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Original Article

A comparative study of long third-generation Gamma nail and long proximal femoral nail antirotation in the treatment of subtrochanteric femoral fracture

Maofeng Gao, Ruofu Zhu, Weidong Shi, Huilin Yang

Orthopaedic Institute, The First Affiliated Hospital of Soochow University, Shizi 188 St. Suzhou, China

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Abstract: Subtrochanteric femoral fracture mainly caused by high-speed and high-energy injuries, it is one of the most complex and severe fractures. In this study, 66 patients with subtrochanteric femoral fractures received operative treatment and complete follow-up. 31 patients were treated with long third-generation Gamma nail (LTGN), and 35 patients were treated with long proximal femoral nail antirotation (LPFNA). Both methods had satisfactory effects. The Harris scoring was excellent, and the rates were 90.32% (LTGN) and 91.43% (LPFNA), respectively. Three cases of nonunion (4.55%) and 5 cases of varusangulation deformity (7.58%) were detected, which occurred in patients with closed reductions. There were 8 cases (12.12%) of obvious hip pain and 12 cases (18.18%) of obvious side knee-joint pain. The comparison between the difficulty in intraoperative operation and postoperative complications did not reach statistical significance. LTGN and LPFNA were applied to subtrochanteric femoral fractures, and both methods can achieve a satisfactory therapeutic effect. However, the operation time and fluoroscopy time of LPFNA are shorter, with corresponding reductions in blood loss. The proportion of nonunion and malunion for patients suffering from open reduction is smaller than that of patients with closed reduction. Thus, this study finds that applying open reduction with a small incision and intramedullary fixation to treat complex trochanteric fracture is the more appropriate choice.

Keywords: Femur, internal fixation, subtrochanteric fracture

Introduction

Subtrochanteric femoral fracture accounts for approximately 10%-30% of hip fractures. Mainly caused by high-speed and high-energy injuries, it is one of the most complex and severe fractures, and it requires comprehensive therapy, of which surgery is the main form. With traffic accidents and injuries on construction sites increasing year by year, high-speed and high-energy injuries often cause subtrochanteric femoral fractures. In addition, subtrochanteric femoral fractures also occur in elderly patients suffering from osteoporosis. In these cases, smaller injuries can cause a complex fracture [1]. Reports in recent years suggest that subtrochanteric femoral fractures are related to the long-term administration of bisphosphonates [2]. Studies of anatomy and biomechanics indicate that the subtrochanteric femoral cortex is a weak area. Furthermore, the local muscle is strong. The traction strength of each muscle group after a fracture can lead to the displacement of fracture fragments to different positions. As such, reduction of subtrochanteric femoral fractures and maintenance after reduction pose numerous challenges. Furthermore, complications, such as nonunion and refracture, occur frequently [1, 3].

Fixation methods for subtrochanteric femoral fractures include extramedullary fixation and intramedullary fixation. With increased understanding of fixation biology and the development of intramedullary fixation technology, the use of intramedullary fixation is expected to increase [4, 5]. In intramedullary fixation, two intramedullary nails, including long Gamma nail (LTGN) and long proximal femoral nail antirotation (LPFNA), are widely used. Both methods can achieve a satisfactory therapeutic effect and reduce complications such as nonunion [6-8]. This study analyzes two intramedullary fixations for treating subtrochanteric femoral fractures, compares factors such as therapeutic effect and complication rate and provides a reference for the treatment of subtrochanteric femoral fractures.

Materials and methods

General information

From February 2006 to October 2015, 76 patients with subtrochanteric femoral fractures received operative treatment at our hospital were selected according to the inclusion criteria. Inclusion criteria: Age more than 18 years andthe diagnosis wassubtrochanteric femoral fractureless than 2 weeks of duration. Exclusion criteria were pathologic fractures, previous chemotherapy and/or radiotherapy, rheumatic diseases.

Of these patients, 8 patients were unable to return for their follow-up visits due to living a long distance from the hospital or moving elsewhere for work, and 2 patients died of severe craniocerebral trauma. In total, 66 cases are included in this study, and long third-generation Gamma nails were applied to 31 patients, and 35 patients were treated by applying long proximal femoral nail antirotation.

Operative methods are divided into the LTGN group and the LPFNA group. Our records include the patient's age, gender, cause of injuries, classification, ASA risk score, preoperative time, hospital stay, combined injuries and condition at the last follow-up. Classification of fractures was implemented according to Seinsheimer classification method. In addition, a detailed record and comparison of two treatment groups before operation was made. Follow-up visits were made at 4 weeks, 3 months, 6 months and 1 year after the date of operation, and a record was kept on the fracture healing and functional recovery processes.

Surgical technique

Patients received tibial tubercle bone traction after admission to the hospital until the day of operation. After traction for one day, anteroposterior and lateral films of the middle and upside of femur were taken at the bedside, and the condition of the fracture was observed. The traction weight in time was adjusted as necessary. Various preoperative examinations, such as routine blood work and routine blood coagulation tests, were conducted. The anesthetist evaluated the risk of operation and implemented combined intravenous and inhalation general anesthesia or continuous epidural anesthesia depending on the condition of the individual patient. An experienced medical group conducted the operation, following the documentation provided by the manufacturer.

Patients were required to lie on a traction bed. The healthy side of the body was fixed in a hip abductionposition where the body was bent at the hips and the knees. The affected limb was kept stretched, and the traction was continued to reduce the fracture. As a complex subtrochanteric femoral fracture is extremely unstable, closed reduction is difficult. To implement reduction of the fracture, direct viewing occurred through a small incision of 5-6 cm. Anatomical reduction of the cortical bone was attempted as much as possible, especially for the inside cortex with greater weight bearing.

In the LTGN group, the nail entry point was selected as the juncture 1/3 before the vertex of greater trochanter. A hollow bent sharp cone was used for the opening of the pulp chamber. An olivaryguide pin of 3 mm was used as a reamed intramedullary guide pin. A soft drill was used for the reamed intramedullary of the femoral shaft. The size increased every 0.5 mm. Distal reamed intramedullary diameter was 1 mm larger than the intramedullary nail in use. The proximal reamed intramedullary diameter was at least 2 mm larger than the intramedullary nail. The length was at least 5 cm from the fracture line. When the arm of the aiming device, the control handle and the sleeve of the aiming device were installed, we assembled the selected intramedullary nail. The intramedullary nail was inserted into the medullary cavity by hand, and we avoided using techniques such as hammering. The intramedullary nail was inserted into the deep part until the half-moon side of the tension screw hole was at the lower part of femoral neck. The channel of the tension screw was drilled by hand, and we inserted the tension screw with an appropriate length. The axis of the tension screw was located at a central position, slightly offset from the coronal plane of the femoral neck. The tension screw was at a central position in the femoral neck, as viewed by side observation. Attention was paid not to penetrate the femoral head.

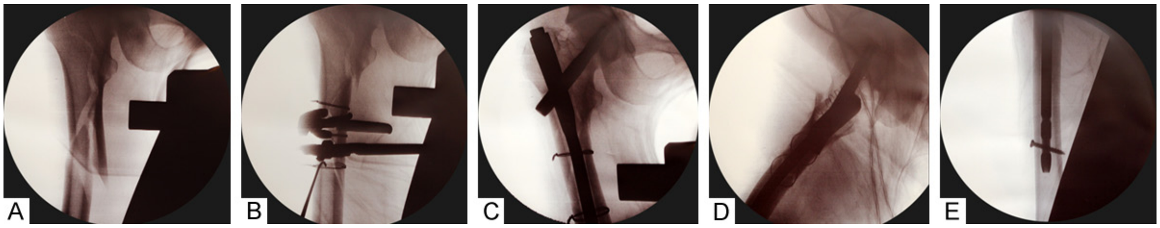

Figure 1. Male, aged 46, right subtrochanteric fracture caused by impact from a heavy weight, Seinsheimer classification type V, C-arm fluoroscopy image obtained intraoperatively. A: Closed reduction was performed on the traction bed, but the reduction of the fracture was unsatisfactory and difficult to maintain. B: The reduction was opened through a small incision and fixed with two pairs of bone forceps and two pieces of wire. C, D: No displacement of the fracture occurred during the implantation of the LPFNA, and the wire was retained postoperatively to ensure the stability of the fracture. E: The distal femur locking nail was inserted with the guidance of the aiming arm.

After screwing in the proximal femoral nail with anti-rotation, traction was loosened. Two distal femur locking nails of 5 mm were inserted with an aiming device and skin protection sleeve. The tail nail was inserted close to the proximal main nail, avoiding ingrowth of bone tissue.

In the LPFNA group, the vertex of the greater trochanter, which is near the inner edge, was selected as the nail entry point. After opening the pulp chamber with a hollow sharp cone, a guide pin of 3.2 mm was inserted, and the implement was completely reamed intramedullary along the guide pin. The PFNA main nail was gently screwed in or a hammer was used to gently knock it in. We were sure not to use excessive force in an attempt to prevent fracture displacement or iatrogenic fracture. When the position of main nail was satisfactory, an angle aiming device was installed. A guide pin was inserted at 5 mm below the femoral articular surface and in the middle of the anteroposterior and lateral femoral head. When sounding and expanding the lateral cortex, the PFNA screw blade with the required length was directly inserted. The distal femur locking nail was inserted with the guidance of the aiming arm, depending on the stability of the fracture. Static fixation was used for circular holes, and dynamic fixation was used for oblong holes. The tail cap was screwed into the top (**Figure 1**). After the wound was washed, drainage was placed, and the incision was closed layer by layer.

Postoperative period and follow-up

Antibiotics were applied to patients from half an hour before operation to 72 hours after operation. The drainage tube was kept for 24-48 h. When the drainage flow was lower than 100 ml/d, the drainage tube was removed. Patients were made to sit up from the day after operation, and functional exercise was implemented through moderate bending of the knee joint and raising the quadriceps femoris of crus. Some patients were assisted with continuous passive motion (CPM). One to two weeks after the operation, patients were instructed to get out of bed and to conduct exercise that did not include weight bearing for the affected limb by leaning on a walk-aid instrument. After leaving the hospital, the patients were reexamined every month. Patients moved from weight bearing in part to walking without a crutch, according to the growth condition of the callus on X-ray films. The time of beginning gradual weight bearing is approximately 4-6 months after operation. When adequate callus appeared on the radiograph, full weight bearing could be conducted. The standard for healing is dependent on the disappearance of the fracture line on an X-ray, lack of pain felt during bearing stress and weight bearing in the true sense.

Statistical analysis

SPSS 19 software was used to conduct statistical analysis. A t test was adopted for comparison between the two groups. A X^2 test was adopted for the comparison of categorical data. A Fisher's exact test was adopted to test data from a fourfold table, which does not conform to the X^2 test conditions. Numerical variables are expressed as $\bar{x}\pm s$. $P<0.05$ was used as the significant standard of difference.

Results

In total, 50 men and 16 women were included in the two groups of patients (**Table 1**). The

Table 1. Details of the 66 patients

	LTGN (n=31)	LPFNA (n=35)	X^2	t	P
Age (years ± SD)	59.48±15.50	58.97±16.35		0.13	0.90
Gender			0.76		0.38
Male	25	25			
Female	6	10			
Causes of injuries			1.64		0.44
Vehicle accidents	9	15			
traumas on construction site	13	12			
Domestic fall	9	8			
Seinsheimer classification			1.60		0.95
II A	2	2			
II B	2	5			
II C	4	5			
III A	10	12			
III B	5	4			
IV	4	4			
V	4	3			
Duration to surgery (days ± SD)	4.52±1.20	4.11±1.57		0.91	0.36
ASA score			2.34		0.31
1	3	3			
2	12	20			
3	16	12			
Combined injuries			4.67		0.46
Closed cerebral trauma	2	3			
Rib fracture	4	1			
Spinal fracture	1	2			
Pelvic fracture	2	1			
Fracture of tibia and fibula	0	1			
Splenic rupture	0	1			
Duration of hospitalization (days ± SD)	15.11±2.89	14.92±2.54		0.89	0.40
Harris hip score					
Excellent	19	26			
Good	9	6			
Poor	3	3			

average age was 59.25. Causes of injuries include 24 cases of traffic accident injuries, 25 cases of traumas on a construction site and 17 cases of injuries from falling. There were 18 cases, which included other injuries during admission to the hospital. These cases comprised 5 cases of closed cerebral traumas, 5 cases of rib fractures, 3 cases of spinal fractures, 3 cases of pelvic fractures, 1 case of fracture of tibia and fibula and 1 case of splenic rupture. For each preoperative evaluation of the two operation groups, there was no statistically significant difference. The average preoperative time was 4.25 days. The average hospital stay was 15.04 days. Post-traumatic function scoring method for the Harris hip joint was used, and patients were scored as excellent, good or poor. Scoring is composed of measurements of pain, joint function, joint motion and walking ability, with 100 points in total. The classification groups used were as follows: 90-100 points are excellent; 80-89 points are good; 70-79 points are middle and fewer points than 70 are poor. The rate of patients with excellent and good scores in the LTGN group was 90.32%, and the excellent and good rate in the LPFNA group was 91.43%. The functional recovery of the patients after the operation all

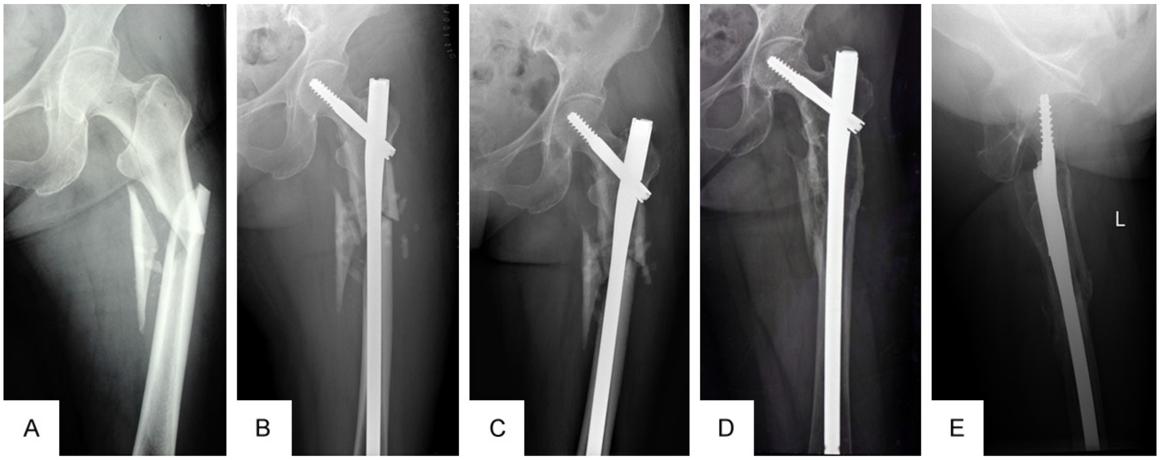

Figure 2. Female, aged 63, left subtrochanteric fracture complicated with femoral neck fracture caused by car accident. A: Seinsheimer classification type IV. B: The internal fixation technique of LTGN was employed after the opening of fracture reduction. Postoperative anteroposterior film revealed the imperfect reduction of medial cortex and allogeneic bone planted intraoperatively. C: Review of the anteroposterior X-ray film two months after the operation showed no significant callus growth. We asked the patient to walk with crutches and to practice only partial weight training with the injured limb. We instructed the functional exercise in the monthly follow-up. D, E: Anteroposterior and lateral X-ray film one year after the operation showed satisfactory position of the internal fixation, continuous callus growth, and a healed fracture.

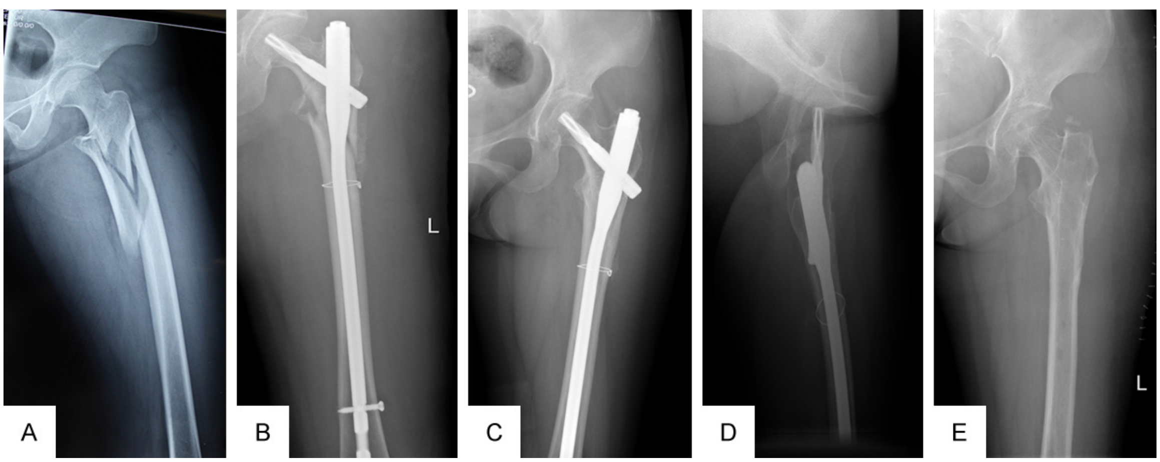

Figure 3. Female, aged 40, left subtrochanteric fracture caused by car accident. A: Preoperative anteroposterior X-ray film showed Seinsheimer classification type III B. B: The internal fixation technique of LPFNA was employed after the opening of fracture reduction, anteroposterior X-ray film was obtained postoperatively. C, D: Anteroposterior and lateral X-ray film one year after the operation indicated disappearance of fracture line, continuous callus growth, and a healed fracture. E: Anteroposterior X-ray film obtained after the removal of internal fixation showed that the osteophytes at the apex of the greater trochanter were chiseled.

attained a satisfactory therapeutic effect. The difference between the two groups did not reach statistical significance. Typical cases are shown in **Figures 2** and **3**.

Between the two groups during surgery (**Table 2**), there were 60 cases (90.91%) of general anesthesia, 38 cases of open reduction (18 cases of LTGN and 20 cases of LPFNA) and 28 cases of closed reduction (13 cases of LTGN and 15 cases of LPFNA). Open reduction accounted for 57.58% of the total. The difference between the two groups did not reach statistical significance. Operation time and intraoperative fluoroscopy time in the LPFNA group was shorter than that of the LTGN group ($P<0.05$). Intraoperative blood loss and postoperative drainage flow in the LPFNA group was lower than that of the LTGN group ($P<0.05$).

No cases of intraoperative death or anesthetic accident occurred in either of the two groups.

Table 2. Operative details of the patients treated by LTGN and LPFNA

	LTGN (n=31)	LPFNA (n=35)	X^2	t	P
Anesthesia			0.00		1.00
General	28	32			
Spinal	3	3			
Reduction mode			0.01		0.94
Open	18	20			
Close	13	15			
Duration of operation (min ± SD)	106.22±28.36	91.71±30.32		2.00	0.04
Fluoroscopy time (min ± SD)	148.26±36.28	128.29±39.96		2.11	0.03
Blood loss (ml ± SD)	214.36±54.69	184.29±61.32		2.09	0.04
Amount of post-operation (ml ± SD)	136.98±31.49	120.29±34.59		2.04	0.04

Table 3. Intra-operative difficulties

	LTGN (n=31)	LPFNA (n=35)	P
Difficulty in reduction	5	7	0.68
Transferred to open reduction	5	5	1.00
Nail insertion	1	1	0.39
Distal locking	4	5	0.54

Table 4. Postoperativecomplications

	LTGN (n=31)	LPFNA (n=35)	P
Nonunion	2	1	0.22
Varus angular deformity	2	3	0.59
Hematoma	4	4	1.00
Superficial infection	0	1	
Pulmonary infection	2	3	0.55
Urinary infection	3	4	0.61
Cerebralinfarction	0	1	
Deep venous thrombosis	0	1	
Hip and thigh pain	4	4	1.00
Knee joint pain	5	7	0.97

There were 16 cases (51.61%) of the LTGN group and 19 cases (54.29%) of the LPFNA group (**Table 3**). The difference of difficulty in operation between two groupsdid not reach statistical significance. There were 12 cases (5 cases of LTGN group and 7 cases of LPFNA group) with difficulty in intraoperative reduction, which were all unstable fractures. Although the traction bed was adopted for reduction, for muscular traction in each direction of a complex fracture, intraoperative reduction is more difficult compared to intertrochanteric fracture and femoral neck fracture. Closed reduction requires repeated fluoroscopy and position adjustment. There were 10 cases (5 cases of each group) that were transferred to open reduction of small incision for difficulty in closed induction. Implement fixation was conducted with the assistance of bone holding forceps and steel wires. Once in reduction and stable, medulla expansion and nailing was implemented. The bone-holding forceps were then removed. If the fracture is unstable, 1-2 steel wires may be required to maintain its position. When the fracture is stable, the steel wires can be removed. Periosteum stripping should be decreased to the minimum extent in the whole process. Difficulty in inserting main nail mainly occurs with closed reduction. Thus, intraoperative fluoroscopy time will be increased as only intraoperative fluoroscopy can guarantee fracture is not displaced during medulla expansion and main nail insertion. As LTGN and LPFNA are both long instruments, which can increase the difficulty of inserting distal locking nails, the LTGN group had 4 cases, and the LPFNA group had 5 cases.

There were 3 cases (4.55%) of non-union that were discovered during follow-up visits 3 months after operation (**Table 4**). However, refracture or severe angular deformity did not occur. Autogenous iliac bone grafting was implemented for two cases. Internal fixation devices were not changed, and postoperative fracture healing was good. There were 5 cases (7.58%) of varusangulation deformity. Among these cases, the LTGN group had 2 cases (6.45%), and the LPFNA group had 3 cases (8.57%). One case of deep venous thrombosis occurred in the LPFNA group, which was improved through emergency intervention thrombectomy and filter screen treatment. In the period of follow-up visits after two months, there were 27 patients suffering from serious local pain and serious knee joint pain, which accounted for 40.9% of the total.

Discussion

Subtrochanteric femoral fracture refers to the fracture between the femoral lesser trochanter and the isthmus of the femoral shaft. This is the fracture that occurs within the range from lesser trochanter to the position 5 cm below it, accounting for approximately 10%-30% of hip fractures [9]. Furthermore, according to recent reports, atypical subtrochanteric femoral fracture caused by drugs is increasing gradually [2]. There is a bimodal distribution to these injuries. Approximately one third of fractures occur in patients younger than age 50 years, and two thirds of fractures occur in the older population [10]. For young patients, fractures are usually caused by high-energy and high-speed injuries, such as a traffic accident, falling from a high height and injury caused by a heavy object. For elderly patients, fractures can be caused by a low-energy injury, such as fall. Furthermore, the condition of young patients who suffer from subtrochanteric femoral fractures is often more complex [1, 10, 11]. For intense violence injuries and muscular traction strength, the degrees of displacement of the fracture become larger, and the involved range is much wider. Thus, operation difficulty is increased [9]. The purpose of the treatment of a subtrochanteric femoral fracture is to make patients walk earlier and to avoid complications caused by long-term bed rest. The purpose is the same as that of intertrochanteric fracture. However, compared with intertrochanteric fracture, one important point is that the healing of a subtrochanteric fracture occurs more slowly and with more difficulty. Furthermore, delayed fracture healing, nonunion and malunionoccur more easily [12-14]. To reduce the occurrence of these serious consequences, bed rest must be long appropriately. Patients with more stable types of fractures can walk with the help of a walker or crutch. For complex types of fractures, only part of the affected limb can bear weight. When there is certain callus, full weight bearing can be implemented. Thus, compared with other peritrochanteric fractures, the therapeutic scheme of subtrochanteric femoral fracture must be tailored to the individual. The frequency of follow-up visits after the operation must also be increased.

Fixation methods for subtrochanteric femoral fractures include intramedullary fixation and extramedullary fixation. According to reports, both methods achieve the satisfactory therapeutic effect [15-18]. Although not based on scientific evidence from controlled randomized trials, there has been a gradual change in the operative techniques used to stabilize these fractures, from the extramedullary devices to the current widespread use of intramedullary nails. Long Gamma nail and long PFNA are intramedullary fixation instruments, which are applied to subtrochanteric femoral fractures in China. In this study, long Gamma nail and long PFNA applied to subtrochanteric femoral fractures are compared. The purpose of this study is to look for a more suitable method for treating subtrochanteric femoral fractures and to provide a reference for clinical diagnosis and treatment work.

Based on the mature application of the third-generation Gamma nail (TGN) in the treatment of intertrochanteric fractures, long third-generation Gamma nail (LTGN) can also be used for the treatment of a subtrochanteric femoral fracture. Furthermore, LTGN can achieve a satisfactory effect [19, 20]. It combines dynamic hip and intramedullary nail technology and relies on a thick intramedullary nail to fix the fracture and recover the normal angle of the hip joint. The fixture is in the medullary cavity, and it is closer to weight line. With the long intramedullary nail system (the lengths of the main nails are 340 mm, 360 mm and 380 mm), the normal neck-shaft angle and the front inclination angle are maintained to ensure that there is no angle or rotation displacement at the fracture. The advantages of general Gamma nail and femoral nail are combined. Sufficient medulla expansion is required to reduce strong distal stress or the potential risk of fracture, which can be caused by Gamma nail, so the nail complies more with curve of the femoral medullary cavity. The distal end of the nail extends beyond the fracture line by at least 5 cm to prevent intraoperative and postoperative refracture or unstable fixation [21].

The PFNA system was designed through the improvement of PFN by AO/ASIF in 2004. Compared with Gamma nail, PFNA also has the advantage of intramedullary fixation. Furthermore, the screw blade, which is fixed from femoral head to the neck, has a unique advantage. Drilling in advance is not needed in the driving process for this special design. Instead, it can be directly driven into the femoral head and neck to compact the cancellous bone and to reduce the loss of cancellous bone. Thus, the resultant force of the screw blade in the femoral head and neck is increased. Anti-rotation and pulling resistance effects become much stronger. LPFNA is the special model that is used for subtrochanteric femoral fractures, which has lengths of 340 mm, 380 mm and 420 mm. Its efficacy in treating fracture at the upper-middlelong segment has been already shown [6, 21, 22].

In this study, operation time, intraoperative fluoroscopy time, intraoperative blood loss and postoperative drainage flow are compared to evaluate the wound degree of the two methods. The result indicates that the operation time and fluoroscopy time of the LPFNA group is much shorter and the intraoperative blood loss and the postoperative drainage flow are also less. This difference has statistical significance ($P<0.05$). Operation time is also related to the fracture classification and mode of reduction. Open reduction does not prolong the operation time. Another aspect influencing the operation time is the implantation of the distal locking nail. As they are all long instruments, implantation of the distal locking nail is more difficult compared with that of the common nail [6]. Thus, we tried to use less pressing strength when screwing in the distal locking nail as far as possible so that the bit can be naturally screwed in the bone along the path of the aiming device.

Occurrences of difficulty during operations repairing subtrochanteric femoral fractures are more frequent than those repairing peritrochanteric fractures. In the operations presented in this study, there were 12 cases of difficulty in reduction because the fracture condition was serious, and traction from many directions appeared. Although a traction bed was used, reduction was still difficult. There were 10 cases of closed reduction failure, which were transferred to open reduction. Closed reduction of subtrochanteric femoral fracture is much more difficult than that of intertrochanteric fracture, which occurs more easily in elderly patients suffering from osteoporosis. In considering how to respond to difficulty in reduction, the surgery needs to be changed to open reduction and limited incision of the lateral femur. Furthermore, we attempted to stripthe periosteum to the minimum extent. If we deliberately implemented nailing in a closed reduction for a closed fracture, soft tissue injury at fracture was often aggravated. It was also difficult to obtain a satisfactory effect in the fracture contraposition. In addition, the incidence of nonunion and malunion was likely to be increased [6, 7]. To prevent the frequent occurrence of fracture displacement during marrow expansion and main nail insertion, our approach was to adopt limited open reduction bone-holding forceps for fixation or to adopt wire binding for fixation, and when the fracture is firmly in place, begin nailing.

Kennedy [6] et al. used cerclage wiring and intramedullary nail fixation on 17 cases of Zickel 1B subtrochanteric femoral fracture. All patients achieved satisfactory results, except for one case in which nonunion occurred due to too many wires. Thus, the method of first using fixation with one steel wire (two at most) and then using intramedullary fixation is recommended for treatment of complex subtrochanteric femoral fracture. Afsari A et al treated 44 cases of subtrochanteric femoral fractures with clamp-assisted reduction and intramedullary nail fixation techniques, which resulted in excellent reductions and a high union rate. They stress that careful attention to detail is important in performing these maneuvers, with a special emphasis on minimal soft-tissue disruption [7]. A biomechanics study of combining cerclage wiring and a Gamma3 nail in the repair of a subtrochanteric femoral fracture by Müller T et al indicates that the wire cerclage is able to avoid complications such as varus deformation and cutout in subtrochanteric fractures and preserves the biomechanically important medial buttress [23]. Our findings agree with opinion presented in that work. With a limited opening, a small incision with a length of 5-6 cm was made, and the fracture is reduced with minimal stripping of the periosteum, especially important for the medial cortex, which bears the maximum compression strength of the human body. When stable fixation was reached after cerclage wiring, maneuvers such as nailing become more convenient. After implantation of intramedullary nail, if the fracture is in a stable position, steel wire can be removed. Among cases of this group, 3 cases of delayed fracture healing were detected among those with closed reduction. Thus, we believe in the necessity of implementing open reduction of limited incision for complex subtrochanteric femoral fractures.

Complications such as intraoperative death, anesthetic accident, deep infection, breakage of internal fixation and refracture did not occur to patients in this group. In the two groups, there were 3 cases (2 cases in the LTGN group and 1 case in the LPFNA group) non-union was detected at follow-up visits 3 months after operation. For this condition, traditional method is to repeat the operation, changing the intramedullary nail to a much thicker model and to conduct bone grafting at the fracture [13]. We implemented autogenous iliac bone grafting, postoperative local immobilization and close follow-up visits for all 3 cases. After growth of the callus, we gradually implemented weight bearing of the affected limb. Fracture healing was good at the last follow-up visit. These results suggest that if nonunion is discovered at an early stage and refracture or angulation deformity does not occur, simply taking autogenous iliac bone grafting can lead to fracture healing. Furthermore, trauma and operation expenses can be reduced.

Subtrochanteric femoral fracture is at the area of high stress concentration, and it can easily lead to comminuted fracture. This area is composed of hard cortical bone, and fracture healing time is long. Thus, the failure rate of internal fixation is as high as 20% [12]. Li [3] et al. conducted an analysis on the treatment of 46 cases of subtrochanteric femoral fracture. They found that reconstructing the continuity and integrity of the medial cortex in subtrochanteric fractures can reduce the failure of internal fixation and the incidence of nonunion. The five cases of varus deformity in this study include 2 cases of III A type, 2 cases of IV type and 1 case of V type. Comminuted fracture of the femoral medial cortex and the failure of complete anatomical reduction during operation are present in these three types of fracture. Thus, under the pressure of a bending load, fracture varus deformity will occur [12]. Attempting weight bearing under unprotected conditions too early may also lead to fracture varus deformity. Thus, full weight bearing can only be implemented when the growth of certain callus can be observed on X-ray films.

There were 5 cases of pneumonia and 7 cases of urinary system infection in the two groups, which were related to multiple traumas and long-term bed rest. Although patients with trauma can sit up on the next day after operation, release from bed rest occurs relatively late. The incidence of these two complications is increased to some extent. There was 1 case of deep venous thrombosis in the LPFNA group, which was transferred to the intervention therapy department to receive a thrombectomy and filter screen treatment. There were 8 cases (12.12%) of postoperative hip and thigh pain. However, an abnormality, such as removal of internal fixation or femoral head necrosis, was not discovered on the radiographs. Some studies think that this pain is related to injury to the gluteus medius during implantation of the intramedullary nail and mechanical compression of the intramedullary fixation instrument [5, 24]. It may also be related to soft tissue injury occurring at that time [11, 14]. There were 12 cases (18.18%) of knee joint pain in the follow-up period. The degree of pain is so intense that we are puzzled. Some patients have to take medicine to control the pain. Under these condition, the quality of life of these patients is negatively influenced. As tibial tubercle traction was used in this group, we think knee joint pain may be caused by the long period of tibial tubercle traction before operation. Extensive tibial tubercle traction will lead to chronic injury of knee joint ligament. Thus, it is important to shorten time spent in preoperative traction and to exercise the knee joint soon after operation.

Conclusion

Long Gamma nail and long PFNA have high rates of success and minimal rates of complications in the repair of subtrochanteric femoral fractures. In comparing the two groups, we found that intraoperative trauma of LPFNA group is less than that of LTGN. Furthermore, the operative procedure is much simpler. Closed reduction can further reduce damage to the periosteum and increase the incidence of nonunion compared with limited open reduction. This contradicts the prevailing views held in the past. We propose that applying a long intramedullary fixation instrument to treat subtrochanteric femoral fractures with limited open reduction is a more reasonable therapeutic method. To achieve a good therapeutic effect, preoperative preparation, functional rehabilitation exercises pre-operation and post-operation and the preparation of an individual comprehensive therapeutic plan for each patient are necessary.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Weidong Shi, Orthopaedic Institute, The First Affiliated Hospital of Soochow University, Suzhou 215000, China. Tel: 0086-512-67780111; Fax: 0086-512-67781165; E-mail: 228793567@qq.com

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