

Risk Factors Associated with Femoral Neck Fracture Outcomes in Adults: Retrospective Clinical Study

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ABSTRACT

Introduction: The aim of this study was to evaluate the factors affecting the clinical and radiological results of the patients who underwent internal fixation due to femoral neck.

Methods: Sixty-nine patients are included in this study. Follow-up periods were determined as a minimum of six months. Fractures were classified with Garden and Pauwel's classifications. 12 hours was the cut-off limit between early and delayed fixation. The standard treatment was cannulated screw fixation. Trauma mechanism, reduction quality and patient dependent factors such as smoking and diabetes were evaluated. Non-union and avascular necrosis (AVN) was diagnosed with X-ray or computerized tomography if needed. Harris Hip score (HHS) was used as a functional scoring modality.

Results: Twenty-five (36.2%) patients were female and 44 (63.8%) were male. Twenty-six patients (37.7%) were under 40 years old and 43 (62.3%) were older. Forty-two (60.9%) of these fractures were classified as Garden 1-2 (non-displaced) and 27 (39.1%) were classified as Garden 3-4 (displaced). While 39 patients (56.5%) were operated on before the 12-hour cut-off point; 30 patients (43.5%) were operated on later. Fourteen patients (20.3%) were diagnosed with non-union and 12 (17.4%) with AVN. Mean HHS was 88.7±14.2 (47-100). Displaced group (Garden 3-4) showed a higher incidence of non-union (40.7% vs.7.1%) and AVN (25.9% vs. 11.9%) compared to the non-displaced group (Garden 1-2). The timing of surgery did not have a statistically significant impact on outcome in terms of non-union and AVN. The complication rates were higher in patients with poor reduction.

Conclusion: Our complication rates were similar to the literature. Age, gender, fracture side, smoking, and time to fixation were found as irrelevant with non-union and AVN rates. Non-union was significantly higher in the displaced group and no significant difference was found in AVN rates. The reduction quality was significantly associated with complications.

Keywords: Femoral neck fractures, internal fixation, time to surgery

Introduction

Femoral neck fractures are an important cause of mortality and morbidity with an increasing frequency. Although it was calculated as 1.3 million fractures per year in the 90s, it is expected to increase to 4.5 million in the 2050s as the average life expectancy increases (1). Femoral neck fractures constitute 3% of all hip fractures in the young population. Despite its low incidence, it maintains its importance due of high complication rates (2). The treatment of femoral neck fractures has always been controversial and no definitive algorithm has been formed. The main goal in young and active patients is to obtain a functional hip by preserving the femoral head. For this purpose, the primary choice has been internal fixation methods. In elderly patients with comorbidities, low expectation of union, and hip arthrosis, the first choice is usually arthroplasty.

According to meta-analysis studies, 11 to 19% osteonecrosis and 23 to 37% non-union are seen despite all these treatment protocols (3). Fracture type, time to surgery, reduction quality, stability, trauma mechanism, and comorbidities and their impact on outcomes are still debated. In this study, we evaluated the factors affecting the clinical and radiological results of the patients who underwent internal fixation due to the femoral neck.

Methods

Sixty-nine patients who underwent internal fixation for femoral neck fractures in our clinic between 2011 and 2018 were retrospectively evaluated. Verbal informed consent was obtained from all patients in the study. Pathological fractures, stress fractures, concomitant acetabular fractures, fracture-dislocations, and patients with a history of steroid use were not excluded. After a comprehensive trauma evaluation in



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the emergency room, patients were prepared for surgery. Surgery was performed as soon as possible after anesthesia consultation. Relevant radiographs were taken and classified according to Garden and Pauwel's fracture classification. All patients were operated on in the supine position on the traction table. After closed reduction, all patients were fixed in the triangle configuration using three 6.5 mm cannulated screws. On the first postoperative day, patients were mobilized in a non-weight bearing regime. Postoperative X-rays were evaluated according to the Garden alignment index (4). Follow-up time was a minimum of six months with decreasing frequency. Patients' age, gender, past medical history, smoking, drug history, and complaints were recorded. The time to surgery cut-off was determined as 12 h. Those who were operated on before 12 h were determined as early and those who were operated on after 12 h were determined as delayed. Postoperative examinations included gait, range of motion, and limb length discrepancy evaluations. Hip anteroposterior and lateral radiographs and computerized tomography scans were performed when a non-union was suspected. Complications such as shortness, deformity, infection, non-union, and avascular necrosis (AVN) were recorded (Figure 1). AVN was classified according to the Ficat-Arlet classification using radiography. Harris Hip score (HHS) and visual analog scale (VAS) were used to determine the functional outcomes. This research was approved by the Institutional Review Boards of the authors' affiliated institutions. The study was approved by the University of Health Sciences Turkey, İstanbul Training and Research Hospital Clinical Research Ethics Committee (approval number: 1070, date: 18.08.2017).

Statistical Analysis

SPSS 22.00 was used for data analysis. In the descriptive statistics of the data, mean, standard deviation, median lowest and highest, frequency and ratio were used. Kolmogorov-Smirnov test was performed for distributing variables. The chi-square test or Fisher test was used for the analysis of qualitative independent data. The statistical significance level was determined as $p < 0.05$.

Results

Study Characteristics

Twenty-five of 69 patients (26.3%) were female and 44 patients (73.7%) were male. There were 26 patients (37.6%) under the age of 40 and 43 (62.4%) between the ages of 40 and 60. Our average follow-up period was 16.4 ± 10.1 (6-84 months). Twenty-one patients (30.4%) presented with a simple fall, 30 (43.4%) patients with a fall from a height, and 18 (26.2%) patients with a traffic accident. Forty-two patients (60.9%)



Figure 1. a) Displaced femoral neck fracture, b) Femoral neck fracture fixed with cannulated screw, c) Non-union and implant failure was seen at 3rd month control X-ray

were evaluated as Garden type 1-2, 27 (39.1%) patients as Garden type 3-4 fractures on initial X-rays. According to Pauwel's classification, 26 patients (37.6%) were type 1, 36 patients (52.1%) were type 2, and 7 patients (10.3%) were type 3. While 39 patients (56.5%) were operated on before the 12-hour cut-off point; 30 patients (43.5%) were operated on later. Fixation was achieved with cannulated screws after closed reduction in all patients. Twenty-nine patients had a history of smoking, and 11 patients had a history of diabetes mellitus (DM). Sixteen patients underwent a second surgery due to complications. Eight of these were converted to total hip arthroplasty, 3 patients' implants were removed due to local irritation, and 5 patients needed re-osteosynthesis.

Functional Outcomes

Non-union was detected in 20.2% (14/69) patients and AVN in 17.3% (12/69). According to the Ficat-Arlet classification, two patients were stage 2A, five patients were stage 2B, three patients were stage 3, and two patients were stage 4. Mean HHS was 88.7 ± 14.2 . HHS was excellent in 46 patients, good in 6 patients, fair in 8 patients, and poor in 9 patients. VAS score was 1.7 ± 2.3 (Table 1).

Complications

Non-union and osteonecrosis rates were similar among patients who were younger and older than 40 years. In the younger group ($n=40$), 19.2% ($n=5$) non-union and 26.9% ($n=7$) osteonecrosis were observed. In the older group ($n=43$), non-union and osteonecrosis rates were 20.9% ($n=9$) and 11.6% ($n=5$) respectively, and showed no significant difference with respect to AVN and non-union ($p > 0.05$) (Table 2).

Complication rates were significantly higher in patients with high-energy trauma. In the patients with low energy trauma ($n=21$), only 1 patient was diagnosed with non-union and 3 patients had radiographic signs of AVN, while in 48 patients who presented with high-energy trauma 13 (27.1%) were diagnosed with non-union and 9 (18.7%) with AVN ($p < 0.05$) (Table 2).

In the non-displaced group ($n=42$), 3 patients (7.1%) were diagnosed with non-union and 5 patients (11.9%) showed radiographic evidence of AVN. The displaced group showed a higher incidence of both nonunion [40.7% (11/27)] and AVN [25.9% (7/27)]. Non-union was significantly higher in the displaced group ($p < 0.05$). Fracture displacement didn't have a significant impact on osteonecrosis. ($p > 0.05$) Non-union rate was 7.6% (2/26) with Pauwels' type 1, 22.2% (8/36) with type 2, and 57.1% (4/7) with type 3. The AVN rate was 7.6% (2/26), 22.2% (8/36) and 28.5% (2/7) respectively. Pauwels' classification showed no significant impact on the outcome in terms of non-union and osteonecrosis ($p > 0.05$) (Table 2).

A good reduction was achieved in 81.1% (56/69) patients, a moderate reduction in 11.5% (8/69), and a poor reduction in 7.4% (5/69). Complications developed in 62.5% (5/8) of patients with moderate reduction and 80% (4/5) of patients with poor reduction. There was a significant relationship between reduction quality and complications ($p < 0.05$) (Table 3).

The non-union rate was 30% (9/30) and the AVN rate was 16.6% (5/30) among smokers. The non-union and AVN rates were 12.8% (5/39) and 17.9% (7/39) respectively, with non-smokers. There was no significant difference between the smoking and non-smoking groups in terms of complications ($p > 0.05$) (Table 2).

Discussion

Femoral neck fractures make up 3% of all hip fractures in the young adult population. Although the rate seems to be low, femoral neck fractures remain important due to the high complication rate (5,6). In our study, similar to the literature, we found 20.2% non-union and 17.3% AVN.

Despite all treatment protocols, the high complication and revision rates despite proper treatment require evaluation of each factor that could impact the results.

		Min.-max.	Median	Mean \pm SD/n-%
Age		19-60	48.0	46.2 \pm 11.8
Age	<40	-	-	26 (37.7%)
	\geq 40	-	-	43 (62.3%)
Gender	Female	-	-	25 (36.2%)
	Male	-	-	44 (63.8%)
Smoking	(-)	-	-	39 (56.5%)
	(+)	-	-	30 (43.5%)
DM	(-)	-	-	58 (84.1%)
	(+)	-	-	11 (15.9%)
Side	Right	-	-	28 (40.6%)
	Left	-	-	41 (59.4%)
Following time (month)		6-96	36.0	41.2 \pm 27.8
Trauma mechanism				
Simple		-	-	21 (30.4%)
Falling from high		-	-	30 (43.5%)
Traffic accident		-	-	18 (26.1%)
Garden	I-II	-	-	42 (60.9%)
	III-IV	-	-	27 (39.1%)
Pauwel	I	-	-	26 (37.7%)
	II	-	-	36 (52.2%)
	III	-	-	7 (10.1%)
Time to surgery	<12 H	-	-	39 (56.5%)
	\geq 12 H	-	-	30 (43.5%)
VAS		0-8	1.0	1.7 \pm 2.3
HHS		47.0-100.0	95.8	88.7 \pm 14.2
HHS	Poor	-	-	9 (13.0%)
	Fair	-	-	8 (11.6%)
	Good	-	-	6 (8.7%)
	Excellent	-	-	46 (66.7%)
AVN	(-)	-	-	57 (82.6%)
	(+)	-	-	12 (17.4%)
Union	(+)	-	-	55 (79.7%)
	(-)	-	-	14 (20.3%)
Revision	(-)	-	-	53 (76.8%)
	(+)	-	-	16 (23.2%)

DM: Diabetes mellitus, VAS: Visual analog scale, HHS: Harris Hip score, AVN: Avascular necrosis, min.: Minimum, max.: Maximum, SD: Standard deviation

The role of the patient's age in the results is one of the most discussed factors. Loizou and Parker (6) with 1,023 patients, a 20.6% complication rate was found for patients under 60 years of age, and 12.5% for patients over 60 years of age, and reported that complication rates at younger ages were higher. Schweitzer et al. (7) in a study they conducted with 29 patients, reported that the AVN rate increased with age but non-union did not change. In our study, we did not find a significant difference between groups over and under 40 years of age in terms of complications. We believe that more comprehensive prospective studies should be conducted in terms of the effect of the age on the results.

We found a significant difference in the impact on the outcome between high-energy trauma such as falls from height and traffic accidents compared to low-energy trauma such as a simple fall. While femoral neck fractures are usually caused by low-energy trauma in the elderly population, they usually occur after high-energy trauma in young adults. Schweitzer et al. (7) reported that low or high-energy trauma did not impact the rate of non-union and AVN. Zhou et al. (8) investigated 42 patients with different trauma mechanisms, such as a fall from height, traffic accident, or beating; similarly found no difference between groups. Slobogean et al. (5) reported that the displacement and complication rates increased because of high-energy trauma. We think that high-energy trauma affects the results because it causes displaced fractures.

Table 2. Statistical comparison of risk factors associated with AVN and non-union

		Non-union (n)	p	AVN (n)	p
Age	<40 years	19.2	0.865	26.9	0.104
	\geq 40 years	20.9		11.6	
Sex	Female	8.0	0.056	20.0	0.667
	Male	20.2		15.9	
Smoking	(-)	12.8	0.079	17.9	0.889
	(+)	30.0		16.6	
Diabetes mellitus	(-)	18.9	0.530	15.5	0.390
	(+)	27.2		27.2	
Garden	1-2 (non-displaced)	7.1	0.001	11.9	0.134
	3-4 (displaced)	40.7		25.9	
Pauwel	I	7.6	0.063	7.6	0.116
	II	22.2		22.2	
	III	28.4		28.5	
Time to surgery	<12 H	25.6	0.208	20.5	0.435
	\geq 12 H	13.3		13.3	

AVN: Avascular necrosis

Table 3. Complication rates associated with reduction quality

		Complication	(+)	(-)	p
Reduction quality (Garden index)	Poor		80.0%	20.0%	-
	Fair		62.5%	37.5%	0.001 ^{x2}
	Good		21.4%	78.6%	-

The time to surgery is the most discussed topic regarding the results of femoral neck fractures. Loizou and Parker (6) also reported no difference between the groups with a preoperative time of fewer than 12 hours and more than 48 hours in their study with 1,023 patients. Wang et al. (9) reported 14.4% AVN in 146 patients with femoral neck fractures who underwent internal fixation and found it unrelated to the time to surgery. Kang et al. (10) reported 10.7% AVN and 7.1% non-union in their study with 84 patients and found these complications unrelated to the preoperative delay. Despite many studies arguing that the time to surgery does not affect the rate of AVN, there is still controversy in the literature (11). Yeraniosian et al. (12) in a systematic study examined 935 patients and reported that the risk of AVN increased in the group with time to surgery of more than 24 hours. Papakostidis et al. (13) in their meta-analysis of 7 studies, reported that the rate of non-union increased after 12 hours, but AVN incidence was not impacted. When all these studies are evaluated, it is seen that there is no consensus on the impact of the preoperative delay on the results. In our study, we did not find a significant relationship between preoperative time and complication rates.

One of the important factors affecting the outcome is the initial displacement of the fracture. The initial displacement can also be an indicator of the energy level of trauma. There is a consensus that the complication rates are high in patients with a high degree of displacement (14-17). In displaced fractures (Garden 3-4), 40.7% (11/27) non-union and 25.9% (7/27) AVN were observed. While the fracture displacement was associated with non-union ($p < 0.05$), the difference in AVN rates was not statistically different ($p > 0.05$). Although fracture displacement didn't seem to affect AVN rates, we believe that it should be re-evaluated with long-term follows up since AVN rates may increase in the future.

Another factor that may affect the results of femoral neck fractures in the method of fixation. Samsami et al. (17) found that a dynamic hip screw is superior to an anatomic plate or a cannulated screw construction in a vertical fracture in their study on cadavers. Kostic et al. (18) compared between 2 and 3 screw constructions; found similarly good results and argued 2 parallel screw construction is simpler and not inferior to 3 screw construction. Bhandari et al. (19) researched the optimal treatment method in their meta-analysis and found no significant difference between DHS and cannulated screws in all fracture types. In our study, we used 3 screw construction as the preferred method and we have found a similar rate of the union to the literature.

Femoral neck fracture fixation is generally a fairly simple procedure with close reduction and percutaneous fixation. Although the most important and challenging step of surgery is generally achieving a good reduction. The reduction quality is generally evaluated with the Garden alignment index in the literature (20,21). Wang et al. (9) found a correlation between reduction quality and osteonecrosis in their study. Chang et al. (22) detected complications in 21 of 28 patients with poor reduction quality and found the quality of reduction significantly associated with the results. Kang et al. (10) also argued poor reduction leads to early non-union and progressive loss of reduction. Garden et al. (23) in their original paper have found no cases of AVN in 57 patients

with good reduction but 65% (53/81) osteonecrosis in patients with poor reduction. In our study, we have found lower complication rates in patients with good reduction (Garden alignment index) when compared to moderate and poor reduction.

The high risk of AVN in the femoral head is due to its limited vascularization. Factors such as smoking and DM can risk this fragile balance for the side of osteonecrosis (25-27). In our study, we found no statistically significant difference between the smoking and non-smoking groups and we couldn't evaluate the impact of diabetes on the outcome due to the limited number of patients.

Study Limitations

Our study has several limitations. This was a retrospective study with a limited number of patients. Due to limited follow-up time, some cases of AVN may not be detectable on an X-ray. The type of instrument and reduction was constant between groups and we couldn't compare different modes of fixation and reduction.

Conclusion

Femoral neck fractures in young adults maintain their importance because of high complication rates. Fixation with cannulated screws after closed reduction is a reliable treatment method. Although we found no difference in impact between demographic characteristics such as age, gender, and comorbidity, further studies with a greater number of patients can help identify patient-dependent risk factors. High-energy trauma results in a higher amount of displacement and poor reduction results in worse outcomes and a higher incidence of complications. Although we have found no relationship between time and surgery and complication rate; the timing of surgery is still debatable.

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Istanbul Training and Research Hospital Clinical Research Ethics Committee (approval number: 1070, date: 18.08.2017).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: B.A., M.E., K.A.D., Y.Ö.; **Concept:** Z.D., K.A.D.; **Design:** M.E., Z.D., K.A.D., Y.Ö.; **Data Collection or Processing:** B.A., Y.Ö.; **Analysis or Interpretation:** B.A., M.E., K.A.D.; **Literature Search:** B.A., M.E., K.A.D.; **Writing:** B.A., Y.Ö.

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