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Closed Reduction and Hollow Screw Fixation with Attachment Point of Gluteus Maximus as Reference Mark for the Treatment of Femoral Neck Fracture

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Keywords:

Femoral neck fracture; Anatomy; Orthopedic procedures

1. Abstract

1.1. Background: Femoral neck fractures are commonly encountered in orthopaedic practice, and internal fixation with hollow screw is the mainly choice for surgical treatment. How to accurately insert a guide pin and hollow screw is a topical issue for research.

1.2. Methods: A retrospective analysis was performed on 120 cases of femoral neck fracture treated by closed reduction and hollow screw fixation. In observation group, hollow screws were inserted using the attachment point of gluteus maximus as reference, while the control group used traditional insertion protocol. Operation time, the number of adjustments for the first guide pin and the frequency of intraoperative perspective were recorded to make comparisons between the two groups.

1.3. Results: The operation time of the observation group was significantly shorter than that of the control group, and the number of adjustments for the first guide pin and the frequency of intraoperative perspective was significantly less than that of the control group ($P < 0.001$). All cases were followed up for an average of 27.81 months. Postoperative radiographs showed good reduction for fracture and bone union in all patients, with an average healing time of 14.59 weeks. There was no significant difference between the prognosis of the two groups.

1.4. Conclusion: Using the attachment point of gluteus maximus as reference can provide an accurate location for hollow screw and shorten the operation time, reduce the number of guide pin adjustments and the frequency of intraoperative perspective, which has high clinical practical value.

2. Introduction

Femoral neck fractures are commonly encountered injuries in orthopaedic practice and accounting for approximately 54% of hip fractures and 3.58% of bone fractures [1]. The femoral neck is a risky anatomic location, which involves massive blood vessels supplying the femoral head, consequently, complications such as nonunion and avascular necrosis of the femoral head can easily occur after fracture [2]. It is essential that surgeons are able to achieve an accurately anatomic reduction and high-quality fixation [3]. For young and elderly patients suffering femoral neck fracture with mild fracture displacement, currently internal fixation with hollow screw is the mainly choice for surgical treatment [4]. Due to the thick muscles in the hip, it is difficult for surgeons to find an obvious reference position, thus how to accurately insert a guide pin and hollow screw is a topical issue for research [5], which will contribute to improve the operation quality and shorten the operation time, reduce the need for adjustments of guide pin as well as the frequency of intraoperative perspective. In this study, we developed a new approach to insert guide pin and hollow screw using the attachment point of gluteus maximus as reference in closed reduction and internal fixation, which significantly improved the efficiency and accuracy of surgery and reduced the risk of fracture displacement or avascular femoral head necrosis due to repeated insertions.

3. Methods

3.1. Subjects

This study was designed as a prospective observational cohort study, which included consecutive 120 patients who underwent closed reduction and internal fixation with hollow screw for femoral neck fracture in our institution between January 2015 and August 2021. The inclusion criteria were as follows: (a) Low-energy trauma caused by indirect mechanisms;(b) Fresh closed femoral neck fracture;(c) Normal activity and function before injury; (d) No serious diseases of internal medicine;(e) Femoral neck fracture of Garden's type III for patients aged < 75 years old, and Garden's type IV for patients aged < 60 years [6]. The exclusion criteria were as follows: (a) Old fracture; (b) Comminuted fracture caused by high-energy trauma; (c) Combined with severe osteoarthritis according to ISOA (index of severity for osteoarthritis) score and K-L (Kellgren-Lawrance) grades of hip osteoarthritis [7]; (d) Combined with severe internal diseases who cannot tolerate surgery.

After enrollment, all the patients were asked to perform routine examination, anteroposterior and lateral view of X-ray and CT for both hips were taken to made a comprehensive understanding of the fracture, meanwhile the neck-shaft angles were measured for each side. A simple randomization method and table of random numbers was used. If the selected number is even, the patient is allocated to the observation group, and if it is odd, the patient is allocated to the control group in a 1:1 ratio. In the observation group, patients were inserted with guide pins and hollow screws using the attachment point of gluteus maximus as the reference landmark, and in the control group, patients were treated with Kirschner wires placed on the body surface as the reference mark to insert guide pins and hollow screws. All study subjects were asked for informed consent, and the study protocol was approved by the Medical Ethics Committee of Xi'an Jiaotong University Health Science Center. All methods were performed in accordance with the relevant guidelines and regulations.

3.2. Surgical Procedures

Overall, the surgery was performed under general anesthesia by 4 different surgeons, and the two groups of patients was equally assigned to each surgeon. The patients were positioned supine on a radiolucent table with the arm on the injured side secured over the chest. Closed reduction was performed in abduction and external rotation until satisfactory fracture reduction quality was achieved. The reduction was checked under image intensifier in both AP and lateral views. Maintain the affected extremity in adduction and internal rotation for internal fixation. In the observation group, a 2cm longitudinal incision was made in the proximal lateral thigh, starting from about 5 cm below the tip of the greater trochanter of the femur. After separated the deep fascia and split the vastus lateralis from posterior margin, the attachment point of gluteus maximus was exposed. Marked 0.5 cm above the superior margin of the attachment point of gluteus maximus and the middle point of the anteroposterior margin of the femoral shaft as the insertion point, according to the preoperative measured neck-shaft angle, a hollow screw guide pin was inserted toward the femoral neck, and the other two guide pins were inserted anterosuperiorly and posterosuperiorly about 1.5 cm apart from the first guide pin. Overall, the three guide pins distributed in an inverted triangle configuration and parallel to each other [13]. In the control group, a Kirschner wire was placed on the skin in front of the hip, and fixed by sterile tape after the direction of the Kirschner wire was confirmed to be parallel to the neck-shaft angle under image intensifier. A 2cm longitudinal incision was made in the proximal lateral thigh, starting from about 5 cm below the tip of the greater trochanter of the femur, and three guide pins were inserted parallel to the Kirschner wire into the femoral neck, distributed in the configuration of an inverted triangle. In all patients, 3 appropriate hollow screws with a diameter of 7.3 mm (Depuy-Synthes company, Switzerland) were placed after the guide pins were satisfactorily inserted.

3.3. Postoperative Treatment

To prevent infection and deep venous thrombosis, all the patients routinely received antibiotic and anticoagulant therapy. On the second day after surgery, the patients were instructed to perform rehabilitation training including hip flexion (<90°) and strength exercises. Passive hip flexion and extension, and active hip flexion and extension were performed 1 and 2 weeks postoperatively, respectively. Protective weight-bearing exercise was executed after 3 to 4 weeks postoperatively. The patients could transition to full weight-bearing exercise when the fracture line was dim or disappeared on radiography, in general 6 to 8 weeks postoperatively.

3.4. Statistical Analysis

The operation time, the number of adjustments for the first guide pin, and the frequency of intraoperative perspective were compared between the two groups. SPSS software version 24.0 (IBM Corporation, Armonk, NY, USA) was used for all statistical analyses. Normality of the data was evaluated using the Shapiro-Wilk test, the data with normal distribution were compared by two independent sample t-test and expressed as mean ± standard deviation ($x \pm s$). The number of guide pin adjustments and intraoperative perspective times was expressed as M (P_{25}, P_{75}) and the Mann-Whitney U test was used for comparison. The categorical variables, such as gender, sides, Garden's type were compared by Chi-square test. An α value of 0.05 was considered to be statistically significant.

4. Result

The observation group included 26 males and 34 females, aged 26 ~ 70 (53.72±10.25) years; 31 cases on the left side and 29 cases on the right side; the fractures were classified according to Garden's classification: 28 cases of type II, 18 cases of type III, and 14 cases of type IV. The control group consisted of 27 males and 33 females, aged 30 ~ 72 (52.68±9.04) years; 30 cases on the left side and 30 cases on the right side; 28 cases of type II, 20 cases of type III, and 12 cases of type IV. Overall, there was no significant difference in gender (χ^2=0.034, P =0.854), age (t=0.581, P =0.563), fracture side (χ^2=0.033, P =0.855), and Garden classification of fractures (χ2=0.259, P =0.878) between the two groups. The general information in detail of patients treated by different surgeons is provided in (Table 1).

The operation time of the observation group was 27.75±4.45 min, which was significantly shorter (t= 5.929, P<0.001) than that of the control group (37.50±8.78 min), and the number of adjustments for the first guide pin in the observation group was 3 (2, 4) times, in the control group the number was 5.75 (4,7) times, the number in the observation group was less than that in the control group, and the difference was statistically significant (Z=-9.253, P<0.001). The frequency of intraoperative perspective in the observation group was 4 (3, 5) times, and 8.5 (7, 10) times in the control group, which had a significantly difference (Z=-9.082 , P<0.001). Table 2 shows the surgical data in detail of patients treated by different surgeons.

Postoperative radiographs showed good reduction for fracture and bone union in all 120 patients, according to Garden's alignment index, in the observation group, 52 cases were classified to lever I, and 8 cases were classified to level II; In the control group, 54 cases were lever I and 6 cases were level II, no significant difference was found between the two groups (χ2=0.323, P=0.570). All the patients were followed up for an average of 27.81 (12-48) months with an average healing time of 14.59 (12-20) weeks, and there was no significant difference between the healing time of the observational group and control group (14.47±1.73 and 14.72±1.95, respectively, t=-0.743, P=0.459). During the follow-up, there were 2 cases of patient with Garden type IV fracture in the observation group and 3 cases of patients with Garden type IV fracture in the control group developed ischemic necrosis of femoral head. Overall, there was no significant difference between the prognosis of the two groups (χ2=0.209, P=0.648).

Table 1: Comparison of general data between the two groups of patients

Surgeon	Group	Age	Gender (male/female)	Sides (right/left)	Garden's type (II/III/IV)
A	Observational	49.07±5.76	10-May	7-Aug	8/4/2003
	Control	50.33±8.97	8-Jul	7-Aug	7/4/2004
	P	0.66	0.456	1	0.901
B	Observational	55.53±8.52	9-Jun	8-Jul	7/4/2004
	Control	53.93±10.19	9-Jun	6-Sep	8/5/2002
	P	0.656	1	0.464	0.656
C	Observational	56.93±8.93	10-May	9-Jun	6/6/2003
	Control	53.33±8.44	9-Jun	8-Jul	7/6/2002
	P	0.282	0.705	0.464	0.871
D	Observational	53.33±14.13	5-Oct	7-Aug	7/4/2004
	Control	53.13±7.97	7-Aug	9-Jun	6/5/2004
	P	0.964	0.456	0.464	0.91
Total	Observational	53.72±10.25	26/34	29/31	28/18/14
	Control	52.68±9.04	27/33	30/30	28/20/12
	P	0.563	0.854	0.855	0.878

Table 2: Comparison of surgical data between the two groups of patients

Surgeon	Group	Operation time	Adjustment times of guide pin	Frequency of intraoperative perspective
A	Observational	28.67±4.15	3(3,4)	5(4,5)
	Control	38.60±7.78	6(6,7)	9(8,11)
	P	<0.001	<0.001	<0.001
B	Observational	28.47±3.80	3(2,4)	5(3,5)
	Control	38.20±8.16	6(5,7)	8(7,9)
	P	<0.001	<0.001	<0.001
C	Observational	27.27±5.73	3(1,3)	4(2,4)
	Control	33.67±6.82	6(5,7)	8(6,9)
	P	0.01	<0.001	<0.001
D	Observational	26.60±4.00	3(2,3)	4(3,5)
	Control	39.53±11.36	6(6,9)	8(6,9)
	P	<0.001	<0.001	<0.001
Total	Observational	27.75±4.45	3 (2, 4)	4 (3, 5)
	Control	37.50±8.78	5.75 (4,7)	8.5 (7, 10)
	P	<0.001	<0.001	<0.001

5. Discussion

Owing to the anatomical structure and biomechanical characteristics of the femoral neck, complications such as fracture nonunion and femoral head necrosis are prone to occur after fracture and result in significant morbidity and mortality [8]. For young adults and select active older individuals, the treatment of choice can be closed reduction and internal fixation with hollow screw, which has the advantages of minimal tissue invasion, less blood loss, shorter operation time and quicker return to daily activities [4, 9]. Previous researches have suggested that three hollow screws inserted in an inverted triangular configuration into the femoral neck can provide an adequate mechanical stability to resist the increased shear forces generated [5, 10]. The quality of fracture reduction and internal fixation is considered to be the most important prognostic factor, which has an obvious correlation with the incidence of complication such as fracture nonunion and avascular femoral head necrosis [3].

In a routine surgery of femoral neck fracture with internal fixation, the first step is to insert the lowest guide pin and hollow screw, which requires a highly accuracy because the remaining two guide pin and hollow screws are inserted taking the first screw as reference. Because of the thick muscle in hip, there is no obvious landmark to help a surgeon locating the insertion point of the first screw. Previously, the insertion of first screw referred to a Kirschner wire placed on the skin in front of the hip joint, and an interoperative fluoroscopy was used to adjust the direction of Kirschner wire until it consists with the preoperative plan [11]. In clinical practice, due to the different soft tissue thickness, the above procedure always requires repeated fluoroscopic confirmations and guide pin adjustments, which is time-consuming. In addition, due to the instability of the fracture and continuous intraoperative traction, although a good reduction of the fracture was previously achieved, a fracture displacement and rotation may occur [12], resulting in another closed reduction procedure, even an open reduction, which is frustrated during the surgery.

Although navigation-assisted techniques and surgical robots may perfectly solve the problem [13, 14], because of the high equipment and technique requirements, they are difficult to be utilized in an ordinary medical institution. Therefore, it is necessary to develop a convenient and accurate approach to help a surgeon locate the first guide pin's insertion. Previous studies of biomechanics of the femoral neck fracture with internal fixation have suggested that, to achieve an optimal support and fixation, the first screw should be located at the lower margin of the lesser trochanter of the femur, passing through the Ward's triangle and clinging to the femoral calcar, finally entry the femoral head (Figure 1) [15, 16]. According to the anatomy of gluteus maximus muscle [17], the lower edge of the lesser trochanter of the femur is generally close to the upper edge of attachment point of gluteus maximus (bony landmarks: the superior edge of gluteal tuberosity), moreover, the authors found in clinical practice that the above two structures locate at the same level (Figure 2). Therefore, using the attachment point of gluteus maximus as a reference to insert guide pin is theoretically feasible.

In order to verify this theoretical approach in clinical practice, we performed the femoral neck fracture with closed reduction and internal fixation surgery in both traditional approach and this new approach. To control the bias between operators, 4 different surgeons were asked to perform surgery using the above two approaches according to the grouping of patients, and the operation time, the number of adjustments for the first guide pin, the frequency of intraoperative perspective were recorded to make a comparison. The results showed that for all 4 surgeons, using the attachment point of gluteus maximus as a reference to insert guide pin can significantly shorten the operation time, reduce the numbers of guide pin adjustments and the frequency of intraoperative perspective, moreover, no difference was found in prognosis the patients between the two group. In a word, the new approach is not only theoretically feasible but also clinically efficient.

The simplified insertion procedure is as follows: making a 2cm longitudinal incision in the proximal lateral thigh, starting from about 5 cm below the tip of the greater trochanter of the femur. After separating the deep fascia and splitting the vastus lateralis from posterior margin, the attachment point of gluteus maximus will be accessible. The middle point of the anterior and posterior edges of the femoral shaft is the insertion point. The first guide pin is inserted in the direction of the femoral head with an anteversion angle of about 15°. Compared to the traditional approach, the above new approach requires a longitudinal straight incision of femur, the necessity lies in: (a) it is beneficial to exposure and operation. The muscles and soft tissues in the hip are thick, and the anterior and posterior edges of the femur cannot be located without an incision, nor to insert a guide pin or hollow screw; (b) the incision is made in order to avoid the muscles and soft tissues attachment or wrapping around the guide pin during the insertion process, which will contribute to protect the tissue in surgical area; (c) when the fracture union, the incision can be utilized for the removal of internal fixation.

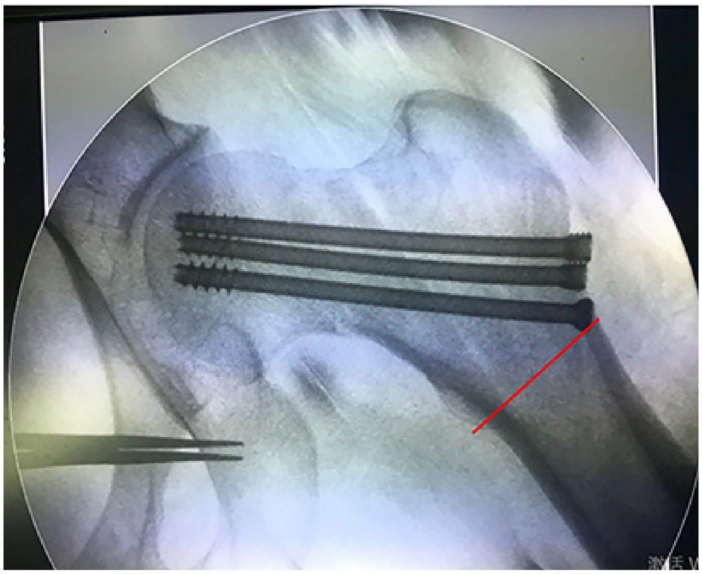

Figure 1: intraoperative image. From which it can be seen that the lowest hollow screw is located at the level of the lesser trochanter of the femur, clinging to the femoral calcar. Overall, the three guide pins distributed in an inverted triangle configuration and parallel to each other.

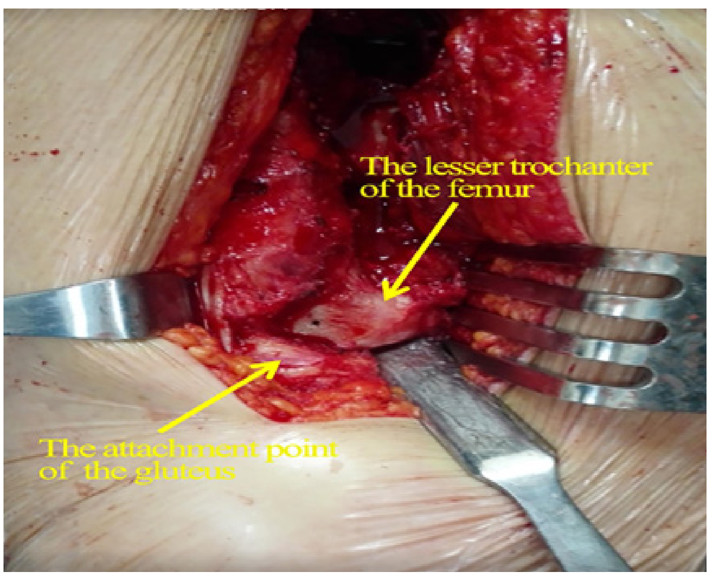

Figure 2: The anatomy around the hip joint. An intraoperative picture taken from a total hip arthroplasty, from which it can be seen that the lower edge of the lesser trochanter of the femur and the upper edge of attachment point of gluteus maximus (bony landmarks: the superior edge of gluteal tuberosity) locate at the same level.

6. Conclusion

The finding of this study showed that compared with the control group in which Kirschner wire was placed on the body as a reference to insert guide pins and hollow screws, the observation group could significantly shorten the operation time, reduce the numbers of guide pin adjustments and the frequency of intraoperative perspective, in turn reduce the risk of fracture displacement caused by repeated operation. In conclusion, this study described an accurate inserting location for closed reduction and internal fixation of femoral neck fracture, which will contribute to improve the operation quality and reduce the risk of complications, and has comparatively higher practical value.

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