

Clinical results of cannulated screw internal fixation via direct anterior approach for femoral neck fractures in young adults: a retrospective study

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Abstract

Purpose: To investigate the effectiveness of open reduction and cannulated screw fixation via direct anterior approach (DAA) for the treatment of femoral neck fractures in young adults.

Methods: The data from 43 young patients with irreducible femoral neck fractures who underwent this procedure from January 2013 to December 2017 were retrospectively analyzed. Garden's alignment index was measured after the operation and at the final follow-up to determine the reduction quality, and the Harris score was recorded at the final follow-up to assess hip function.

Results: The average follow-up duration was 19 months (range, 12-31 months). Implant failure was observed in 3 cases and was associated with femoral neck shortening, and nonunion occurred in 2 patients. A total of 6 patients exhibited features of avascular necrosis (AVN), four of whom (Ficat grade III) underwent total hip arthroplasty and two of whom (Ficat grade II) were asymptomatic at the final follow-up. There were no statistically significant differences in Garden's alignment index, as measured on X-ray radiographs, immediately after surgery and at the final follow-up. At the final follow-up, the mean Harris score was 82.41 ± 14.06 . The Harris score was considered excellent for 17 cases, good for 13 cases, fair for 3 cases, and poor for 4 cases. The rate of excellent and good outcomes was 81.1%.

Conclusions: For cases of irreducible femoral neck fractures, open reduction and cannulated screw fixation via DAA can yield relatively good clinical outcomes.

Introduction

Femoral neck fractures are common in elderly individuals and are predominantly caused by low-energy trauma. However, the main causes of injuries in young adults are high-energy injuries, such as road traffic accidents or falls from a height, which usually lead to severe displacement and basicervical or more distal neck fractures[1, 2]. In these cases, the fracture pattern tends to be more vertical, and there is usually severe displacement of the bone, so it is difficult to reduce the displaced bone fragments by the closed reduction method. In addition, implants for these fractures normally bear large vertical shear forces; therefore, they are biomechanically unstable, and implant failure is likely to occur.

It is well known that the incidence of complications such as nonunion, implant failure and avascular (AVN) in cases of displaced femoral neck fractures is relatively higher than that in cases of nondisplaced fractures, and displaced fractures and poor reduction are the main causes of surgical failure[3].

As with other fractures, the most important goal of surgical treatment for femoral neck fractures is anatomical reduction and subsequent stable internal fixation[1].

The direct anterior approach (DAA) is an internervous approach that does not damage the blood supply of the femoral head and provides direct fracture site visualization for anatomical reduction.

Because the fracture mechanism and fracture type in young patients are different from those in elderly people, more consideration should be given to the selection of implants.

For improved medial support and stability, many implants have been used for irreducible displaced femoral neck fractures, such as dynamic condylar screws (DCSs)[4], dynamic hip screws (DHSs)[5], medial buttress plate augmentation with cannulated screws[6], anteromedial femoral neck plates with cannulated screws[7], and percutaneous compression plates (P.C.P.)[8]. All of these methods have good curative effects with a low incidence of complications, including nonunion and AVN.

In this retrospective study, we used open reduction and cannulated screw fixation via DAA to treat femoral neck fractures in young adults. Although some curative effects have been demonstrated, some limitations have been exposed regarding implant failure and femoral neck shortening, which can guide the development of future treatments.

Methods

Patients

The inclusion criteria were as follows: (1) an age of 18–60 years; (2) a closed fracture; and (3) an injury surgery interval of < 3 weeks.

The exclusion criteria were as follows: (1) patients with ipsilateral intertrochanteric fractures or subtrochanteric fractures; (2) those who have consumed high-dose hormones for long periods of time; (3) those with alcoholism; (4) those with pathological fractures; (5) those with severe chronic systemic diseases; (6) comatose patients; and (7) those with incomplete medical data.

Operative Techniques

All surgeries were performed by the same team of surgeons, and spinal or general anesthesia was used. The patients were placed on a fluoroscopic operating table in the supine position, and a small cushion was placed under the hip to elevate the operative area for improved visualization with radiographs. Anteroposterior (A-P) and true lateral views of the proximal femur were obtained by C-arm imaging. All patients in our study underwent open reduction via DAA after 2–3 closed reduction failures. An 8–10 cm longitudinal incision approximately 3 cm lateral and 3 cm distal to the anterior superior iliac spine (ASIS) was made distally towards the lateral aspect of the knee. The gap between the sartorius muscle and the fascia lata was exposed, the lateral femoral cutaneous nerve was protected, and the ascending branch of the lateral femoral circumflex artery (LFCA) was identified and ligated. Two Hohmann retractors were placed above and below the femoral neck outside of the capsule, providing an excellent view of the entire femoral neck and fracture sites. Typically, there is a large amount of hematoma in the joint, which can expand the capsule and produce "a sensation of tension". The anterior joint capsule was opened in a T-shape, the hematoma in the joint was removed, and the fracture site was exposed. K-wires (2.0 mm) were

placed into the anterior femoral head, the joystick method was used to reduce the fracture, and anatomical reduction of the bone fragments was achieved with manipulation of the lower limb. After further confirmation by X-ray imaging, two K-wires were used to temporarily fix the fractures. Under X-ray guidance, three wires were implanted in an inverted triangular pattern through a small incision until the tips of the K-wires reached 0.5 cm below the cartilage, and then three 7.3 mm fully thread cannulated screws (Changzhou Waston Medical Appliance Co., Ltd) were implanted into the subchondral bone. Inserting the posterior K-wire into the upper part of the femoral neck was avoided to prevent injury to the upper blood vessels. After the hip joint mobility and stability of fixation were evaluated, the wound was flushed with saline, the joint capsule was sutured, and the fascia and skin were closed layer by layer.

Postoperative Treatment

The lower limbs were placed in an abducted, neutral position after the operation. X-ray examinations were performed on the second day after the operation, antibiotics were administered to prevent bacterial infections within 24 hours, all patients were required to initiate physiotherapeutic exercises after the operation, [low molecular weight heparin](#) was subcutaneously injected every day, and dual lower limb air pressure pumps were used to prevent deep vein thrombosis of the lower extremities. The patients were instructed to perform toe-touch weight-bearing with crutches or a walker for more than three months, and partial weight-bearing was allowed when the growth of the bridged callus was evident; full weight-bearing was gradually allowed.

Follow-ups

All patients were required to undergo follow-ups at 1, 2, 3, 6, and 12 months and once a year postoperatively. At each follow-up, X-ray examinations were performed to observe the fracture healing status and determine whether AVN occurred. On the X-rays, any degree of necrosis above Ficat stage II was defined as AVN. MRI examinations were performed for patients suspected of having AVN. The reduction quality was evaluated according to Garden's alignment index immediately after the operation and at the final follow-up. The Harris hip function score was used to evaluate hip function. The maximum score was 100 points; scores of 90 to 100 points were considered excellent, 80 to 89 points were considered good, 70 to 79 points were considered fair, and <70 points were considered poor.

Statistical Analysis

All statistical analyses were conducted using 20.0 SPSS software (SPSS Inc., Chicago, United States). Categorical variables are expressed in numbers and percentages, and continuous variables are shown as the mean±standard deviation. Student's t-test was used to analyze the preoperative and postoperative continuous variables, and a P value of < 0.05 was regarded as statistically significant.

Results

Patient demographic data

Out of 43 patients, 6 were lost to follow-up. We present the results of 37 patients included in this study (as shown in table 1). There were 25 males and 12 females aged 41.4 years (range, 18-60 years), all patients had closed fractures, the causes of the injuries included road traffic accidents (n=17), falls from a height (n=15), and intense exercise (n=5). Ten patients had a history of smoking. The average duration from the injury to operation was 3.5 days (range, 1-8 days). There were 21 cases of Pauwels Type III fractures, 13 cases of Pauwels Type II fractures, and 3 cases of Pauwels Type I fractures. According to the fracture site classification, 2 cases were subhead fractures, 14 cases were transcervical fractures, and 21 cases were basicervical or more distal neck fractures. There were 20 cases on the right side and 17 on the left side. The operations were successfully completed, and no blood vessel or nerve injuries occurred. The operation time was 85 minutes (range, 70-120 minutes), and the bleeding volume was 280 ml (range, 150-550 ml). No cases of superficial or deep wound infection or deep vein thrombosis were observed postoperatively.

Follow-ups

The data of 37 patients with complete medical records were analyzed, and the average follow-up duration was 19 months (range, 12–31 months). The X-ray results showed epiphyseal formation at 3.5 months (range, 2–5 months) postoperatively. The fractures had completely healed when the patients were asymptomatic, and the fractures were not visible at 5.5 months (range, 4–9 months). There was no statistically significant difference in Garden's alignment index from immediately after surgery to the final follow-up. Implant failure was observed in 3 cases (8.1%) and was associated with femoral neck shortening. Nonunion occurred in 2 patients (5.4%), and 6 patients (16.2%) had features of AVN; four of whom (Ficat grade III) underwent hip arthroplasty and two of whom (Ficat grade II) were asymptomatic at the final follow-up(as shown in table 2).

Clinical Outcomes

After the operation, the mean Garden's alignment index was 159.19 ± 3.19 in the A-P view and 179.81 ± 1.84 in the lateral view. At the final follow-up, the mean Garden's alignment index was 158.84 ± 2.78 in the A-P view and 179.11 ± 1.85 in the lateral view, and the difference from before to after the operation was not statistically significant(as shown in Table 3) ($P > 0.05$).

At the final follow-up, the mean Harris score was 82.41 ± 14.06 , and it was considered excellent in 17 cases, good in 13 cases, fair in 3 cases, and poor in 4 cases. The rate of excellent and good outcomes was 81.1%(as shown in Table 4).

Discussion

A recent meta-analysis described the complications of femoral neck fractures in young adult patients; the reoperation rate was approximately 18%, the nonunion rate was approximately 9%, the avascular necrosis rate was approximately 14%, and the implant failure rate was nearly 10%[9]. Although surgical techniques, instruments and imaging methods have improved, complications such as nonunion (10–30%) and AVN are still evident in 15–33% of patients[10, 11]. Most reports of nondisplaced fractures (Garden classification stage I and stage II) show high rates of union and few complications, with nonunion and AVN rates of less than 6%[12, 13]. We found that open reduction and triangle cannulated screw fixation via DAA results in an 81.1% of excellent and good outcomes rate in a series of irreducible femoral neck fractures, with a nonunion rate of approximately 5.4%, an avascular necrosis rate of 16.2%, and an implant failure rate of nearly 8.1%.

Open Reduction and Internal Fixation (ORIF) or Closed Reduction and Internal Fixation (CRIF)

Whether closed reduction or open reduction is ideal for femoral neck fractures is still controversial. A total of 17 case-control studies with 2065 patients were reviewed, and it was revealed that AVN after the operation presented no association with the patient's age, injury-operation interval, fracture reduction mode, preoperative traction or mechanism of injury[14]. During the operation, it is difficult to anatomically reduce a displaced femoral neck fracture in a closed reduction pattern. If closed reduction is used repeatedly, the blood supply of the femoral head will be damaged. Therefore, we agree that to reduce the risk of complications such as AVN, nonunion, implant failure, anatomical reduction and stable internal fixation, only anatomical reduction should be performed. Normally, a varus angulation of less than 160° in the AP view and a posterior angulation of more than 5° in the lateral view indicate an unsatisfactory reduction[3]. If anatomical reduction cannot be achieved after 2–3 closed reductions, open reduction and internal fixation should be performed. Open reduction allows direct and controlled treatment of fractured fragments. Stone JD et al. [15] treated fully displaced femoral neck fractures in pediatric patients with open reduction and internal fixation (ORIF), and the authors observed a significantly higher quality of reduction than that with closed reduction and internal fixation (CRIF) and subsequently fewer complications, including AVN of the femoral head.

In addition, intracapsular hematomas, which may lead to a high intra-articular pressure, block the blood supply of the femoral head in the acute stage after injury, and eventually lead to avascular necrosis of the femoral head, can be removed with the open surgical approach[16].

Bonnaire Fet al.[17] measured the intraarticular pressure of 55 patients with intracapsular femoral neck fractures and found that hemarthrosis caused increased intraarticular pressure in 75% of the patients. Moreover, no significant difference was found between nondisplaced and displaced fracture types. There is sufficient evidence in the literature showing a correlation between increased intraarticular pressure following femoral neck fractures and reduced perfusion of the femoral head[18, 19]. Based on the data

available, we supposed that capsular decompression by capsulotomy can compromise circulation in the femoral head.

The Approach

Femoral neck fractures with good fracture reduction heal more quickly than those with poor reduction. Moreover, the anatomical reduction of fractures is easier to achieve when a larger area at the fracture site is exposed[20].

The anterolateral (Watson-Jones approach) and Smith-Petersen approaches are the two most frequently used approaches for femoral neck fractures[21]. Smith-Petersen is a commonly used approach for deep circumflex iliac artery bone grafting [22]. However, this incision leads to a large amount of damage, so it is not suitable for patients who do not need bone flap transplantation. The modified Smith-Petersen approach, also known as DAA, is widely used in anterior hip arthroplasties[23]. Ye Ye et al.[6] suggested that this is an internervous approach between the femoral nerve and superior gluteal nerve, and it can provide an excellent visualization of the whole femoral neck fracture and placement for a medial buttress plate.

A study of exposure measurements of fresh-frozen human pelvises that underwent both the modified Smith-Petersen and Watson-Jones approaches revealed that the modified Smith-Petersen approach provided much better visualization and palpation of the medial femoral neck and articular surface than did the Watson-Jones approach[24].

One of the advantages of the Watson-Jones approach is that the fracture can be exposed under direct vision and the surgeon can directly reach the femoral site through the incision made with this approach. This approach is suitable for most basal neck fractures and transcervical fractures, and it is also recommended that an implant is placed in the lateral femur[25]. Other authors believe that the Watson-Jones approach has limited efficacy in treating femoral neck fractures, but the use of a single incision for fracture reduction and implant placement is attractive to surgeons[25].

The Approach And The Blood Supply

One question is whether this treatment will damage the blood supply to the femoral head. Stephen C. Stacey et al. [1] argue that surgeons should identify and protect the ascending branch of the lateral femoral circumflex artery (LFCA) because it is very important to the blood supply of the femoral head. However, Ganz's well-accepted study shows that the deep branches of the medial femoral circumflex artery (MFCA) mainly supply blood to the femoral head[26]. Based on this theory, the LFCA and its branch should be located in the middle of the DAA, and ligation of these vessels will not jeopardize the blood supply to the femoral head[6]. Therefore, we agree that the vessel damaged in the DAA approach is the LFCA, which has been shown to have only a weak relationship with the femoral head blood supply.

However, it should be noted that a "T" capsule incision is performed through the anterior capsule, and the capsule incision along the acetabulum edge should be sufficiently distant from the posterior edge to avoid damaging the entry point of the MFCA.

Similarly, the repeated implantation of K-wires into the posterior superior area of the femoral neck also leads to a risk of damage to the blood supply of the femoral head because of the proximity of the wires to the MFCA.

The Fixation

Cannulated screw fixation is a widely accepted technique for femoral neck fracture fixation because it is simple and minimally invasive.

The divergent type or parallel type is better than the convergent type regarding the resulting biomechanics[27]. Three cannulated screws are arranged in an inverted triangle, which can also reduce the risk of fracture under the trochanter after fixation[28]. Previous biomechanical studies have shown that in cases of comminuted posterior femoral neck fractures, additionally using a fourth screw can improve the fixation strength[29].

Similarly, in fractures with high-risk patterns (i.e., Pauwels type III), utilizing a trochanteric lag screw has been shown to be biomechanically superior than using an inverted triangle pattern[30]. Zhuang L et al. [7] reported that the use of an anteromedial femoral neck plate and two cannulated compression screws is associated with a low incidence of complications, including nonunion and avascular necrosis. Pauwels type III femoral neck fractures are subjected to increased varus displacement moments, leading to nonunion rates ranging from 16–59% and AVN rates ranging from 11–86%[31]. In a study by Ye Ye et al. [6], fixation with buttress plate augmentation of three cannulated screws resulted in an 89% union rate in a series of Pauwels type III femoral neck fractures, which was higher than those in previous studies using cannulated screws alone.

Our study found that although DAA can provide good exposure, the incidence of nonunion, implant failure and AVN is relatively higher than that of other studies[6, 7]. Therefore, using only three cannulated screws may not be the best method to fix femoral neck fractures in young adults.

Conclusion

For cases of irreducible femoral neck fractures, open reduction via DAA can yield reductions of relatively good quality, but at the long-term follow-up, some cases in this study showed a high incidence of implant failure, nonunion, and AVN. Therefore, in some young and active patients, especially those with Pauwels Type III fractures, it may be more appropriate to enhance the stability of internal fixation with additional implants such as medial buttress plates.

Limitations Of The Study

The current study has some limitations. First, this is a retrospective study. Second, the sample size was small, and the follow-up was relatively short. Third, our study did not include a control group. However, this is a preliminary report. We will continue this study with a larger sample size and a longer follow-up period to increase the relevance of our results.

Abbreviations

DAA: direct anterior approach; AVN: avascular necrosis; DCSs: dynamic condylar screws; DHSs: dynamic hip screws; PC.C.P.: percutaneous compression plates; A-P: anteroposterior; ASIS: anterior superior iliac spine; LFCA: lateral femoral circumflex artery; ORIF: open reduction and internal fixation; CRIF: closed reduction and internal fixation; MFCA: medial femoral circumflex artery; CT: Computed tomography; MRI: Magnetic Resonance Imaging

Declarations

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Authors' contributions

Zu-jian Xu and Bing Luo conceived this study, participated in its design. Rui Huang and Fa-dong Li searched the relevant literature and inquired the medical records. Yi Yuan and Rui Huang wrote the manuscript. Jia-fu Yang revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Yes, data and material were available, not been published, and is not under consideration elsewhere.

Ethics approval and consent to participate

Permission was obtained from the Institutional Review Board of the Affiliated Hospital (Traditional Chinese Medicine) of Southwest Medical University.

Consent for publication

Written informed consent was obtained from each patient to authorize the publication of their data.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1

Demographic profile and other details of the 37 patients.

Variables	Mean (SD)	N (%)
Age, in years	41.4 (15.5)	
Sex		
Male		25 (67.6)
Female		12 (32.4)
Causes of injury		
Road traffic accidents		17 (45.9)
Falls from a height		15 (40.5)
Intense exercise		5 (13.5)
Smoking habit, yes		10 (27.0)
Pauwels Type classification		
Type I		3 (8.1)
Type II		13 (35.1)
Type III		21 (56.8)
Fracture site classification		
Subhead fracture		2 (5.4)
Transcervical fracture		14 (37.8)
Basicervical fracture		21 (56.8)
Side of fracture		
Right		20 (54.1)
Left		17 (45.9)
Injury-operation interval, in days	3.5 (1.1)	

^a Some patients had multiple medical diseases.

Table 2

The incidence of complications related to the fracture.

Complications	Count	Percentage (%)
LFCN injury	0	0
Superficial or deep wound infections	0	0
Avascular necrosis	6	16.2
Nonunion	2	5.4
Implant failure (cannulated screw back out or breakage)	3	8.1

Table 3

Garden's alignment index at different times

Follow-up time	Garden's alignment index (°)	
	A-P view	Lateral view
Immediately after the operation	159.19±3.19	179.76±3.43
Final follow-up	158.84±2.78	178.68±3.22
<i>t</i> value	0.874	1.399
<i>P</i> value	0.167	0.968

Table 4

Harris score at different times

Follow-up time	Harris score	Harris score grade			
		excellent	good	fair	poor
Final follow-up	82.41±14.06	17	13	3	4

Figures



Figure 1

Typical case: a 48-year-old male, a. preoperative CT scan showing a Pauwels Type II femoral neck fracture; b. postoperative incision image showing a DAA incision and a lateral incision; c. postoperative anteroposterior (A-P) radiograph; d. postoperative lateral radiograph; e. A-P radiograph at one year postoperatively showing that the fracture healed completely.



Figure 2

Typical case: a 56-year-old female, a. preoperative A-P radiograph showing a Pauwels Type III femoral neck fracture; b. postoperative A-P radiograph showing an anatomic reduction of the femoral fracture; c. MRI showing AVN (Ficat III) at 18 months postoperatively; d. A-P radiograph showing that total hip arthroplasty had been performed.