerably reduced the incidence of non-union, it can still occur at a rate of 10-37%. The factors that cause non-union are delayed and poor reduction, blood flow disorders and failure to obtain a stable fixation. The persistence of pain in patients loading on their extremities after surgical fixation suggests that there may be a problem of non-union or delayed union. On average, union takes place in 6-12 months in femoral neck fractures. In their study on femoral neck fractures, Patterson et al. (22) reported that 36% of the patients had non-union and mentioned that infection accompanied non-union in 23% of these patients and that the 38% of the patients had non-anatomical reduction. Lee (16) reported that 9% of the 116 patients with femoral neck fractures who were fixed with cancellous screws had non-union. Kınık (18) reported a non-union rate of 3% among their cases for whom they performed fixation with multiple cancellous screws. In our study, non-union was observed in 4 of 24 patients (16.7%) who underwent fixation for fracture treatment. The mean age of these patients, one male and three female, was 50 years. Two of them had Garden-2 type fracture and other two had Garden-4. These patients had inadequate fixation and reduction. One of our four patients underwent open reduction, bone grafting and fixation for non-union, which was detected 1.5 years later in their follow-ups. For another patient, fixation was performed along with bone grafting due to non-union. Although union was achieved in these two patients, severe avascular necrosis developed after union. Total hip prosthesis was applied to two patients who did not have union. The rate of non-union in our cases was consistent with the literature. The factors stated in the literature as the cause of non-union were also present in our cases.

Rogmark et al. (19) reported success in 64% of the patients who underwent surgical fixation for a femoral neck fracture. Slobogean (10) obtained poor outcomes in 57% of patients for whom internal fixation was applied. The author mentioned that osteosynthesis has the risk of avascular necrosis and nonunion, and hemiarthroplasty involves the risks of arthroplasty loosening and acetabular wear while total hip arthroplasty has disadvantages of high cost and high mortality rate. However, the author reported that the best result was achieved in cases who had osteosynthesis. Öner (4) evaluated internal fixation for femoral neck fractures and reported that when multiple screws were used 36.5% of the cases had very good outcomes while 45.5% had good, 9% had moderate and 9% had poor outcomes. Kınık (18), on the other hand, reported that 28.6% of the patients had very good outcomes, 38.1% good, 14.3% moderate and 19% had poor outcomes with multiple screw fixation. In the present study, 20 patients were followed up for an average of 48 months. An evaluation of our patients based on Harris hip score rating chart indicated that excellent results were achieved in five patients (25%), very good results in eight patients (40%), good results in four patients (20%), moderate results in two patients (10%) and poor results in one patient (5%). Thus, our findings were consistent with the literature. Based on our findings, it could be stated that fracture type and intervention time are important factors for the outcomes of patients.

CONCLUSION

Femoral neck fractures are a common type of injury in orthopedic practice and could result in significant morbidity and mortality as a result of inappropriate treatment. In order to minimize the rates of non-union, avascular necrosis or other complications in patients who underwent surgical fixation, appropriate and acceptable reduction of femoral neck fracture should be achieved as soon as possible and a stable fixation should be performed. A good reduction and stable fixation could improve the outcomes in patients with femoral neck fractures.

LIMITATIONS

Retrospective study design, limited number of patients and short follow-up periods were among the limitations of the study. Studies with higher efficiency levels and larger patient populations are needed.

Financial disclosures: *The authors received no support from any financial institution or organization for this study.*

Conflict of Interest: *The authors declare that they have no competing interest.*

Ethical approval: *Clinical research ethics committee of Fırat University approved the study (Approval No: 17.12.2013/09-05).*

REFERENCES

1. Caviglia HA, Osorio PQ, Comando D. Classification and diagnosis of intracapsular fractures of the proximal femur. CORR. 2002; 399:17-27.
2. Yaradılmış YU, Okkaoğlu MC, Huri P, et al. Correlation between instability and fracture location in femur neck fracture: Biomechanical analysis. ETD. 2020;59:160-4.
3. Leighton RK. Fractures of the neck of the femur. Bucholz RW, Heckman JD, Court-Brown CM (Editors). Rockwood & Green's Fractures in Adults. Chapter 44, 8th ed. Philadelphia: Lippincott Williams & Wilkins. 2015:1754-91.
4. Öner K, Paksoy AE, Özer A. Fixation of femoral neck fractures with three cannulated screws: biomechanical changes at critical fracture angles. JOSAM. 2020;4:660-3.
5. Alolabi B, Bajammal S, Shirali J, et al. Treatment of displaced femoral neck fractures in the elderly: a cost-benefit analysis. JOT. 2009;23:442-6.
6. Jain AK. Surgical Treatment of Orthopaedic Trauma: A Comprehensive Text and Video Guide. Indian J Orthop. 2018;52:539-561.
7. Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris Hip Score (HHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), Oxford Hip Score (OHS), Lequesne Index of Severity for Osteoarthritis of the Hip (LISOH) and American Academy of Orthopedic Surgeons

(AAOS) Hip and Knee Questionnaire. ACR. 2011;63-11:200-7.

8. Edwards PK, Queen RM, Butler RJ, et al. Are Range of Motion Measurements Needed When Calculating the Harris Hip Score? J Arthroplasty. 2016;31:815-9.
9. Gurusamy K, Parker MJ, Rowlands TK. The complications of displaced intracapsular fractures of the hip: the effect of screw positioning and angulation on fracture healing. J Bone Joint Surg Br. 2005;87:632-4.
10. Slobogean GP, Sprague SA, Scott T, Bhandari M. Complications following young femoral neck fractures. Injury. 2015;46:484-91.
11. Ozturkmen Y, Karamehmetoglu M, Azboy İ, Acikgoz İ, Canikoglu M. Comparison of primary arthroplasty with early salvage arthroplasty after failed internal fixation for displaced femoral neck fractures in elderly patients. AOTT. 2006;40:291-300.
12. Han Z, Taxi W, Jia H, et al. Multiple cannulated screw fixation of femoral neck fractures with comminution in young- and middle-aged patients. JOSR. 2022;18:280.
13. Karslı B, Gönder N. Displaced Femoral Neck Fractures: Anatomic Reduction or Early Surgery?. Eur J Ther. 2021;27:1-7.
14. Wazir NN, Mukundala VV, Choon DS. Early results of prosthetic hip replacement for femoral neck fracture in active elderly patients. J Orthop Surg. 2006;14:43-6.
15. Lavelle DG. Fractures and dislocations of the hip. Canale ST (Editor) Campbell's Operative Orthopaedics. Chapter 52, 10th ed. Philadelphia: Mosby Inc. 2003:2908-22.
16. Lee KB, Howe TS, Chang HC. Cancellous screw fixation for femoral neck fractures: one hundred and sixteen patients. Ann Acad Med Singap. 2004;33:248-51.
17. Petersen MB, Jørgensen HL, Hansen K, Duus BR. Factors affecting postoperative mortality of patients with displaced femoral neck fracture. Injury. 2006;37:705-11.
18. Kınık H, Polat O, Mergen E. Femoral neck fractures treated with cannulated screw. AOTT. 2006;33:13-17.
19. Rogmark C, Carlsson A, Johnell O, Sernbo I. Primary hemiarthroplasty in old patients with displaced femoral neck fracture: a 1-year follow-up of 103 patients aged 80 years or more. Acta Orthop Scand. 2002;73:605-10.
20. Grosso MJ, Danoff JR, Murtaugh TS, et al. Hemiarthroplasty for displaced femoral neck fractures in the elderly has a low conversion rate. J Arth. 2017;32:150-4.
21. Kumar S, Geevarughese NM, Rajnish RK, et al. Outcomes of displaced, comminuted, intracapsular neck femur fracture in young adults managed with three screw inverted triangle versus four screw diamond configuration: a comparative pilot study. Indian J Orthop. 2021;56:566-72.
22. Patterson JT, Tangtiphaiboontana J, Pandya NK. Management of Pediatric Femoral Neck Fracture. JAAOS. 2018;26:411-9.