ORIGINAL RESEARCH

Age is Not the Most Important Factor in the Prognosis of Femoral Neck Fracture: An Analysis of Long-Term Clinical Follow-Up

Fa-xin Ju, MD; Lin-feng Tang, MD; Jun-fei Wang, MD; Rui-xing Hou, MD

ABSTRACT

Objective • The prognosis of femoral neck fractures is affected by factors including age and type of fracture. This study aimed to explore the associations among postsurgical outcomes of internal fixation for femoral neck fracture (healing rate, necrosis rate, and joint function score) and age and type of fracture.

Methods • We retrospectively analyzed 297 cases of femoral neck fracture treated with internal fixation between February 2008 and October 2018. The postoperative femoral neck nonunion rate (a measure of healing) and femoral head necrosis rate were determined by x-ray and computed tomography. The Harris hip score (a measure of joint function and pain) was calculated. The effects of age and fracture type on these factors were analyzed.

Results • There was no significant difference in the rate of femoral head necrosis and postoperative joint function scores among the different age groups. There was a significant difference in the postoperative rate of femoral head necrosis by Garden ($P=.001$) and Pauwels ($P=.01$) fracture types. No significant differences were noted for the Harris hip score for fractures characterized by the Pauwels classification ($P=.09$). However, the Harris hip scores differed significantly among groups for fractures categorized by the Garden classification ($P=.001$).

Conclusions • Fracture type but not age is closely related to femoral head necrosis and Harris hip score after internal fixation of femoral neck fractures. (*Altern Ther Health Med.* 2023;29(6):430-435).

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INTRODUCTION

The round-shaped femoral head is located near the proximal end of the femur, and the femoral neck, which is narrow at the distal end of the femoral head, is prone to fractures. Femoral neck fractures are commonly encountered in clinical practice, and untreated fractures often lead to more serious limb disabilities or even death.[1] Femoral neck fractures are more common in middle-aged and older people, accounting for 3.58% of total body fractures and 53% of hip fractures.[2-4] In contrast, cases of younger patients with femoral neck fractures are extremely rare, as are cases caused by high-energy injuries. Femoral neck fractures in older patients are generally caused by either direct or indirect low-energy injuries, such as falls from low places (<2 m), falls on flat ground, and compression fractures from sneezing.[5] With the rapid development of the transportation and construction industries, the incidence of femoral neck fracture in younger adults is gradually increasing, and most of these fractures are caused by violent, high-energy injuries.[6]

Currently, the Garden and Pauwels classifications of femoral neck fracture are the main classification schemes for guiding treatment decisions in clinical practice. Surgical procedures for femoral neck fracture include normal position fixation, closed reduction, internal fixation, and hip hemiarthroplasty.[7] The technology for hip arthroplasty is quite mature, with many possible products of choice. At the same time, there has been continuous progress in the technology for minimally invasive internal fixation and closed reduction surgery.

After internal fixation, the rates of femoral head necrosis (FHN) and fracture nonunion are significantly reduced.[8] Previous studies have demonstrated that age is one of the important factors associated with FHN or functional recovery after internal fixation of femoral neck fractures.[9,10] For example, age greater than 65 years has been reported as an independent risk factor for FHN after internal fixation of femoral neck fractures.[9] However, another study reported no association of age with FHN after internal fixation of femoral neck fractures.[5] A study reported reoperation rates were lower as patient age increased in patients with femoral neck fractures who were treated with hemiarthroplasty.[11] Liu et al[12] found there was no significant correlation between age and postoperative avascular necrosis of the femoral head, but the authors proposed that the risk of avascular necrosis of the femoral head might be lower in older patients, which might be related to the injury mechanism. Osteoporosis of varying degrees is common in older people. Low-energy trauma can cause femoral neck fracture with relatively little damage to the blood supply, while femoral neck fracture in middle-aged and younger people is mostly caused by high-energy trauma, with complex fracture types, serious damage to the blood supply, difficult reduction, and postoperative avascular necrosis of the femoral head.[12] These studies suggest that age is a factor that cannot be negligible. But, necrosis and the function of the femoral head are closely related to factors such as fracture type and degree of displacement.[5] Therefore, the choice of internal fixation or hip arthroplasty should be based on a comprehensive patient evaluation. It is suggested that patients with a femoral neck fracture, regardless of age, should ideally be first treated with internal fixation to give the patients a chance to self-heal if they are in good physical condition; joint replacement by hip arthroplasty can still be used if they do not heal or if they develop FHN.[13]

This study retrospectively analyzed data from patients treated with internal fixation to ascertain the factors that could affect clinical treatment and to provide a basis for clinical decision-making and individualized treatment for the benefit of patients.

MATERIALS AND METHODS

Participants and data collection

From February 2008 to October 2018, 320 patients with Garden class II, III, or IV femoral neck fractures were treated with internal fixation. All collected data were from our organization. All patients were diagnosed preoperatively with a femoral neck fracture based on x-ray and computed tomography. Adults with femoral neck fractures and with no other ipsilateral lower extremity fractures or soft tissue injuries were selected. We excluded patients who had died by the time of follow-up; patients who had received surgery more than 72 hours after their injury; and patients with incomplete pre- or postoperative clinical history, multiple ipsilateral limb fractures, or femoral neck fractures with a second revision. In total, 297 eligible patients with complete follow-up data were enrolled. Patients provided informed consent, and this study was approved by the ethics committee of Ruihua Affiliated Hospital of Soochow University.

We divided the 297 patients into 3 groups based on age as follows: group A, 18 to 40 years; group B, 41 to 60 years; and group C, greater than 60 years.

Classification of femoral neck fracture

The Garden and Pauwels classifications for each patient were determined in consultation with 3 or 4 qualified orthopedists or radiologists with more than 20 years of experience to avoid or minimize interobserver discrepancies.[14] The Garden classification was as follows: class I, incomplete fracture; class II, complete fracture with no displacement; class III, complete fracture with partial displacement; and class IV, complete fracture with complete displacement. No Garden class I fractures were included in this study, as these fractures do not require hospitalization. The Pauwels angle classification was as follows: type I, less than 30°; type II, 30° to 50°; and type III, greater than 50°.

Surgery

Patients were treated with internal fixation; most of these procedures involved the use of hollow nails with diameters of 6.5 or 7.3 mm (from different manufacturers) and other internal fixation systems as follows: the locking plate and screw system, Synthes femoral neck system (a nail plate, hollow screw, and small steel plate), and the sliding hip screw system (sliding hip screw and dynamic hip screw).[14]

Postoperative treatment

External fixation was generally not required after surgery. Those patients with severe external rotation of the hip joint could wear T-shaped shoes to avoid extreme external rotation of the hip joint. All patients underwent postoperative rehabilitation. The patients were required to abide strictly within the range of allowable pain during functional exercises. The limb was not loaded, and the patients could sit up by 2 days postoperatively (with <90° hip flexion) and began to carry some load on the involved hip and knee within weeks. Passive hip flexion and extension exercises were performed for 1 week after internal fixation, and active hip flexion and extension exercises were performed within 2 weeks after internal fixation. The affected limb was prohibited from bearing weight for up to 6 weeks postoperatively. If the 6-week postoperative radiograph showed no fracture displacement or obvious bone cracks, then the patient was advised to use crutches for partial weight-bearing. If the 3-month postoperative radiograph showed no fracture displacement or no blurred fracture lines, the patient was advised to bear their full weight.

Evaluation criteria

FHN and femoral neck nonunion rates, as determined by x-ray and computed tomography, were calculated and compared in the different age groups. X-ray examination and Harris hip scoring[15] of the affected and contralateral hips were performed during follow-up. The Harris hip scoring system is a widely used measure of hip function and is often used to evaluate the effectiveness of hip preservation and joint replacement. The Harris hip scoring system consists of 4 aspects—pain, function (gait and functional activity), deformity, and range of motion (flexion, extension, adduction, and internal and external rotation), with the ratio of score allocation as 44:47:4:5, respectively. The Harris hip score gives more importance to postoperative pain and changes in joint function than joint activity. The Harris hip scores were classified as follows: excellent, 90 to 100; good, 80 to 89; fair, 70 to 79; and poor, less than 70. The Harris hip scores of the different hip joint types were compared.

Statistical analysis

SPSS version 21.0 software (IBM Corp) was used for statistical analysis. Results are presented as percentages. The chi-square test was used to make statistical inferences, and the degree of deviation between the actual and theoretical inference values was evaluated. Larger chi-square test values indicated more inconsistent results. Statistical significance was set at $P < .05$.

RESULTS

Garden and Pauwels classification assessed by age group

Among the 297 patients followed up, 164 were male, and the mean (SD) age was 50.0 (14.4) years (range, 18-85 years). The mean follow-up time was 49.67 months (range, 13-128 months). The Garden and Pauwels classifications of all fractures are shown in Figure 1.

Correlation of age with FHN, femoral neck nonunion, and Harris hip scores

Fracture healing was examined by x-ray and computed tomography, and the results were analyzed (Table 1). The number of cases with FHN was 8 in group A, 1 in group B, and 20 in group C. The number of cases with femoral neck nonunion was 4 in group A, 7 in group B, and 1 in group C. Among the 297 patients, 6 had femoral neck nonunion within 12 months of surgery. The cases of FHN occurred within 13 months of surgery. The age groups were not associated with FHN rate ($P = .86$) or femoral neck nonunion rate ($P = .79$).

For the Harris hip score results (Table 2), group A had 56 patients with excellent scores, 9 with good scores, 1 with moderate scores, and 7 with poor scores; group B had 113 patients with excellent scores, 22 with good scores, 5 with moderate scores, and 17 with poor scores; group C had 48 patients with excellent scores, 13 with good scores, 1 patient with moderate scores, and 5 with good scores. The chi-square test showed no significant difference in the Harris hip scores between the age groups ($P = .81$). There was no significant difference in the FHN and femoral neck nonunion rates and Harris hip scores by age group.

Correlation of fracture type with FHN and femoral neck nonunion rates and Harris hip scores

Tables 3 and 4 compare cases by their FHN and femoral neck nonunion rates and Harris hip scores. Among Garden class

Table 1. Femoral head necrosis rate and femoral neck nonunion rate were compared among age groups

Age Group	Osteonecrosis	Nonunion	Osteonecrosis rate(%)	Nonunion rate(%)
A Group (n = 73)	8	1	10.96	1.37
B Group (n = 157)	20	4	12.74	2.55
C Group (n = 67)	7	1	10.45	1.49

Note: The age group comparison of necrosis rate of femoral head: $\chi^2 = 0.301$, $P = .860$; Comparison of age groups in the rate of femoral neck nonunion: $\chi^2 = 0.471$, $P = .790$.

Table 2. Comparison of Harris hip scores for age groups

Age Group	≥90 points	80-89 points	70-79 points	≤70 points	Good rate(%)
A Group (n = 73)	56	9	1	7	76.71
B Group (n = 157)	113	22	5	17	71.97
C Group (n = 67)	48	13	1	5	71.64

Note: Comparison of age groups: $\chi^2 = 3.020$, $P = .806$.

Figure 1.

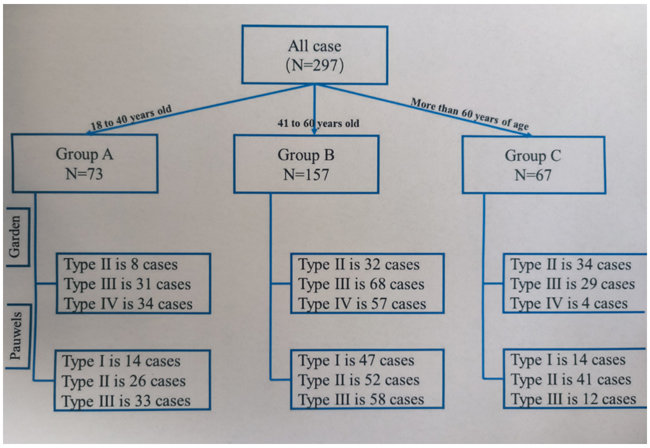

Figure 2.

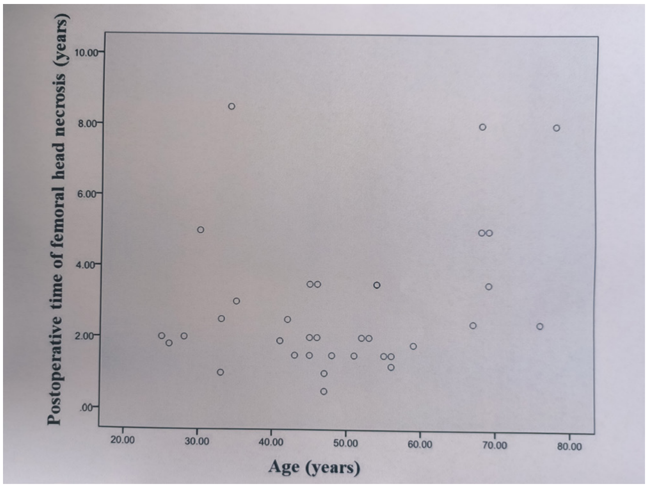

Table 3. Correlation analysis of Garden classification with Harris score, femoral head necrosis and femoral neck healing

Type	≥90 points	80-89 points	≤79 points	Osteonecrosis	Nonunion	Good rate(%)	Osteonecrosis rate(%)	Nonunion rate(%)
Garden I (n = 74)	45	19	10	5	0	60.81	6.67	0
Garden II (n = 128)	104	16	8	13	4	81.25	10.16	2.31
Garden III (n = 95)	68	9	18	17	2	71.58	17.89	2.11

Note: Garden type $\chi^2 = 18.318$, $P = .001$; Comparison of necrosis rate of femoral head in Garden classification: $\chi^2 = 15.168$, $P = .001$; Comparison of nonunion of femoral neck in Garden classification: $\chi^2 = 2.319$, $P = .314$.

Table 4. Correlation analysis of Pauwel classification with Harris score, femoral head necrosis and femoral neck healing

Type	≥90 points	80-89 points	≤79 points	Osteonecrosis	Nonunion	Good rate(%)	Osteonecrosis rate(%)	Nonunion rate(%)
Pauwel I (n = 75)	52	16	7	5	0	69.33	6.67	0
Pauwel II (n = 119)	90	18	11	10	3	75.63	8.40	2.25
Pauwel III (n = 103)	75	10	18	20	3	72.82	19.42	2.91

Note: Pauwels type: χ^2=7.953, $P = .093$; Comparison of necrosis rate of femoral head with Pauwels classification: $\chi^2 = 8.971$, $P = .011$. Comparison of nonunion of femoral neck with Pauwels classification: $\chi^2 = 2.068$, $P = .356$.

II fractures, 45 cases had excellent Harris hip scores, 19 had good Harris hip scores, and 10 had fair or poor Harris hip scores, with 5 cases of FHN and no cases of femoral neck nonunion. Among Garden class III fractures, 104 cases had excellent Harris hip scores, 16 had good Harris hip scores, and 8 cases had fair or poor Harris hip scores, with 13 cases of FHN and 4 cases of femoral neck nonunion. Among Garden class IV fractures, 68 cases had excellent Harris hip scores, 9 had good Harris hip scores, and 18 cases had fair or poor Harris hip scores, with 17 cases of FHN and 2 cases of femoral neck nonunion. The Garden classification was significantly associated with the Harris hip score ($P = .001$) and the FHN rate ($P = .001$) but not with the femoral neck nonunion rate ($P = .31$).

Among Pauwels type I fractures, 52 cases had excellent Harris hip scores, 16 had good Harris hip scores, and 7 had fair or poor Harris hip scores, with 5 cases of FHN without femoral neck nonunion. Among Pauwels type II fractures, 90 cases had excellent Harris hip scores, 18 had good Harris hip scores, and 11 had fair or poor Harris hip scores, with 10 cases of FHN and 3 cases of femoral neck nonunion. Among Pauwels type III fractures, 75 cases had excellent Harris hip scores, 10 had good Harris hip scores, and 18 had fair or poor Harris hip scores, with 20 cases of FHN and 3 cases of femoral neck nonunion. The Pauwels classification was significantly associated with the FHN rate ($P = .01$) but not with the Harris hip score ($P = .09$) or femoral neck nonunion rate ($P = .36$).

Correlation between age and postoperative FHN

Among 297 patients, only 6 had FHN. The correlation coefficient between the age and the time of FHN after surgery was $r = 0.299$ ($P = .08$). Thus, age was not significantly correlated with the time of FHN after surgery, as shown in Figure 2. FHN occurred approximately 2 years after surgery, and the occurrence of FHN greater than 5 years after fracture was rare.

DISCUSSION

Femoral neck fractures are more common in the older population and are closely related to osteoporosis. It is generally believed that the older population has higher rates of FHN and femoral neck nonunion and lower postoperative hip function than in the younger population. Thus, some doctors use 65 years of age as an important threshold for choosing between internal fixation and hip arthroplasty. However, hip arthroplasty is expensive, has a limited life span, can require revision, and can have complications such as infection and loosening of the prosthesis.[16] With the extensive development of intraoperative positioning navigation systems, surgical traction systems, and internal fixation technologies, internal fixation technology has improved significantly in clinical practice. Multiple cannulated screw fixation remains the standard and widely accepted method for the fixation of femoral neck fractures[4,17] because of its simplicity, minimally invasive nature, and low cost. Currently, an inverted triangular structure consisting of 3 parallel screws is widely used for the internal fixation of femoral neck fractures in patients with osteoporosis.[18] In cases of femoral neck fractures with significant posterior cortical comminution defects, an additional fourth screw can significantly enhance the structural strength of the femoral neck.

Age was thought to be an important factor influencing femoral neck fractures. We included patients older than 65 years in this study, with the oldest aged 85 years. Internal fixation is usually used for patients younger than 60 years. In our study, we first conducted a comprehensive assessment of patients older than 60 years and enrolled those who were in good physical condition and could receive secondary hip replacement if there were postoperative complications; we did not limit the patients' age and chose only patients who had received femoral neck internal fixation.[19,20] According to our results, there was no significant difference in the rates of FHN and femoral neck nonunion and the Harris hip scores with age. A possible reason is that the Garden classification of fractures and risk of postoperative ischemia and necrosis are higher in younger patients because their injuries are mostly caused by severe trauma.[21,22] Femoral neck fractures in older patients are mostly caused by osteoporosis and are low-energy fractures. Thus, in older patients, the amount of blood supply destruction is relatively low and the rate of FHN is not necessarily high.

The Garden classification is based on the degree of femoral neck displacement; higher classification types indicate more serious injuries, more difficulties for reduction and internal fixation, and a higher probability of postoperative ischemia and necrosis.[23] In this study, Garden class IV fractures led to higher FHN rates than Garden class III fractures, which, in turn, led to higher FHN rates than Garden class II fractures. More severely displaced fractures reflect a higher level of trauma at the time of injury, which can cause more severe damage to the local microvessels, bone trabeculae, and other fine structures, leading to a slower rate of blood supply reconstruction postoperatively. Therefore, Garden classification is an important factor influencing the development of FHN after femoral neck fractures.[24-26]

The Pauwels angle classification is based on differences in fracture stability, with greater Pauwels angles reflecting greater shear forces, more unstable fractures, and a higher probability of bone nonunion and FHN.[27,28] Our study showed significantly higher FHN rates in Pauwels type III fractures than in fracture types I and II, and type II fractures had slightly higher FHN rates than type I fractures. As the Pauwels angle increases, the shear force acting on the fracture becomes the dominant force, leading to increased failure rates of internal fixation.[28,29] Therefore, Pauwels classification is also an important factor influencing the development of FHN after femoral neck fracture.

The Harris hip function scoring system, which is important in evaluating the efficacy of hip surgery, is correlated with the occurrence of FHN after femoral neck fracture, with better scores indicating a lower probability of FHN. However, the postoperative Harris hip score exhibits a collinear relationship with the Garden and Pauwels classification systems. In this study, the Harris hip scores were higher for Garden class III fractures than for Garden fracture classes II and IV. A possible explanation is that a higher Garden classification indicated a more severe femoral neck fracture, making the femoral head more prone to postoperative ischemia and necrosis and decreasing postoperative functional recovery.[30] In contrast, the Harris hip scores for Pauwels type I fractures were lower than for Pauwels type III fractures, which, in turn, were lower than Pauwels type II fractures. The Harris hip score is a subjective index for evaluating the postoperative effect of surgery for femoral neck fracture, making it susceptible to subjective patient factors. After initial analysis of follow-up data, we categorized the postoperative Harris hip score of patients that developed FHN and required secondary hip replacement as poor (<70 points).

We found no significant correlation between age and the time of FHN after surgery. The time of FHN after surgery in most patients was approximately 2 years, and the occurrence of FHN more than 5 years after fracture surgery was rare. It can be inferred that incomplete reconstruction of the blood supply system after fracture healing put the femoral head in a state of ischemia and typically manifested as FHN within 2 years, rather than that ischemia and necrosis began 2 years after the fracture.

There are several limitations to our study. This is a retrospective study, which may cause some bias. The patients in our study were required to be non–weight-bearing for a prolonged period after surgery (up to 6 weeks postoperatively). Pfeufer et al[31] suggested that the primary therapeutic goal for patients must be early mobilization at full weight-bearing. Therefore, it is necessary to further investigate whether early weight-bearing or immediate weight-bearing is safe by conducting a prospective, randomized study.

CONCLUSIONS

Age is not a deciding factor in FHN and hip function after internal fixation of femoral neck fractures. However, necrosis and function of the femoral head are closely related to fracture type and degree of displacement. The choice of internal fixation or hip arthroplasty should be based on a comprehensive patient evaluation.[32,33] Internal fixation remains a better treatment for femoral neck fractures, even in older individuals. Early operation, properly closed reduction, high-quality internal fixation, late loading, and other measures can effectively prevent fracture displacement, reduce bed time and fracture complications, and reduce the occurrence of FHN.[34]

DATA AVAILABILITY

The data used to support this study are available from the corresponding author upon request.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

FUNDING

This work was supported by the 2015 Six Talent Peaks Project in Jiangsu Province (No. 2015-WSW-066).

AUTHOR CONTRIBUTIONS

Conception and design of the research: Jun-fei Wang, Rui-xing Hou and Fa-xin Ju; acquisition of data: Jun-fei Wang and Fa-xin Ju; analysis and interpretation of data: Jun-fei Wang, Rui-xing Hou and Fa-xin Ju; statistical analysis: Jun-fei Wang,Linfeng Tang and Fa-xin Ju; obtaining funding: Jun-fei Wang; drafting the manuscript: Jun-fei Wang and Fa-xin Ju; revision of manuscript for important intellectual content: Jun-fei Wang, Rui-xing Hou and Fa-xin Ju. All authors read and approved the final manuscript.

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