

Biomechanical study on the treatment of Pauwels type III femoral neck fracture by open reduction and internal fixation with hollow nail internal fixation

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Abstract. – OBJECTIVE: We aimed to explore the therapeutic effect of open reduction and internal fixation with hollow nail internal fixation for Pauwels type III femoral neck fracture.

PATIENTS AND METHODS: From January 2016 to February 2021, a total of 100 eligible patients with Pauwels type III femoral neck fracture were involved in this study and divided into two groups randomly: the combined remedy group and the closed therapy group, with 50 patients in each group. After that, 50 subjects in the combined remedy group were treated with open reduction and support plate combined with hollow screw internal fixation, and the treatment conditions were observed and recorded. The closed therapy group received routine treatment.

RESULTS: Among the 100 patients selected, the operation time of the combined remedy group was significantly lower than that of the closed therapy group, and the intraoperative bleeding was also significantly less. In the closed therapy group, the time of getting out of bed after the operation and the excellent and good rate were better; moreover, the functional score and pain score of three months after the operation were significantly better than that of one month after the operation. The functional score and pain score of one month after the operation were not statistically significant for the combined remedy group or the closed therapy group.

CONCLUSIONS: In the treatment of Pauwels type III femoral neck fracture with open reduction and internal fixation combined with hollow nail internal fixation, the operation time and intraoperative bleeding volume were significantly decreased, but the postoperative recovery time was enhanced compared to that of total joint replacement. After the operation, the functional score and pain score had a significant relationship with the recovery time, and there was no significant relationship with the type of treatment. Therefore, in clinical treatment, doctors should take appropriate treatment methods for their patients.

Key Words:

Open reduction, Internal fixation with hollow nail internal fixation, Pauwels type III femoral neck fracture, Clinical effect.

Introduction

Femoral neck fracture refers to the hip fracture between the bottom of the femoral neck and the synovium or joint of the femoral neck. Because femoral neck fracture is a special part, with a long course of disease and many complications, it is very harmful to the quality of life and health of sufferers^{1,2}. Open reduction, sleeve screw internal fixation and total hip replacement are the most commonly used surgical treatments^{3,4}. Necrosis of the femoral head is also a frequent complication in the treatment of femoral neck fractures because the main blood supply of the femoral head comes from the external femoral artery and the internal femoral vessels near the femoral neck^{5,6}. In addition, because the distance between the ligament of the femoral artery annulus and the nutrient vessels in the femoral shaft varies greatly, a small part of the blood supply comes from the femoral artery fovea. Therefore, during the initiation and contraction period of these types of fractures, since the iatrogenic inflammation level of the medial femoral circumflex external vessels is reduced to the lowest point by direct anterior approach (DAA), the main blood flow supply of the femoral head is hardly affected. In the treatment of middle-aged and old people, the general treatment is artificial joint replacement. In young and middle-aged sufferers, the femoral neck fracture generally suffers from violent factors and has a high probability of fracture displacement. Therefore, it is very difficult to adopt artificial joint replacement for closed treatment^{7,8}.

If adolescent patients with Pauwels type III femoral neck fracture are treated with the traditional closed treatment, the fracture of Pauwels type III femoral neck is easily cut off and displaced due to the large shear force, and it is easy to cause nonunion of bone after the nail is removed, which may lead to necrosis of the femoral head. Therefore, most of the young and middle-aged Pauwels type III femoral neck fractures will be treated with open reduction and support plate combined with hollow nail internal fixation^{9,10}. Our hospital selected patients from January 2016 to February 2021 for appropriate treatment; the specific treatment results are shown in Figure 1.

Patients and Methods

Patients

This prospective study was performed by selecting 100 eligible patients with Pauwels type III femoral neck fractures who were admitted from January 2016 to February 2021 in our hospital, and the fractures were all displaced fractures. Ethical approval was granted by the Jiujiang University Clinical Medical College and participants gave written informed consent to be involved in the study. The selected subjects had no surgical contraindications (such as diabetes, severe renal dysfunction, and hemorrhagic diseases). Among the 100 eligible subjects, there were 48 males and 52 females, with an average age of 42.5 years; moreover, 43 had old fractures and 57 had fresh fractures. The individuals were randomly divided into two groups, namely, the combined remedy group and the closed therapy group, with 50 people in each group. The patients in the two groups had no statistical significance in the basic information (age, sex, basic information and other

general information), and met the experimental requirements of a single variable.

Methods

Preoperative work

After pre-operative work, the complications of the two groups were controlled to avoid affecting the accuracy of the experimental results. When treating sufferers with old fractures, it was necessary to take X-rays, and the operation could be performed only when the length of the lower limbs of the patients was determined to be in recovery; patients with fresh fractures were operated on within three days after the fracture and should be observed for more than one day.

Operation

The closed therapy group was treated with closed therapy, and the patients were placed in the supine position during the artificial joint replacement. The combined remedy group was treated with an open reduction supporting plate combined with hollow nail internal fixation for type III femoral neck fracture. Epidural anesthesia or general anesthesia was usually used in the open reduction supported steel plate combined with hollow nail internal fixation. The operation was performed in the supine position. Generally, the gluteal joint is cut forward first: about 2 cm from the posterior part of the bone spur of the superior anterior process, about 1 cm from the distal part to the most distal and posterior part, and about 8 cm from the anterior part of the greater trochanter. The subcutaneous tissue was cut off, and the lateral femoral cutaneous nerve was inserted into the trachoma fascia. The muscle was stretched inward, the lateral tendon fascia was bent outward, the waist and knee were also

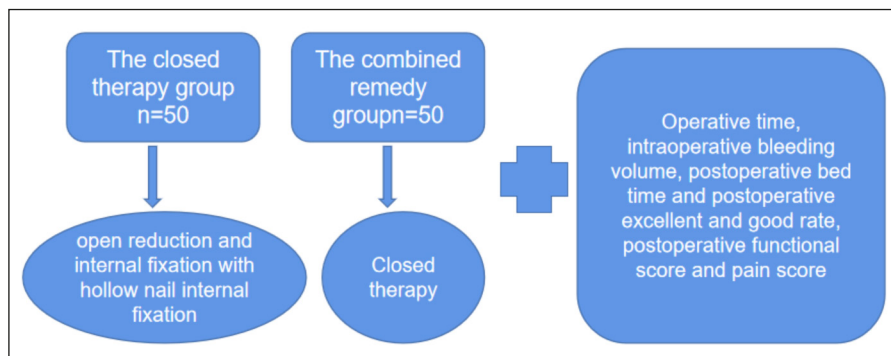


Figure 1. Study impact on the treatment of Pauwels type III femoral neck fracture by open reduction and internal fixation with hollow nail internal fixation.

bent, the hand and fingers were moved along the cross-section of the quadriceps femoris, and they were quickly separated, exposing the femoral capsule, and the inner side of the quadriceps femoris was pulled. The hip joint capsule was cut longitudinally or T-shaped along the axial direction of the femoral neck to remove hematoma and visual impairment.

Postoperative Treatment

The same postoperative treatment was adopted for the two groups of patients. Prophylactic antibiotics, physical prophylaxis, and small molecule heparin or ribavirin were given 24-48 hours after the operation to prevent deep venous thrombosis. Twenty-four hours after the operation, the quadriceps femoris was contracted equidistantly. There was no weight-bearing until the 4th week after the operation and mild activity in the 6th week after the operation. Postoperative routine X-ray examination showed fracture healing.

Observation Indicators

The clinical effects and postoperative effects on Harris hip joint of the two groups were compared and analyzed. Harris's hip joint effect evaluation was based on hip joint activity, pain, range of motion, and synovial joint sharpness, with a total score of 100. If the score was less than 70 points, the result was poor; 70-79 points, it was tolerable; 80-89 points, the patients had good function; 90-100 was good. If the total sco-

re reached 80 points, it was considered a good function. Then, the ability and pain of the two groups were investigated to evaluate the efficacy of postoperative rehabilitation. The flow diagram of this study is shown in Figure 2.

Statistical Analysis

SPSS 17.0 software (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of the experimental data. The data of each group are compared using the *t*-test, and the counting data are compared using the Chi-square test. A *p* < 0.05 was considered statistically significant.

Results

Experimental Results

Among the 100 patients selected, the operation time of the combined remedy group was significantly shorter than that of the closed therapy group, and the bleeding volume during the operation was also significantly lower (*p* < 0.05). The patients in the closed therapy group had a better time getting out of bed and an excellent rate after the operation (*p* < 0.05). The functional score and pain score 3 months after the operation were significantly better than those in the 1st month after the operation (*p* < 0.05). The functional score and pain score one month after the operation were not statistically significant for the combined remedy group or the closed therapy group (*p* > 0.05). In the combined

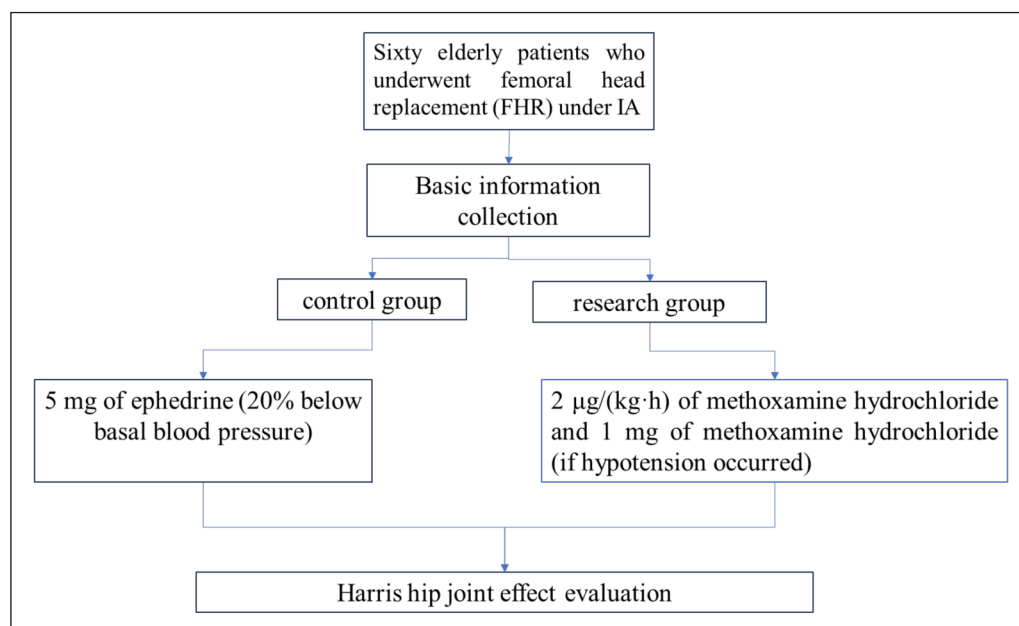


Figure 2. Flow diagram.

remedy group, the operation time and intraoperative bleeding were significantly decreased, but the recovery time after the operation was improved compared to that after total joint replacement. In clinical treatment, doctors should take appropriate treatment methods for patients. The experimental results are shown in Tables I, II, and III.

Intraoperative Results

If the closed reduction of Pauwels type III femoral neck fracture fails to achieve satisfactory reduction after 2-3 times, open reduction is recommended. Otherwise, the blood supply will affect the femoral head through iatrogenic stimulation of the supporting ligament artery, which may increase the necrosis rate of the femoral head^{11,12}.

Influence of Blood Supply of the Femoral Head¹³⁻¹⁵

The main blood supply of the femoral head comes from the external femoral artery and the internal femoral vessels near the femoral neck. Therefore, during the initiation and contraction period of these types of fractures, DAA reduces the iatrogenic inflammation level of the medial femoral circumflex to the lowest point, but hardly affects the normal blood supply of the femoral head, nor does it increase the incidence rate of femoral head necrosis. The operating point of DAA is the interface between the brachial nerve and the femoral nerve. This is a true intermuscular method with a clear scope of application and small damage, which can reduce fractures under direct vision^{16,17}. In the process

Table I. Comparison of intraoperative conditions and Harris scores of sufferers in the combined remedy group and the closed therapy group ($\bar{x}\pm s$).

Group	Number of experimenters	Operation time (min)	Intraoperative blood loss (ml)	Time of getting out of bed after operation (d)	Harris score
The combined remedy group	50	52.6 ± 12.2	168.7 ± 48.2	74.3 ± 5.6	81.7 ± 4.1
The closed therapy group	50	87.3 ± 12.8	381.5 ± 57.7	15.3 ± 4.2	89.1 ± 3.9
<i>t</i>		12.4236	17.9010	53.6732	8.4852
<i>p</i>		<i>p</i> < 0.05	<i>p</i> < 0.05	<i>p</i> < 0.05	<i>p</i> < 0.05

Table II. Comparison of excellent and good rate between the combined remedy group and the closed therapy group (n, %).

Group	Number of experimenters	Excellent rate (%)
The combined remedy group	50	26 (65.0)
The closed therapy group	50	37 (92.5)
χ^2		22.5957
<i>p</i>		<i>p</i> < 0.05

Table III. Comparison of functional and pain scores of sufferers in the combined remedy group and the closed therapy group in the 1st and 3rd months after operation ($\bar{x}\pm s$).

Group	Number of experimenters	Functional score		<i>t</i>	<i>p</i>	Pain score		<i>t</i>	<i>p</i>
		1 st month after operation	3 rd month after operation			1 st month after operation	3 rd month after operation		
The combined remedy group	50	57.53±4.70	82.58±5.27	25.826	<i>p</i> < 0.05	3.55±0.92	1.04±0.63	16.387	<i>p</i> < 0.05
The closed therapy group	50	57.77±4.92	75.43±4.34	19.598	<i>p</i> < 0.05	3.83±1.05	1.96±0.79	10.362	<i>p</i> < 0.05
<i>t</i>		0.257	7.625			1.460	6.628		
<i>p</i>		<i>p</i> < 0.05	<i>p</i> < 0.05			<i>p</i> > 0.05	<i>p</i> < 0.05		

of reduction, 2.5 mm Kirshner wire is used as a fixator to drill holes on the femoral head and remove the affected limb, so as to achieve a good reduction effect. The hollow nail is placed under the cross-section of the thigh rotor; the affected connector is placed at mark "4", the thigh neck faces the actual inner surface, and the steel plate is placed under direct vision. The anatomical reduction can provide the largest fracture contact surface¹⁸⁻²⁰, ensuring maximum mechanical stability and smooth fracture healing. The internal fixation of this group of fractures is not removed. Since the shielding voltage generated by the inner carrier plate is low and negligible, it does not need to be removed again. Necrosis of the femoral head is an inevitable serious complication. Although femoral neck fracture is related to many factors, it is considered to be one of the main causes of femoral head necrosis²¹. Five years later, all 19 cases of fractures have been cured, but the necrosis of the femoral head and the relationship between necrosis rate and operation need further study and observation. This combined remedy group of patients with femoral neck fractures recovered smoothly and worked well. A positive effect was also observed in the treatment of femoral neck fractures in young and middle-aged people, which is worth recommending.

Surgical Ideas and Demonstration

Figure 3 shows a 56-year-old male admitted to the hospital with pain limitation of the left hip due to trauma.

The CT suggested a femoral neck fracture. Pauwels classification type III was as follows: a) preoperative CT; b) Postoperative reexamination; c) 6 weeks after the operation, the fracture position was good, and internal fixation was stable without loosening.

Figure 4 shows a 62-year-old male with a left femoral neck fracture caused by trauma.

Pauwels type III was as follows: a) CT confirmed that the femoral neck fracture belonged to Pauwels III; b) Postoperative reexamination; c) 3 months after operation, fracture healing and internal fixation were stable.

Discussion

Femoral neck fracture refers to the fracture at the joint between the lower part of the femoral neck and the synovial joint of the femoral neck. Because femoral neck fracture leads to many complications, it has caused great harm to the life safety and health of patients²². Open reduction, cannula screw internal fixation, and total hip replacement are the most used surgical treatments.



Figure 3. Treatment on a 56-year-old male with pain limitation of the left hip due to trauma. The CT suggested a femoral neck fracture. Pauwels classification type III was determined as follows: (a) preoperative CT; (b) Postoperative reexamination; (c) 6 weeks after the operation, the fracture position was good, and internal fixation was stable without loosening.

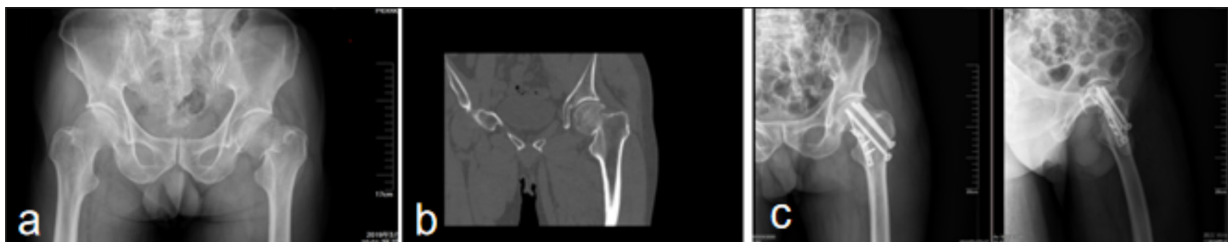


Figure 4. Treatment on a patient with a left femoral neck fracture caused by trauma. Pauwels type III was determined as follows: (a) CT confirmed that the femoral neck fracture belonged to Pauwels III; (b) Postoperative reexamination; (c) 3 months after the operation, fracture healing, and internal fixation were stable.

Because middle-aged and old people have lower bone looseness and stability, the muscle strength gradually weakens. Therefore, because femoral neck fracture is more common in the middle-aged and elderly, the most commonly used treatment method in the treatment of middle-aged and elderly patients is artificial joint replacement. The therapeutic effect of open reduction and internal fixation with hollow nail internal fixation for Pauwels type III femoral neck fracture made a significant contribution to the disease therapy. In this study, we found that in the treatment of Pauwels type III femoral neck fracture with open reduction and internal fixation combined with hollow nail internal fixation, the operation time and intraoperative bleeding volume have significantly decreased, and the postoperative recovery time is enhanced compared to that of total joint replacement. After the operation, the functional score and pain score had a significant relationship with the recovery time, and there was no significant relationship with the type of treatment. Therefore, in clinical treatment, doctors should take appropriate treatment methods for patients.

The complications of elderly patients with femoral neck fractures mostly focus on cardiovascular diseases, respiratory diseases, and cerebrovascular diseases²³. In the clinical diagnosis of a femoral neck fracture, once conservative traction treatment is carried out, femoral head necrosis, simple fracture, multiple organ dysfunction, infection, and osteoporosis can occur. Therefore, it is a simple and feasible method to choose surgical treatment for middle-aged and elderly femoral neck fractures. In young and middle-aged cases, femoral neck fractures are generally affected by trauma, and the probability of fracture displacement is also high²⁴. Therefore, it is very difficult to adopt artificial joint replacement for closed treatment.

Selection of Treatment Methods

When the internal fixation is performed, the failure end has a high shear strength. The greater the Pauwels angle, the greater the shear force. When the maximum shear force is greater than the maximum external force exerted by the internal nail, the error-broken end will move forward, and the internal nail will fail. For this kind of fracture, researchers²⁵ believe that dynamic hip screw fixation and anti-rotation screw fixation are good biomechanical environments. However, the main function of the reverse rotation screw is reverse rotation, which provides limited shear force between the fracture ends of the reverse

rotation. According to the fracture support plate theory²⁶, if the support plate is placed at the fracture end of the femoral neck, it can effectively transfer and offset the shear force on the fracture surface of the bone, thus improving the safety of the fracture, and the fracture recovery rate and reducing the occurrence of necrosis of the femoral head. However, if dynamic hip screws and medial support plates are used, the treatment cannot be carried out in time and must be carried out simultaneously on the front and side. The treatment injury area is large, the duration is long, and the bleeding is much. Therefore, DAA can be used to repair open fractures. This treatment method is often the preferred one when treating young people. The incidence factors of old-age fracture are generally osteoporosis, low stability, and weak muscle strength, often accompanied by cardiovascular system disease, respiratory system disease, cerebrovascular disease, and other complications. Therefore, it is a simple and effective method to select surgery for the treatment of middle-aged and old-age femoral neck fractures.

Conclusions

In the treatment of Pauwels type III femoral neck fracture with open reduction and internal fixation combined with hollow nail internal fixation, the operation time and intraoperative bleeding volume have decreased, and the postoperative recovery time is enhanced compared to that of total joint replacement. The functional score and pain score had a significant relationship with the recovery time after the operation, and there was no significant relationship with the type of treatment.

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Conflict of Interest

The authors have no conflict of interest to declare.

Ethics Approval

Ethical approval was granted by the Jiujiang University Clinical Medical College (JJFY-201512-K011).

Informed Consent

Patients gave written informed consent to be involved in the study.

Authors' Contributions

Z.-Z. Li is the supervisor of the team in all research steps, including design, data analysis, and manuscript writing. Z.-Y. Cao completed the cases involved in this article. J.-J. Liu, as the first author, has the main role in experimental data collection, data gathering, preparation of results, and data analysis. Z.-L. Wang assisted in data processing and proofread the manuscript. L.-Y. Zhang assisted in data processing. K. Sun assisted in data processing, and J. Li assisted in data processing. All authors have read and approved the manuscript.

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