

# Efficacy Evaluation for the Treatment of Subcapital Femoral Neck Fracture in Young Adults by Capsulotomy Reduction and Closed Reduction

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## Abstract

**Background:** Subcapital femoral neck fracture in young adults has many complications, and the incidence is increasing year-by-year. The selection of the proper operation method to avoid them is an ambiguous matter. This study aimed to evaluate the treatment effect of subcapital femoral neck fracture by the capsulotomy and internal fixation with iliac bone grafting or closed reduction and internal fixation in young adults.

**Methods:** From March 2003 to February 2010, 65 young patients with subcapital femoral neck fractures were treated, including 39 males and 26 females with average age of 34.5 years (range, 19–50 years); 29 cases of the left side and 36 cases of the right side. They were randomly divided into Group A with 34 cases treated by closed reduction and internal fixation and Group B with 31 cases treated by the capsulotomy and internal fixation with iliac bone grafting. The two groups had no significant differences in sex, age, body mass index and preoperative Harris Hip Score. The observation criteria involved the length of the incision, blood loss, operation time, nonunion rate, avascular necrosis of the femoral head (ANFH) rate and Harris Hip Score.

**Results:** Four of 65 patients were lost follow-up, and the follow-up rate was 93.8%, the average follow-up time was 38.7 months (range, 33–47 months). In Group A, the incision length was  $5.1 \pm 2.2$  cm, blood loss was  $84.0 \pm 13.2$  ml, and operation time was  $52.9 \pm 10.2$  min. In Group B, the incision length was  $15.4 \pm 4.6$  cm, blood loss was  $396.0 \pm 21.3$  ml, and operation time was  $116.5 \pm 15.3$  min. Nonunion occurred in 8 patients (25.2%) in Group A and 1 patient (3.3%) in Group B. ANFH occurred in 9 patients (29.1%) in Group A and 2 patients (6.7%) in Group B. Postoperative Harris Hip Score was  $89.0 \pm 5.6$  in Group A and  $95.0 \pm 4.5$  in Group B. The above index of two groups was considered statistically significant ( $P < 0.05$ ).

**Conclusions:** Capsulotomy and internal fixation with iliac bone grafting can improve fracture healing, reduce ANFH in young adults. It is a safe and effective operation for subcapital femoral neck fracture.

**Key words:** Internal Fixation; Open Reduction; Subcapital Femoral Neck Fracture; Young Adults

## INTRODUCTION

Femoral neck fracture is one of the common orthopedic traumas, mostly caused by indirect violence. It occurs mainly in the elderly and the proportion of young adults accounts for only 2–3%.<sup>[1,2]</sup> However, with the rapid development of transportation in recent years, high-energy trauma is more and more common.<sup>[3,4]</sup> And the incidence of femoral neck fracture in young adults is also increasing in clinic year-by-year (approximating 6000 annually).<sup>[2,3,5,6]</sup> What is important is that subcapital femoral neck fracture in young adults is often associated with higher incidences of nonunion and avascular necrosis of the femoral head (ANFH), which will

result in a devastating outcome.<sup>[7-11]</sup> Although closed reduction and internal fixation have minimal invasion and short operation time,<sup>[12]</sup> it can develop those complications that result from bad reduction and fixation.<sup>[13-15]</sup> The selection of the proper operation method to avoid those complications is an ambiguous matter and research focus for many researchers.<sup>[4,16-19]</sup> In this paper, we evaluated the efficacy and advantages of capsulotomy and internal fixation with iliac bone grafting in treating subcapital femoral neck fracture in comparison with closed reduction and internal fixation in young adults.

## METHODS

### General data

From March 2003 to February 2010, 65 young patients with subcapital femoral neck fracture were enrolled. There

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were 39 males and 26 females with an average age of 34.5 years (ranged, 19–50 years). Twenty-nine cases were left side, and 36 cases were right side, including 24 cases of traffic accident, 25 cases of falling from a height and 16 cases of falling down. From the incident to the operation, the mean day was 2.6 days (ranged, 1–5 days). All the patients shared some common clinic symptoms: (1) Deformity: Most patients suffered from slight flexion of hip and knee joint and externally rotate deformity. (2) Pain: Except for spontaneous pain in the hip, it would be more obvious when moving the affected limb. When the heel or greater trochanter was knocked, longitudinal knock pain can be felt in the hip. Besides, the physical examination would found out tenderness in the groin under the middle of the inguinal ligament. (3) Swelling: Most of femoral neck fracture belonged to intracapsular fractures, and there was not so much blood loss. Besides, there were thick muscle groups surrounding the joint, so local swelling was not easy to be observed from appearance. (4) Functional abnormal: Patients with displaced fracture could not sit up or stand up. (5) Greater trochanter of the affected limb lifting, presented like this: (a) The greater trochanter is above the Nelaton line, (b) the horizontal distance between greater trochanter and anterior superior iliac spine is shortened compared with the normal side. The gender, age, body mass index and garden classification of Group A and B showed no statistical differences [Table 1].

### Preoperative preparation

The affected limb underwent bone traction on the traction frame and limited the movement. Prepared 400 ml red blood cell and plasma respectively for two groups and used intravenous antibiotics 30 min before operation.

### Operation methods

#### Closed reduction and internal fixation (Group A)

Under epidural anesthesia, patients were placed on a fracture table in a supine position. Longitudinal traction was used to restore the shortened displacement. And then applied abducting force on the lateral side and internally rotated the leg, gradually decreasing traction at the same time. The whole process was visualized under the C-arm image intensifier television fluoroscopy and to make sure that the fracture position, anatomical morphology, length of the affected leg and the rotational deformity should be adjusted as much as possible. After reduction, on the lateral side of the affected lower limb, a 2.5 mm Kirschner wire was inserted percutaneously to serve as a guiding wire toward the femoral

head under fluoroscopic visualization, which was 5–6 cm distal from the greater trochanter. The guiding wire crossed femoral neck and femoral calcar, and stopped at 0.5–1.0 cm under the joint surface of the femoral head. Then inserted two pointing Kirschner wires, and one of them should attach closely to the cortex of the posterior rim. After confirmed by X-ray that guiding wires crossed the fracture line and penetrated into the subchondral bone of the femoral head, implanted the cannulated screws for internal fixation with the help of guiding wires. After the fixation, fluoroscopy was used again to verify whether the screw threads crossed fracture line and identify the position of screws. Then the three guiding wires were extracted. After making sure that the joint motion was unlimited, repeatedly washed and closed the incision. Antimicrobial drugs were administered for 3–5 days to keep off the infection.

#### Capsulotomy and internal fixation with iliac bone grafting (Group B)

Under epidural anesthesia, patients were placed on a fracture table in a supine position. An anterior lateral incision was made over the affected hip and extended to anterior superior iliac spine. The fracture segment was exposed by opening anterior joint capsule and cleaning the intracapsular hematoma and embedded tissues. A 2 cm × 3 cm × 1 cm osteogroove was cut by an oscillating saw along the long axis of the femoral neck in the anterior surface of the distal fragment. The fracture was restored and maintained this state. Two guiding wires adjusted through the osteogroove were placed parallelly under the greater trochanter. Selected a suitable length cannulated screws and inserted along the guiding wires while the angle and depth of the guiding wires were adjusted appropriately. Distal screw threads crossed fracture line and completely penetrated into the femoral head under direct vision. After proper amount of iliac bone was made into bone granules, they were placed into osteogroove and fracture end. The harvested bone blocks were put back to cover the bone groove and then fixed. The incision was closed by layers. A hemovac drain was placed before the fascial closure. Thirty degrees of external abduction of the affected limb with slight traction was performed and held with a splint spica of hip. Regular antiinfection, improving circulation, spasmolysis treatment, and full drainage for 48–72 hours ought to be managed postoperatively.

#### Postoperative management

The patients began isometric quadriceps exercise on the 1<sup>st</sup> day postoperatively after anesthesia disappearing. Two

**Table 1: General data of patients in group A and group B (mean ± SD)**

Groups	Cases	Gender		Age (years)	BMI (kg/m <sup>2</sup> )	Illness time (days)	Classification	
		Male	Female				Type III	Type IV
A	31	19	12	33.9 ± 8.9	22.1 ± 0.8	2.64 ± 1.5	14	17
B	30	17	13	34.6 ± 9.1	21.9 ± 1.1	2.58 ± 1.7	12	18
Test values		$\chi^2 = 0.02$		$t = 0.63$	$t = 1.17$	$t = 1.41$	$\chi^2 = 0.29$	
P		0.90		0.06	0.24	0.16	0.59	

BMI: Body mass index.

weeks after surgery, patients were allowed to sit up on the bed and perform no-weight bearing activity like moving ankle joints. No-weight bearing with crutches or a walker was allowed after 6 weeks after surgery. The toe-touch weight-bearing with crutches or a walker was allowed after at least 8 weeks. If there was evidence of healing at 8 weeks, patients were allowed to begin partial weight bearing (up to 50% of body weight) with crutches or walker. Full weight bearing was allowed at 12 weeks. Patients were instructed to wean off the crutches when they were able to ambulate without a significant limp.<sup>[20]</sup> The condition of fracture healing, ANFH and the function recovery of the affected hip were periodically followed.

### Criteria of efficacy evaluation

(1) Excellent (Harris Hip Score: 90–100): Femoral neck fracture was healed, anatomic structure of the femoral head was recovered to normal as well as hip joint function and no pain exist. (2) Good (Harris Hip Score: 80–89): Femoral neck fracture was healed, anatomic structure of femoral head was recovered to normal, and restoration of patient's hip joint function to 70% of the level as before the fracture and no pain exist. (3) Fair (Harris Hip Score: 70–79): Femoral neck fracture was healed, the anatomic structure of the femoral head was less satisfied recovered. Restoration of hip joint function to 50% of normal with pain. (4) Poor (Harris Hip Score below 70) femoral neck nonunion, obvious collapse of femoral head appearance, obviously restricted range of hip joint movement and pain exist.<sup>[21]</sup>

### Statistical analysis

The SPSS 18.0 statistical software (SPSS Inc., USA) was used for data analysis. The measurement data were reported as the mean  $\pm$  standard deviation (SD), in-group comparison adopted pairing sample *t*-testing, and between-group comparison adopted independent sample *t*-testing. Qualitative data was expressed as frequency and percentage, and the statistical processing adopted  $\chi^2$  testing. *P* < 0.05 value was considered as statistically significant.

### RESULTS

Four of 65 patients were lost follow-up, and the follow-up rate was 93.8%, the average follow-up time was 38.7 months (range, 33–47 months). In Group A, the incision length was  $5.1 \pm 2.2$  cm, blood loss was  $84.0 \pm 13.2$  ml, and operation time was  $52.9 \pm 10.2$  min. In Group B, the incision length was  $15.4 \pm 4.6$  cm, blood loss was  $396.0 \pm 21.3$  ml, and operation time was  $116.5 \pm 15.3$  min. Nonunion occurred in 8 patients (25.2%) in Group A and 1 patient (3.3%) in Group B. ANFH occurred in 9 patients (29.1%) in Group A and 2 patients (6.7%) in Group B. Postoperative Harris Hip Score was  $89.0 \pm 5.6$  in Group A and  $95.0 \pm 4.5$  in Group B. The above index of two groups was considered statistically significant (*P* < 0.05) [Tables 2–4].

**Table 2: Comparison of observing criteria between group A and group B**

Groups	Total cases	Operation time (min)	Incision length (cm)	Blood loss (ml)
A	31	52.9 $\pm$ 10.2	5.1 $\pm$ 2.2	84.0 $\pm$ 13.2
B	30	116.5 $\pm$ 15.3	15.4 $\pm$ 4.6	396.0 $\pm$ 21.3
<i>t</i>		1.69	0.96	1.10
<i>P</i>		<0.05	<0.05	<0.05

**Table 3: Comparison of postoperative complications in the two groups**

Groups	Total cases	Nonunion		Femoral head necrosis	
		Cases	Rate (%)	Cases	Rate (%)
A	31	8	25.2	9	29.1
B	30	1	3.3	2	6.7
$\chi^2$		6.64		0.38	
<i>P</i>		0.01		0.04	

**Table 4: Comparison of Harris Hip Score in group A and group B**

Groups	Preoperative	2 weeks postoperative	<i>t</i>	<i>P</i>
A	8.9 $\pm$ 4.2	89.0 $\pm$ 5.6	0.63	<0.01
B	9.4 $\pm$ 2.1	95.0 $\pm$ 4.5	0.85	<0.01
<i>t</i>	0.71	1.06		
<i>P</i>	0.13	0.04		

### DISCUSSION

#### Characteristics of subcapital femoral neck fractures in young adults

Different from femoral neck fractures in elderly patients, because of strong external force with severe damaging of medial femoral circumflex artery and lateral femoral circumflex artery, young adults are more likely to develop to nonunion and ANFH.<sup>[9–11]</sup> Foveolar artery is barely injured, but only small area blood supply cannot prevent it.<sup>[15]</sup> For this type of fracture, accurate anatomic reduction and stable internal fixation should be achieved in principle<sup>[22]</sup> to improve blood supply as much as possible.<sup>[23]</sup> It will be very difficult to treat once nonunion, and ANFH occur, and patients maybe have to receive the second even the third surgeries.

#### Shortcomings of closed reduction and internal fixation

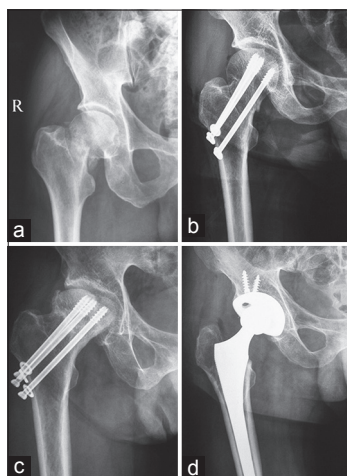
Avascular necrosis of the femoral head and nonunion are closely related to unsatisfied fracture reduction or fixation.<sup>[24,25]</sup> Even though the procedure of the closed reduction and internal fixation under the C-arm image intensifier television fluoroscopy has less traumas to the blood supply of femoral head, it is difficult to make all the patients in anatomical reduction and some of them get the unsatisfied results. (1) C-arm image intensifier television fluoroscopy just shows the plane radiograph, so it's difficult to ensure whether the screws penetrate through the femoral

head, which results in failing fixation or acetabular wear. (2) Three cannulated screws fix solidly in principle,<sup>[26]</sup> but with limited place they are easy to crash each other. (3) Using three screws require more accurate skills than using two. If the position and direction of guiding wires were frequently adjusted, the screws would get insufficiency pullout strength with excessively cannulated bone removed. (4) Three cannulated screws, which are also more likely to damage blood vessels in marrow and interfere with blood supply of the femoral head than two screws, will increase failure rate. (5) In addition, subcapital femoral neck fracture belongs to intracapsular fracture. The synovial fluid bathing the fracture may interfere with the healing process. Meanwhile, the soft tissues will grow into it. Both of them will prevent fracture from healing.<sup>[27-29]</sup> Therefore, the closed group which includes 31 cases presented higher nonunion, ANFH rate and lower Harris Hip Score (8 cases account for 25.2%, 9 cases account for 29.1% and  $89.0 \pm 5.6$  points respectively), even though better in trauma index (the incision length was  $5.1 \pm 2.2$  cm, total amount of intra-operative blood loss was  $84.0 \pm 13.2$  ml, and operation period was  $52.9 \pm 10.2$  min) [Figure 1].

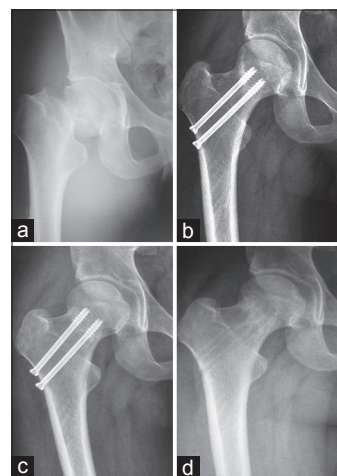
### Advantages of capsulotomy reduction and iliac crest graft and internal fixation

Compared with the closed reduction and internal fixation, capsulotomy reduction and iliac crest graft and internal fixation has the following characteristics: (1) Accurate anatomic reduction:<sup>[18]</sup> With direct visualization and sufficiently exposure, satisfactory anatomic reduction can be achieved which provides basis for fracture healing. In addition, it may open some of the retinacular vessels that are temporarily closed by kinking or stretching and may permit the reestablishment of some vascular. (2) Stable internal fixation: With direct visualization and chipped bone groove, the trace of the two or three cannulated screws crossing the

fracture line can be seen clearly, which ensure they can be placed to the best position.<sup>[30,31]</sup> The harvested bone blocks are put back, and iliac bone granules are grafted into the bone groove, which will recover local bone conditions effectively and provide mechanical support.<sup>[30]</sup> Moreover, stable fixation gives support for the new capillary around to grow into the ossiferous place which can avoid capillary fracture again. It is a solid foundation for fracture healing. (3) Iliac cancellous bone grafting: This is good for osteogenesis and fracture healing.<sup>[24]</sup> (1) Recovering normal length: It can prevent shortening deformity or joint dislocation. (2) Induction osteogenesis: Protein factors in bone tissue, such as bone morphogenetic protein transforming growth factor- $\beta$  basic fibroblast growth factor, can induce the collagen secretion from nearby tissues and promote the generation and differentiation of bone.<sup>[32-34]</sup> (3) Osteoconduction function: The bone grafted provide scaffolding for the new bone cells and collagen. (4) Accelerate vascularization: The cancellous bone has faster process of vascularization than cortical bone. It can accelerate the healing of cortical bone. Meanwhile, it can prevent soft tissue, and joint fluid enter into the fracture site which would result in delayed union or nonunion.<sup>[27-29]</sup> (4) Capsulotomy reconstructs the blood supply: Schep *et al.*<sup>[35]</sup> found that capsule in high pressure is a key factor influencing the blood supply for the femoral head capsulotomy gives chance for the peripheral capillary blood vessels to grow into the fracture end as well as reducing the pressure, so the blood supply of the fracture and femoral head would be reconstructed. (5) Joint fluid drainage: Joint fluid drains out from the capsule to avoid nonunion. So the open group including 30 cases presented lower nonunion, ANFH rate and higher Harris Hip Score (1 case accounts for 3.3%, 2 cases account for 6.7% and  $95.0 \pm 4.5$  points respectively), even though worse in trauma index (the incision length was  $15.4 \pm 4.6$  cm, total blood loss was  $396.0 \pm 21.3$  ml, and operation period was  $116.0 \pm 15.3$  min) [Figure 2].



**Figure 1:** A 30-year-old female patient was involved in a car accident which resulted in subcapital femoral neck fracture of her right leg who was treated by closed reduction and internal fixation. (a) Preoperative X-rays; (b) X-rays of half a year after operation; (c) X-rays of 1.5 years after operation showed avascular necrosis of femoral head; (d) X-rays of 2 years after operation showed femoral head replacement.



**Figure 2:** A 34-year-old male patient was involved in a car accident which resulted in subcapital femoral neck fracture of her right leg who was treated by the capsulotomy and internal fixation with iliac bone grafting. (a) Preoperative X-rays; (b) X-rays of half a year after operation; (c) X-rays of 1.5 year after operation; (d) X-rays of screw removed 1.5 years after operation.

## Tips of capsulotomy reduction and internal fixation with iliac bone grafting

(1) Fracture ends should be exposed sufficiently, which is in favor of the management of fracture and anatomic reduction. (2) Reduction shall follow the principle that the distal part of the fracture shall be anastomosed to the proximal part. But the proximal part has a wide range of mobility in subcapital fracture, it is better to fix the proximal part first with Kirschner wire if the reduction is difficult. (3) When chip the bone groove, size, depth, and position shall be paid close attention to. It shall be easy to implant the screw and not destruct the stability. (4) Proper amount of bone grafting: Less bone grafting can't achieve the goal of improving fracture healing. (5) To avoid damaging the blood supply of the femoral head, do not put the retractor on the posterosuperior part of the femoral neck when exposing the fracture.<sup>[36]</sup> (6) There is no need to suture the joint capsule where peripheral capillaries will grow into. And it also can reduce the intracapsular pressure and decrease the risk of ANFH.<sup>[37]</sup>

## CONCLUSION

Avascular necrosis of the femoral head and nonunion of the femoral head are most common and challenging complications.<sup>[17-19]</sup> The treatment of subcapital femoral neck fracture using capsulotomy and internal fixation with iliac bone grafting is inferior to the closed reduction and internal fixation in trauma degree index (incision length, total amount of blood loss and operation period.) However, it is superior to latter in clinical efficacy (Harris Hip Score) embodying good therapeutic efficacy. This method can increase fracture healing rate and decline the risks of ANFH in young adults. It is an ideal method for the treatment of subcapital femoral neck fracture.

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