Analysis on risk factors for neck shortening after internal fixation for Pauwels II femoral neck fracture in young patients

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Research article

Keywords: Young patients, Femoral neck fracture, Internal fixation, Neck shortening, Risk factors

Posted Date: September 18th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-37195/v2

Abstract

Background: Femoral neck shortening can occur in young patients receiving closed reduction and internal fixation for Pauwels type II femoral neck fracture. The risk factors for neck shortening, which can affect hip function, are not clear. This study aimed to retrospectively identify risk factors for neck shortening after closed reduction and internal fixation with parallel partially threaded cannulated cancellous screws for Pauwels type II femoral neck fracture in young patients.

Methods: Clinical data from 122 cases with Pauwels type II femoral neck fracture from February 2014 to February 2019 were reviewed and analyzed, and causes of neck shortening were statistically analyzed. These patients were followed (average follow-up: 12 months). And the chi-square test or *t* test was used to compare indicators. Multivariate analysis was conducted with non-conditional logistic regression analysis.

Results: *Statistically* significant differences *were* found in age, sex, BMD, BMI, fracture type, posterior medial cortex comminution, and reduction quality between patients with femoral neck shortening and those without femoral neck shortening. Logistic regression analysis showed that fracture type, posterior medial cortex comminution, and reduction quality were the main risk factors for neck shortening.

ConclusionFracture type, posterior medial cortex comminution, and reduction quality can be used as important reference indexes to predict the possibility of neck shortening after closed reduction and internal fixation with parallel, partially threaded, cannulated cancellous screws for Pauwels type II femoral neck fracture in young patients.BMD and BMI may be also risk factors.

Background

Femoral neck fracture is a rare in young patients and a rare and difficult injury to manage [1], and about 5000 young people have femoral neck fracture every year in Norway [2]. The fracture of the femoral neck in young patients is often caused by high-energy trauma such as motor vehicle collisions. The treatment is anatomical reduction and internal fixation as soon as possible [3,4]. However, the failure rate of treatment of femoral neck fracture in young adults is high [5-7]. This is a challenging problem because there are many treatment options and consensus on the best treatment has been difficult to reach [8]. Multiple cancellous screws or sliding hip screws are still the most commonly used internal fixation implants [9,10]. Young patients are commonly treated by fracture fixation with parallel partially threaded cannulated cancellous screws (PPTCCS) [11,12].

Pauwels type II fracture is described as an unstable fracture: shear stress at the fracture end may have an adverse effect on fracture healing, but internal fixation can reduce shear stress and promote fracture healing [13].However, in treatment of femoral neck fracture in the young, shortening of the femoral neck can occur after fixation with multiple cancellous screws, and this affects the function of the hip joint[14]. This has led to more research on the incidence and resolution of this complication [15,16]. Other studies

have focused on the complications of this operation [17-21]. So far, few studies have attempted to determine the risk factors for shortening by using multivariate regression analysis.

Fully understanding the risk factors for neck shortening after internal PPTCCS for young Pauwels type II femoral neck fracture is of great importance in improving the safety of the operation and ensuring its therapeutic effect. In this study we retrospectively analyzed the main causes of neck shortening after closed reduction and internal PPTCCS in young patients with Pauwels type II femoral neck fracture in order to identify risk factors, and tried to determine the effects of these factors on postoperative neck shortening.

Patients And Samples

Criteria for inclusion and exclusion of patients

Criteria for patient inclusion in the study were age 59 years or younger, Pauwels type II femoral neck fracture confirmed by X-ray and CT, capacity for basic self-care, normal cognition, and the patient's agreement to participate in the study. Exclusion criteria were pathological fracture, multiple fracture, open reduction and mental illness. In this study, the shortening of femoral neck was limited to 5mm, because it has been reported that the shortening of more than 5mm may affect the function of hip joint [22].

Research objectives

The clinical data from 122 young patients with femoral neck fractures treated in our hospital from February 2014 to February 2019 were retrospectively analyzed.

Surgical methods

The patient was placed on a traction bed and their limbs were fixed. C-arm X-ray was used to identify whether fracture reduction was satisfactory or not in the anteroposterior (A/P) and lateral views. Based on satisfactory fracture reduction, three Kirschner pins, as guide needles, were implanted in the femoral neck in an inverted triangle configuration [23] and required to be distributed across the femoral neck in the A/P and lateral views. Finally, three partially threaded cannulated cancellous screws (7.0 mm, titanium alloy, American General Corporation，USA)of suitable length[24] were implanted along the guide needle. The quality of fracture reduction was judged by postoperative examination of the hip joint in the A/P and lateral views.

Research methods

The latest anterior-posterior radiograph of the fractured hip was compared with that of the contralateral uninjured hip. This method used to measure neck shortening in this study is consistent with previous studies [16,25]. Two senior orthopedic surgeons who did not participate in the surgery and two radiologists studied the x-rays for occurrence of neck shortening. Of the 122 patients included, an average one-year follow-up was completed. According to whether it occurred, the 122 young patients with

femoral neck fractures were divided into a neck shortening group (37 cases) and a non-neck shortening group (85cases).Observed indexes included patient's age, sex, bone mineral density (BMD), body mass index (BMI)[26], fracture type, posterior medial cortex comminution, reduction quality, surgical time, time to weight bearing, and time of hospitalization, which were entered into the database. The average value of each index was recorded.

Statistical methods

All data analyses were conducted using SPSS 22.0 statistical software. The occurrence of neck shortening was considered as a dependent variable, while the observed indexes were used as independent variables. Data are reported as the mean ± standard deviation (SD), and were compared using the chi-squared test or *t* test. Non-conditional logistic regression was performed to identify risk factors for neck shortening. The difference in the effective rate was considered statistically significant at $p< 0.05$.

Results

Neck fracture healing rate and Harris score in the neck shortening group and non-shortening group

The study included 65 males (53.28%) and 57 females (46.72%), and the average age was 40.79 ± 19.63 years (range, 18-59 years). According to the Garden classification, there were 26 cases with type I, 29 with type II, 34 with type III, and 33 of type IV. Relevant examinations were performed in pre-operation. The patient's physical conditions were fully assessed. All operations were performed by the same group of surgeons using three partially threaded cannulated cancellous screws. Reduction quality was assessed using the method of Lowell [27]. No weight-bearing was used within 8 weeks after the operation. Partial weight-bearing time was determined according to X-ray review at 8 weeks after the operation. Full weight-bearing started 12 weeks after the operation. The patient received regular monthly outpatient X-ray examination to evaluate whether the fracture was healed or not.

There were 37(30.33%) cases in the shortening group and 85 cases in the non-shortening group. In the shortening group, 33 cases (89.19%) healed, and the average Harris score was 79±13. In the non-shortening group, 74 cases (87.06%) healed, and the mean Harris score was 87±16.The differences in the fracture healing rate and the mean Harris score were not statistically significant ($p>0.05$ for each).The total incidence of nonunion was 12.29% (15/122):10.81% (4/37) in the shortening group, and 12.94% (11/85) in the non-shortening group. (Table 1)

Table 1 - Comparison of healing rate between two groups.

	Shortening	Non-shortening	χ^2	*p*
Healing rate	89.19% (33/37)	87.06% (74/85)	0.026	0.871
Harris score	79±13	87±16	0.386	0.534

Factors influencing the occurrence of neck shortening

There were statistically significant differences in variables between the femoral neck shortening group and non-shortening group, including patient age, sex, BMD, BMI, fracture type, posterior medial cortex comminution, and reduction quality. There were no statistically significant differences between the two groups with respect to surgical time, time to weight bearing, or hospitalization time (Table 2).

Table 2 - Comparison of patient characteristics between the two groups.

Factors		n	shortening group	non-shortening group	χ^2	*p*
Age(y)	18–44	65	14	51	5.086	0.024
	45–59	57	23	34		
Sex	Male	83	30	53	4.157	0.041
	Female	39	7	32		
BMD	T>-2.5	75	17	58	5.408	0.020
	T≤-2.5	47	20	27		
BMI (kg/m^2)	<24.0	60	12	48	8.745	0.012
	24.0≤BMI < 28.0	44	15	29		
	≥ 28.0	18	10	8		
Fracture type	I	26	5	21	7.836	0.049
(Garden classification)	II	29	5	24		
	III	34	12	22		
	IV	33	15	18		
Posterior medial cortex	Yes	82	32	50	8.952	0.002
comminution	No	40	5	35		
Reduction quality	I, II	77	15	62	11.625	0.000
(Garden's alignment index)	III, IV	45	22	23		
Surgical time	≤24hr	79	23	56	0.156	0.692
	>24hr	43	14	29		
Time to weight bearing	≤2 months	91	27	64	0.073	0.787
	>2 months	31	10	21		
Hospitalization time	≤1week	75	22	53	0.091	0.762
	>1week	47	15	32		

Non-conditional logistic regression analysis of factors in fluencing neck shortening

Between-group differences in the above seven factors were statistically significant ($p < 0.05$) by the chi-squared test. These factors were further analyzed using logistic regression. The results showed that BMD (T≤−2.5), BMI (≥28.0 kg/m^2), fracture type (type III, IV), posterior medial cortex comminution (Yes), and reduction quality (Grade III, IV) had an impact on the occurrence of neck shortening (Table 3).

Table 3 -Non-conditional logistic regression analysis of factors influencing femoral neck shortening after fixation with partially threaded cannulated screws in young patients.

Influencing Factors	B	Exp (B)	95% *CI*	*p*
Age (45–59 years)	1.141	0.686	(0.85–13.59)	0.104
Sex (Female)	0.761	0.653	(0.57–10.44)	0.282
BMD (T≤-2.5)	3.489	10.21	(3.89–16.95)	0.007
BMI (≥ 28.0 kg/m^2)	2.767	9.16	(2.42–15.51)	0.004
Fracture type (Garden III, IV)	3.103	10.29	(5.94–21.07)	0.000
Posterior medial cortex comminuted (Yes)	5.614	27.88	(6.26–41.17)	0.000
Reduction quality (Grade III, IV)	2.056	14.94	(5.31–28.85)	0.000

CI, confidence interval

Discussion

Femoral neck fracture is an uncommon fracture in young people. Previous studies have shown that good closed reduction and internal fixation using cannulated screws in the treatment of femoral neck fracture is efficacious [28,29]. However, neck shortening in the course of treatment is still worthy of attention. A considerable proportion of patients present this phenomenon on follow-up imaging, which is less concerned. Its incidence in this study was 30.33% (37/122), very similar to that in a previous study [16]. The total incidence of nonunion was 12.29%, in accord with previous studies [30,31]. And we found that femoral neck shortening was more than 5mm and hip abductor strength was reduced.

Here, we retrospectively studied data from 122 young patients who had Pauwels type II femoral neck fractures treated using parallel partially threaded cannulated cancellous screws and analyzed possible factors influencing neck shortening. Univariate analysis showed that patient age, sex, BMD, BMI, fracture type, and reduction quality were risk factors for neck shortening. Age and BMD were closely related to the occurrence of neck shortening. With increasing age, BMD may decline, and it is clear that bone quality may determine the probability of femoral neck fracture [32]. Reduction of the axial anti-compression strength of the femoral neck leads to its shortening. Sex is also an important influencing factor. Compared with men, women have thinner bone cortex and lower bone density. After menopause, estrogen

decreases rapidly, which further affect the process of fracture repair [33]. BMI also increases the risk of neck shortening after fracture [34]. Increased BMI may directly increase the axial pressure on the fracture end, leading to neck shortening. Therefore, for patients with these risk factors, a comprehensive preoperative evaluation is essential, although this complication may result from a combination of these factors.

Non-conditional logistic regression analysis showed that fracture type (Garden III, IV) and reduction quality (Grade III, IV) were the main causes of postoperative neck shortening. Higher fracture type, posterior medial cortex comminution, and lower reduction quality could indicate a greater risk of postoperative neck shortening in young patients who had Pauwels type II femoral neck fractures. Therefore, more attention should be paid to these three indicators during clinical observations. We found that fracture type (Garden III, IV) may increase the likelihood of neck shortening, as previously reported [12,17]. Garden type III and IV fractures are unstable and often accompanied by comminution or posterior medial bone cortical defects [35]. Comminuted fractures increase bone absorption after surgery and are more likely to produce neck shortening after healing. Destruction of the posterior medial cortex often leads to a lowering of both the quality of reduction and resistance to axial loading, and results in neck shortening, even when complete anatomical reduction is achieved in the operation [36]. Garden's Alignment Index is commonly used to evaluate reduction quality. When the evaluated fracture reduction quality fails to meet the standard of anatomical reduction, the probability of postoperative neck shortening is greatly increased [17]. It is possible that the stress on the fracture's broken end is not uniform, leading to collapse at the fracture site, with consequent neck shortening.

This study has some limitations. First, our results were based on a small number of patients. We still did not accurately predict whether neck shortening was related to the healing rate of the femoral neck fracture. Second, we did not include patients with Pauwels type I and III fractures. Third, because there are few studies on neck shortening and all methods for measuring neck shortening are still in their initial stages, more accurate methods of measurement need to be further explored.

In conclusion, our results support the use of fracture type, the presence of comminution of the posterior medial cortex, and reduction quality as important reference indexes to predict the possibility of neck shortening after internal fixation with parallel partially threaded cannulated cancellous screws for Pauwels type II femoral neck fracture in young patients. BMD and BMI may also be risk factors. The results also suggest that fracture type, posterior medial cortex comminution, and reduction quality might be useful for evaluating postoperative neck shortening. Finally, this study may suggest good RCT's to be done in the future including fully threaded screws, quality of reduction, strictly weight bearing standards to prevent shortening and open reduction to try to get a better quality of reduction in some cases.

Declarations

Ethics approval and consent to participate

Written informed consent was obtained from patients under a protocol approved by the Ethics Committee of Beijing Luhe Hospital affiliated to Capital Medical University.

Consent for publication

Not applicable.

Availability of data and materials

All data analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

Funding

No fund was received.

Authors' contributions

FL Z and XF W designed and initiated the study. FL Z and YK Z collected data. LJ G and XF W performed the statistical analysis. FL Z and LJ G wrote the article.

Acknowledgements

Not applicable

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