



Fixation of femoral neck fractures with three screws: results and complications

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Objectives: To evaluate the results and complications of femoral neck fractures treated with internal fixation with three screws with an average follow-up of three years.

Methods: Thirty seven patients operated upon between June 2000 and May 2005 for fractures of the femoral neck with three screws were identified as the study population. The final results of 26 patients (11 male, 15 female, with an average age of 39.8, range 16-69) that had a minimum of two year follow-up (average 37 months, range 24-64 months) were evaluated. Those patients that had additional fractures were not included in the evaluation. Preoperatively based on Garden classification four patients (15%) were Type I, eight patients (31%) were type 2, six patients (23%) were type three and eight patients (31%) were type 4. Functional results were evaluated according to the UCLA hip score.

Results: The average time to union was 5.5 months (range 3-12 months). One patient did not achieve union and a total hip replacement was done in the 15th postoperative month. Four patients had avascular necrosis (AVN) of the femoral head. The incidence of AVN in patients who had an operation within 24 hours of fracture was 9.5% while 40% in patients operated later than that. In patients with AVN one required a total hip replacement, another required treatment with bipolar hemiarthroplasty, the other two patients did not require further operations. One patient underwent bipolar hemiarthroplasty after screw pullout occurred on the 35th postoperative day. Fifteen patients (58%) had excellent results, five (19%) had good, 5 (19%) had moderate results and one (4%) had a poor result.

Conclusion: Operative treatment with internal fixation using three screws in femoral neck fractures in the first 24 hours after a fracture gives favourable results in young patients that are too young to be considered for arthroplasty.

Key words: Femoral neck fracture; internal fixation; three screws.

Femoral neck fractures constitute 3% of all fractures and a large portion of fractures after the age of 60.^[1] Femoral neck fractures in elderly cases usually occur due to a low-energy trauma and can be treated successfully with internal fixation or prosthesis,

depending on the patient's age and general condition and also the quality of the bone.^[1,2] However, femoral neck fractures in adults and adolescents usually occur due to a higher energy trauma and are accompanied by multi-system injuries. Treatment of

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femoral neck fractures in the young adult age group also show differences from that of elderly patients. Due to the anatomical structure, blood circulation, biomechanical and functional characteristics, fracture union and the treatment features of the upper part of the femur, it is a problematic area for orthopedic surgeons. It is difficult to manage because of both the special blood circulatory system of the femoral neck and fragmentation. Instability and the dynamic stresses loaded to this region should also be managed as soon as possible.^[3] Although there is no clear consensus on either the determination of the treatment modality to be used or the selection of surgical treatment method on fractures in this age group, the protection of the femoral head is fundamental.^[2-4] In addition, the treatment of these fractures in adults may not be in accordance with a standard treatment protocol as they occur due to high-energy trauma and are accompanied by injuries in other organs. In this study we aimed to present an average of three-year follow-up results and the complications in patients with femoral neck fractures who are accepted as young according to physiological age and are not scheduled for arthroplasty after internal fixation with three screws.

Patients and methods

Of the 37 patients who were admitted to our clinic with a diagnosis of femoral neck fracture and were treated with internal fixation between June 2000 and May 2005, 26 patients in whom cannulated or cancellous screws were used as fixation material and regular follow-up could be carried out for at least two years were enrolled in this study. Patients with fractures in other regions along with femoral neck fractures were not included in this study to not to affect the results (Table 1). Of the 26 patients, 11 are male (42%) and 15 are female (58%). The mean age was 39.8 and the age range was 16-69 (Table 2). Twelve patients (46%) had right hip fractures and 14 (54%) patients had left hip fractures.

Sixteen (64%) of the fractures were due to a high-energy trauma. Of these fractures, 13 (81%) were due to falls from heights, two (13%) were due to traffic accident as a passenger, one (6%) was due to traffic accident as a pedestrian. All of the fractures that occurred with a low-energy trauma were due to a simple fall (indoor or simple). Furthermore, the etiological factor was high-energy trauma in all of our

Table 1. Fractures associated with femoral neck fracture.

Associated fractures	Number (n=7)
Subtrochanteric femur fracture	1
Patellar fracture	1
Femoral shaft fracture	3
Femur shaft+tibial plateau fractures	2

Table 2. Range of patients according to age and sex.

Age	Female	Male	Total	Percent
16-20	3	2	5	19%
21-30	3	0	3	12%
31-40	2	3	5	19%
41-50	3	0	3	12%
51-60	4	4	8	30%
61-70	0	2	2	8%
Total	15	11	26	100%

patients who were not included in this study and had additional fractures. The mean age of patients with fractures due to a high-energy trauma was 34.5 and the mean age of patients with fractures due to a low-energy trauma was 48.2. The follow-up period ranged between 24 months and 64 months and the mean follow-up period was 37 months.

Of the patients included in this study, one had mental retardation, one had polio sequelae, two had diabetes mellitus (DM) and one had both DM and hypertension. The period of time from the occurrence of the fracture until the referral to the hospital was between one hour and 336 hours, and the mean period was 16 hours. Although the vast majority of patients were referred to the hospital within 12 hours, but because of one patient referred to the hospital after 10 days and one patient referred after 14 days, the mean time was higher. Both these patients had low-energy trauma fractures.

The diagnosis of the patients was established by anterior-posterior pelvic X-ray and associated hip radiograph. An anterior-posterior X-ray was taken in 15 degrees of internal rotation for the femoral neck fractures which were not dislocated. The two patients who could not to be diagnosed by radiographs were diagnosed by computed tomography (CT) examination. There was no need for magnetic resonance imaging (MRI) or scintigraphy for the diagnosis of any

patient. Garden classification was used in the classification of fractures.^[5] According to Garden classification, four patients (15%) were type-1, eight patients (31%) were type-2, six patients (23%) were type-3 and eight patients (31%) were type-4. Considering displacement of the fracture, 14 patients (54%) had fracture displacement and 12 patients had (46%) no fracture displacement.

Treatment protocol

When the patients were referred to the emergency department, we focused primarily on any life-threatening injuries and priority was given to that injury. Seven patients had other systemic injuries along with femoral neck fractures. At first, routine preparation for general anesthesia for patients who presented to the emergency service with femoral neck fractures was performed. Blood for transfusion arranged for surgery. For thrombo-prophylaxis subcutaneous low molecular weight heparin was administered inpatients, if there were no contraindications. In the preoperative period, patients were kept in the most comfortable position or at slight flexion and external rotation with the help of a "Braun's splint", because the intra-capsular pressure could have increased. Routine antibiotic prophylaxis (IV cefazolin 1 g) was started one hour before the surgery.

After the patients were admitted to the emergency room, surgery was performed as soon as possible. Of the patients admitted to hospital: 17, 4, 3 and 2 patients were operated on within 12 hours, between 12 and 24 hours, between 24 and 48 hours, after a period of more than 48 hours, respectively. Of two patients who were operated upon after a period of more than 48 hours, one was referred to our clinic 10 days after the fracture and the other one was referred 14 days after the fracture. 20 patients were given general anesthesia and six were given spinal anesthesia. After being anesthetized patients were shifted to the operating table in supine position.

Closed fixation was performed in 12 patients and open fixation was performed in 14 patients. Three screws were used for fixation. Patients in who closed fixation was performed, decompression of the fracture hematoma was attempted by performing joint puncture. Open fixation was performed using the anterolateral (Watson-Jones) approach in supine position^[6] and hematoma was evacuated following hip joint capsulotomy. Then, the fracture was

reduced and the fixation was performed using three screws under fluoroscopic control. Reduction was assessed according to the Garden alignment index (GAI)^[11] and by the amount of displacement. The fixation was taken to be appropriate in those with GAI between 155 and 180 degrees and in those where displacement was less than 1/4 of the diameter of the femoral neck.

Postoperative care

On the first day of postoperative follow-up period, patients were seated on the edge of the bed and shown quadriceps isometric exercises. On the second day, they were mobilized with a pair of crutches non-weight bearing and nurses helped them walk in the room. Patients without any other problems were discharged on the third postoperative day. Patients were called back for follow-up on day 45, in the third month, in the sixth month and after one year. The patients were evaluated based on fracture healing. Patients whose fracture union was considered adequate radiologically were allowed partial weight bearing after six weeks and were allowed full weight bearing in third and fourth months.

In clinical evaluation of the latest status of the patients, pain, limitation of movement and shortness were noted. In radiological evaluation, the degree of the union, loss of the alignment of the fracture, trabecular integrity at fracture line, late segmental collapse and the presence of avascular necrosis were observed. Avascular necrosis was assessed according to criteria of Ficat.^[7] Patients were evaluated by UCLA (University of California, Los Angeles) hip evaluation score in terms of function (Table 3). The mean follow-up period was 37 months (range: 24 to 64 months).

Results

No general or local complications occurred in our patients during surgery. There were no patients with pulmonary embolism and deep vein thrombosis. The direct radiography of a patient (with borderline mental retardation) who presented hip pain on the thirty-fifth day after surgery showed that the screws got pulled out and the fracture was displaced. It was seen from the patient's history that the patient started early weight bearing. The patient was re-hospitalized and treated with bipolar prosthesis (Fig. 1). The general and local complications that were observed in our patients are shown in Table 4.

Table 3. UCLA hip evaluation score.

	1 point	2 points	4 points	6 points	8 points	10 points
Pain	Always unbearable, Frequently need to use painkiller	Continuous but tolerable, sometimes painkiller, frequently need to use salicylate	With activity, during rest few or much. Frequently need to use salicylate	Just beginning of activity, then relief. Sometimes using of salicylate	Rarely and gentle	No pain
Walking	Bedridden	Mobilization is provided with a wheelchair or walker	Indoor unsupported, with one crutch 50 m, with double crutches 100 m walking	Unsupported about 50 m, with one crutch 250 m, with double crutches unlimited	Unsupported limping. With one crutch gentle limping	Unsupported. No limping
Function	Completely dependent	Partially dependent	Independent, some housework can be done	Many housework can be done	Standing working	Normal activity

26-30 points: Excellent, 20-25 points: Good, 12-20 points: Moderate, 11 points and below: Bad

According to the UCLA hip score, outcome was perfect in 15 (58%) patients, good in five (19%) patients, moderate in five (19%) patients and poor in one (4%) patient (Fig. 2).

According to the Garden classification, post-operative success of placement was good in 19 patients, moderate in five patients and bad in two patients. The mean time period for fracture union was 5.5 months and ranged between three and 12 months. The patients who had fracture union in three months were all Garden type 1. It was observed that complete fracture union was achieved in a patient in the twelfth month. There was non-union in one patient and total hip prosthesis was performed in this patient in the fifteenth post-operative month. As there was non-union in this patient, this was considered as poor outcome.

Femoral head avascular necrosis (AVN) developed in four patients during their follow-up. Patients who developed avascular necrosis are shown in Table 5 according to the fracture type. A patient with avascular necrosis and Garden type 2 fracture was operated upon, on the tenth day. Of patients with AVN, one received a total hip prosthesis and one bipolar hemiarthroplasty prosthesis. Despite the radiological detection of AVN in two other patients, the UCLA score was good. An additional surgical intervention was not planned for the other patient because he/she was able to tolerate the pain. The AVN rate in the patients (n=21) who underwent internal fixation in the first 24 hours was 9.5% and this rate was 40% in those patients (n=5) who were operated after 24 hours.

Table 4. Complications.

Complications	Number	Percent
Hemorrhagic discharge	2	7.6%
Superficial infection	2	7.6%
Delayed union	1	3.8%
Nonunion	1	3.8%
Avascular necrosis	4	15.3%
Shortening	1	3.8%
Decubitus Ulcer	1	3.8%
Thromboembolism	0	0%

Table 5. According to fracture type rates of avascular necrosis.

Fracture type	Number	Percent	Avascular necrosis (n=4)
Garden type 1	4	(15%)	0
Garden type 2	8	(31%)	1
Garden type 3	6	(23%)	1
Garden type 4	8	(31%)	2

Discussion

Because of the anatomical structure, blood circulation, biomechanical and functional characteristics, fracture union and the treatment features of the proximal end of the femur, it is a problematic area for orthopedic surgeons. The abundance of the treatment methods and the presence of more than 100 implants for internal fixation show the importance of the fracture.^[2,8,9] In elderly patients, the first treatment option is primary hemiarthroplasty, because of poor fracture healing in these common fractures due to

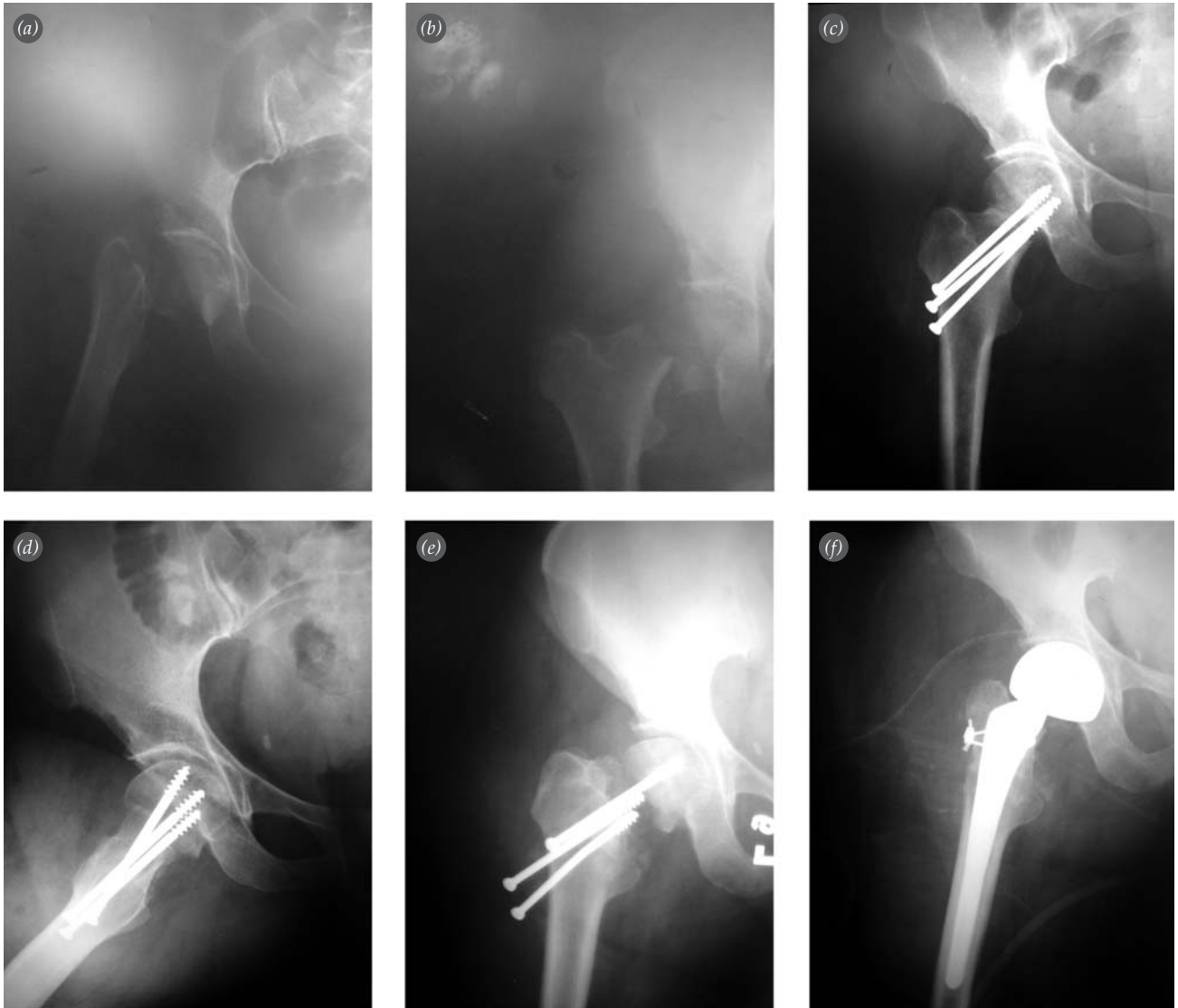


Fig. 1. (a, b) 55 years old female patient. Garden type 4 fracture preoperative graphies; (c, d) Early postoperative graphies; (e) Screws were pulled out in postoperative 35.days; (f) Revision was performed to patient with sementless bipolar hemiarthroplasty.

osteoporosis and difficulty tolerating additional interventions, where as internal fixation is the best treatment modality in young patients in order to preserve the femoral head.^[10-13] The mean age of the patients treated with internal fixation is usually over 60 years in western literatures,^[14] and over 70 years in some publications.^[15] The mean age is lower than that in our country both because patients' life span is shorter and high-energy trauma is common.^[16]

The aims of the treatment of the patients with femoral neck fractures who are accepted as young based on physiological age are the improvement of the fracture outcome by preserving the femoral head, prevention of non-union and avascular necrosis and to

have the patient return to previous functional status with rapid rehabilitation.^[4,17] In femoral neck fractures (FNF), fracture stability is important for the selection of the treatment modality. Garden type 1 and type 2 fractures are stable fractures, and type 3 and type 4 fractures are unstable fractures. Although some authors adopted bed rest and conservative treatment methods because Garden type 1 and type 2 fractures are stable and they unite, "The American Trauma Committee" proved that the fragments gradually relax by resorption in this type of fracture and surgical treatment should be chosen. Non-displaced or impacted fractures should also be treated with internal fixation without causing displacement as soon as possible,

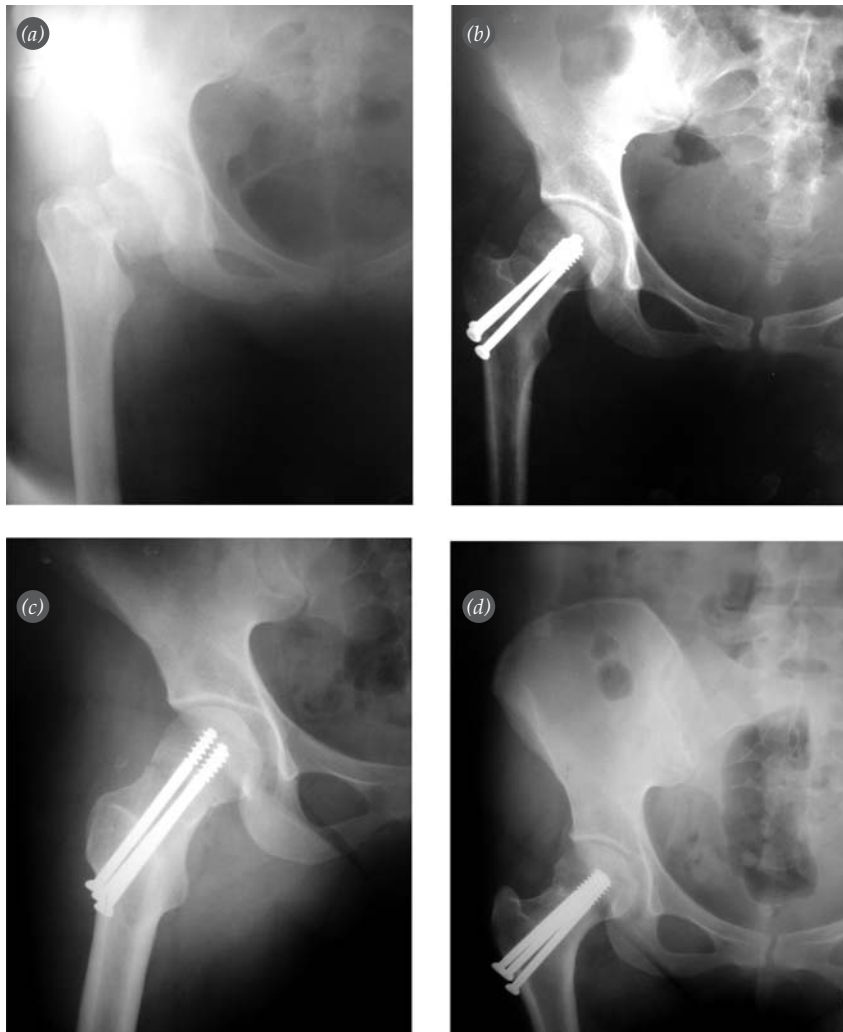


Fig. 2. (a) 23 years old female patient. Garden tip 4 fracture. Preoperative graphy; (b, c) Early postoperative graphies; (d) Postoperative 40. months graphy UCLA hip score: 30 (excellent).

regardless of whether the patient is young or old.^[2,16,18,19] Holmberg et al. reported that the rate of displacement was 31 percent in impacted fractures that were followed conservatively.^[10] Nails, cannulated-cancellous screws or dynamic hip screw (DHS) can be used for fixation.^[2,4] Biomechanical and clinical studies were done for many implants for internal fixation. Nowadays, multi-screw fixation is preferred for femur neck fracture and adequate stabilization is achieved.^[2,20,21] We also used three screws for internal fixation in our patients. The experimental studies showed that three screws are biomechanically more advantageous than two and the fourth screw has no additional contribution to the stability.^[22,23] In their biomechanical study on cadavers, Selvan et al. showed that three screws that are parallel to each other, forming an equilateral triangle in femoral head, are biomechanically the most stable configuration.^[22]

Although decompression of the intra-capsular hematoma is controversial, it is recommended in current literature. The intra-capsular pressure of a robust joint rises up to 320 mmHg due to bleeding from the fracture line. Due to increased intra-articular pressure, the blood flow towards the head of the femur decreases or even stops. As a result, ischemic damage in the femoral head increases. It was shown that the decompression of hematoma with needle aspiration or capsulotomy increases the blood flow towards the head of femur by decreasing the intra-capsular pressure.^[2,4,24] Therefore, it is recommended that the evacuation of the hematoma should be performed as soon as possible.^[12,24,25] In our series, evacuation of the hematoma was performed by joint puncture in a patient who underwent closed fixation and by opening the capsule in patients who underwent open fixation.

The timing of the internal fixation of femoral neck fractures is important for prognosis. Many clinical trials showed that internal fixation, if possible, should be done within the first 24 hours in order to reduce the risk of complications. It was recommended that internal fixation should be done within the first 24 hours, especially in dislocated fractures. Even a very small delay is important in younger patients. Therefore, femoral neck fractures are considered as a true orthopedic emergency in young age.^[1,2,4] Swiontkowski reported that early fixation, ideal placement and the opening of the capsule of the hip joint are the three most important factors for a successful outcome and surgical intervention should be done within 12 hours.^[29] In our series, we tried to operate on the patients as soon as possible. Out of 26 patients evaluated as part of this study, 21 were operated on within the first 24 hours after presentation. Three patients were operated on within 24 to 48 hours and two patients were operated on after 48 hours. The rate of AVN was 9.5% in patients who underwent internal fixation within 24 hours and was 40% in patients who underwent internal fixation after 24 hours.

Some common complications seen after the internal fixation of femoral neck fractures are avascular necrosis (AVN), non-union, fixation failure and implant failure.^[12,19] AVN is the most serious complication of femoral neck fractures.^[12,26] In literature, the rate of AVN ranges between four and 40 percent and varies depending on the timing of fixation, displacement of the fracture, the amount of fragmentation and the patient's age.^[18,26,27] The rate of AVN is 10-15 percent in impacted fractures and non-displaced fractures, and between 30 and 35 percent in displaced fractures. Nikolopoulos^[26] reported that the AVN rate is 19% in non-displaced fractures and 39% in displaced fractures in their series, comprising of 84 patients, whose mean follow-up period was 4.7 years. From our country, in a series including 42 patients, Kayalı et al.^[12] reported that the rate of AVN is 40% and Bulut et al.^[25] reported that the rate of AVN is 16.7%. In our series, AVN was detected in four patients (15%). The fractures of three of these four patients were displaced. AVN developed in one of our patients with Garden type 2 fracture. This patient was operated on 10 days after the fracture occurred.

Rate of additional surgical procedure being performed in patients with AVN is 40-60% in literature.^[13,28] In our study, out of the four patients with

AVN, one underwent total hip arthroplasty and one underwent bipolar hemiarthroplasty. Of the other 2 patients, hip scores and the UCLA scores were moderate and good, respectively. No additional surgical intervention was planned for these patients

In femoral neck fractures, non-union is detected within the first year and requires secondary surgical interventions because it often causes pain.^[4] Non-union depends on the amount of displacement of the fracture, comminution, and the stability and circulatory status of the femoral head. In literature, the rates are between 0 and 33 percent^[12,27,29] The differences in rates depend on the type of the fracture, material and method of the fixation. Non-union can be accompanied by AVN of the femoral head. Vascular damage is the basic factor in non-union and AVN formation.^[30] The main damage is in the vessels at the fracture level inside the bone in non-displaced and impacted fractures, and occurs as a result of different degrees of damage of retinacular vessels in dislocated fractures. The generally adopted idea is that anatomical placement and stable internal fixation decrease healing problems.^[1,2,14] The treatment of non-union of neck of femur fracture is total hip arthroplasty in elderly patients and valgus osteotomy and grafting in younger patients.^[31] In our study, there was non-union in the fracture of a patient during his/her follow-up. This non-union occurred in a fracture that was Garden type 3 and could not be operated upon within the first 24 hours. Total hip arthroplasty was performed in this patient in the fifteenth postoperative month.

In conclusion, in young adults and the middle age group, femoral neck fractures are true orthopedic emergencies and early anatomical reduction and stable fixation are essential in treatment. The patients should be operated on as soon as possible. In patients who are operated upon within the first 24 hours, the chance of success increases. Fixation with just three screws is adequate for treatment. We should be vigilant in terms of additional injuries because they usually occur as a result of high energy trauma. The role of the surgeon and the surgical method should not be forgotten in femoral neck fractures. The surgeon is one of the most important factors affecting the outcome of neck of femur fractures. The quality of the reduction, fixation implant, evacuation of the hematoma and early surgical treatment depends on the surgeon's initiative.

Conflicts of Interest: No conflicts declared.

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