Greater trochanter of the femur (GTF) *vs.* proximal femoral nail anti-rotation (PFNA) for unstable intertrochanteric femoral fracture

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Abstract. – OBJECTIVE: We aim to compare the effects of stem type prosthesis implantation of the greater trochanter of the femur (GTF) and proximal femur nail anti-rotation (PFNA) for treatment of unstable intertrochanteric femoral fracture.

PATIENTS AND METHODS: We retrospectively analyzed 108 patients with unstable intertrochanteric femoral fracture, including 61 cases who underwent GTF treatment and 47 cases who underwent PFNA treatment. We compared the operative time, blood loss, clinical healing and bone healing time, partial weight bearing and full weight bearing time, Harris hip score, rate of complications and rate of adverse reactions of implantation materials.

RESULTS: Comparing the two groups in terms of operative time and blood loss, the differences were not statistically significant (p>0.05). The clinical and bone healing time in the GTF group were shorter than those in the PFNA group and the differences were statistically significant (p<0.05). The partial and full-weight bearing times in the GTF group were significantly shorter than those in the PFNA group. The Harris scores, one and six months after surgery, were higher than those in the PFNA group and by comparing the scores after 12 and 18 months, the differences were not statistically significant (p>0.05). The rate of complications and rate of adverse reactions of implantation material in the GTF group were lower than those in the PFNA group and the differences were statistically significant (p<0.05).

CONCLUSIONS: GTF implantation is more advantageous in functional improvement and in reducing complications compared with PFNA for the treatment of unstable intertrochanteric femoral fracture.

Key Words

Stem type prosthesis of greater trochanter of the femur, Proximal femoral nail anti-rotation, Intertrochanteric femoral, Unstable fracture, Bone healing; Full weight bearing, Harris score of hip joint, Complication.

Introduction

Unstable intertrochanteric femoral fracture, such as comminuted fracture and wedge fracture, often occur in older people with osteoporosis, with an incidence rate of about 12.4-23.1%. It may also occur in younger people, usually as a result of traffic accidents or injury from falls, with an occurrence rate of about 5.6%[1]. The clinical treatment is closely related to the anatomical structure of the hip joint, and rich blood supply is beneficial for clinical healing[2]. Current treatment mainly includes extramedullary fixation systems (such as dynamic hip screw, dynamic condylar screw and percutaneous compression plate), intramedullary systems (such as proximal femur nail anti-rotation (PFNA) and Gamma nail) and artificial thigh bone replacement. It is generally believed that intramedullary fixation is more consistent with the vertical line structure of the human body and can promote bone healing[3]. Joestl et al[4] propose that phase I artificial thigh bone replacement can shorten the early weight bearing and functional exercise times. The present work compares and analyzes the effects of implantation of stem-type prosthesis of the greater trochanter of the femur (GTF) and PFNA for treatment of unstable intertrochanteric femoral fracture, thereby providing a reference for clinical treatment.

Patients and Methods

Inclusion Criteria for the Patients Enrolled in the Study

We diagnosed 108 patients with unstable intertrochanteric femoral fracture in our hospital from June 2013 to June 2015 and they were retrospectively analyzed, including 61 patients who underwent GTF treatment and 47 patients who

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underwent PFNA treatment, all of whom had history of trauma, hip pain, greater trochanter tenderness, external rotation deformity of the lower limbs and other symptoms. All patients had surgical indications and no significant contraindications. Unstable intertrochanteric femoral fracture was verified through X-ray or computed tomography (CT) examination. This study was approved by the Ethics Committee of Liaocheng People's Hospital and Liaocheng Clinical School of Taishan Medical University. Signed written informed consents were obtained from all participants before the study.

Exclusion Criteria

The following conditions were excluded: history of previous femur or hip trauma; surgery and radiation; pathological fractures caused by malignant tumors; severe osteoporosis; combined severe nerve, blood vessel and muscle lesions; poor prognosis; surgical failure; poor compliance; and incomplete medical history.

The GTF group included 39 males and 22 females, aged 56-78 years old with mean age of 65.7 ± 12.3 years. The disease course was 1.0 h-2.0 d with mean time of 21.4 ± 5.5 h. There were 28 cases with Evans type III fractures, 22 cases with type IV and 11 cases with type V. The PFNA group included 26 males and 21 females, aged 53-77 years old with mean age of 65.5 ± 13.4 years. The disease course was 1.5 h-2.5 d with mean time of 21.8 ± 5.9 h. There were 20 cases with Evans type III fractures, 19 cases with type IV and eight cases with type V. By comparing gender, age, disease course and fracture type between the two groups, the differences were not statistically significant ($p>0.05$).

Procedures for GTF Implantation

The main steps of GTF implantation were as follows. An appropriate GTF prosthesis (Taiwan United Company, Taipei, Taiwan) was selected among three specifications, 120 mm, 160 mm and 204 mm. Patients were made to lie in a lateral position under general anesthesia, and the surgical zone was disinfected. A posterolateral approach was taken. An incision of about 12 cm was made to expose the short extractor group. The joint capsule was cut to prepare for reconstruction and effusion in the articular cavity was cleared. The intertrochanteric fracture site and basilar femoral neck were revealed. Osteotomy was conducted vertically above the lesser trochanter and longitudinal osteotomy was conducted inside the greater trochanter. The femoral head was removed and the marking bone block was retained. The acetabulum and surrounding tissues were trimmed, and careful attention was paid to preserve the important ligaments to facilitate anatomic reduction. A cancellous bone graft was made in the femoral head if there were any bone defects. An intramedullary broacher was used to expand the marrow cavity to the appropriate size. Next, we tested the mode and restored the fracture. Its stability was tested. The length of both lower limbs was compared, and the size of the inner ball head was adjusted according to the situation. Diseased limbs were made to act, such as by hip flexion, internal and external rotation, and other movements. Cases of dislocation were examined, and the front prosthetic inclination angle was adjusted if necessary. After the bone marrow cavity was thoroughly washed, it was filled with an embolism. A bone cement injection gun was used to uniformly inject cement into the marrow cavity. The GTF stem was installed under the premise of maintaining a certain front inclination angle. Bone cement setting time was observed. The joint was reduced after bone cement solidification. The adaption of the prosthesis including joint stability, fit tightness and ensuring equal length of both lower extremities was conducted, the greater trochanter fracture block was reduced, and a wire and non-absorbable line was used for bonding reconstruction from the tuberosity stem hole. Satisfactory reduction was confirmed at the fracture site. Following rigid fixation, bleeding was fully stopped and repeated washing was carried out. A drainage tube was placed and fixed with a silk thread and sutured layer by layer, auxiliary materials were placed and bandaging was carried out (Figure 1A).

Procedures for PFNA Surgery

PFNA surgery was conducted as follows. Three specification types of PFNA (Wego Company, Weihai, Shandong Province, China) were selected i.e. common type (240 mm), short type (200 mm) and lengthened type (300-420 mm). Anesthesia, position and disinfection were the same as above. Patients were placed in the supine position on the traction bed, inclined by 10-15° towards the affected side. C-arm fluoroscopy was used to determine the direction of displacement, and displacement distance of the fracture end. The traction force was adjusted according to the specific circumstances in order to avoid damage to blood vessels and muscle. If it was difficult to reduce, a 5 cm long incision was made on the proximal end of the limb at about 4 cm above the greater trochanter. We exposed the greater trochanter vertex position and determined the entry point (which was 1/3 away from the outer vertex position of greater trochanter). A guide needle was inserted from the entry point along the longitudinal axis of the body. Fluoroscopy was used to confirm the guide needle was in the proper position. The opening was expanded and the marrow cavity was expanded along the direction of the guide needle. The marrow cavity at the proximal end was expanded to 17 mm (the marrow cavity cannot be expanded at the distal end). The intramedullary nail and stem were connected. The intramedullary nail was rotated and mounted, and fluoroscopy was used to confirm the satisfactory position and to evaluate the femoral neck front inclination angle, and then an impact guide needle was inserted into the bone from outside to inside. Fluoroscopy was used for examination (the distance from the articular surface of the femoral head should be greater than 0.5 cm). A screw blade was installed after confirming the suitable depth. The nail was placed at the distal end, and satisfactory reduction at the fracture site was reconfirmed. Following rigid fixation, bleeding was fully stopped, washed repeatedly, and a drainage tube was placed and fixed with a silk thread. It was sutured layer by layer. Auxiliary materials were placed and bandaging was carried out (Figure 1B). Patients were made to lie on their backs for 6 h without pillows after surgery. A continuous infusion micro-analgesia pump

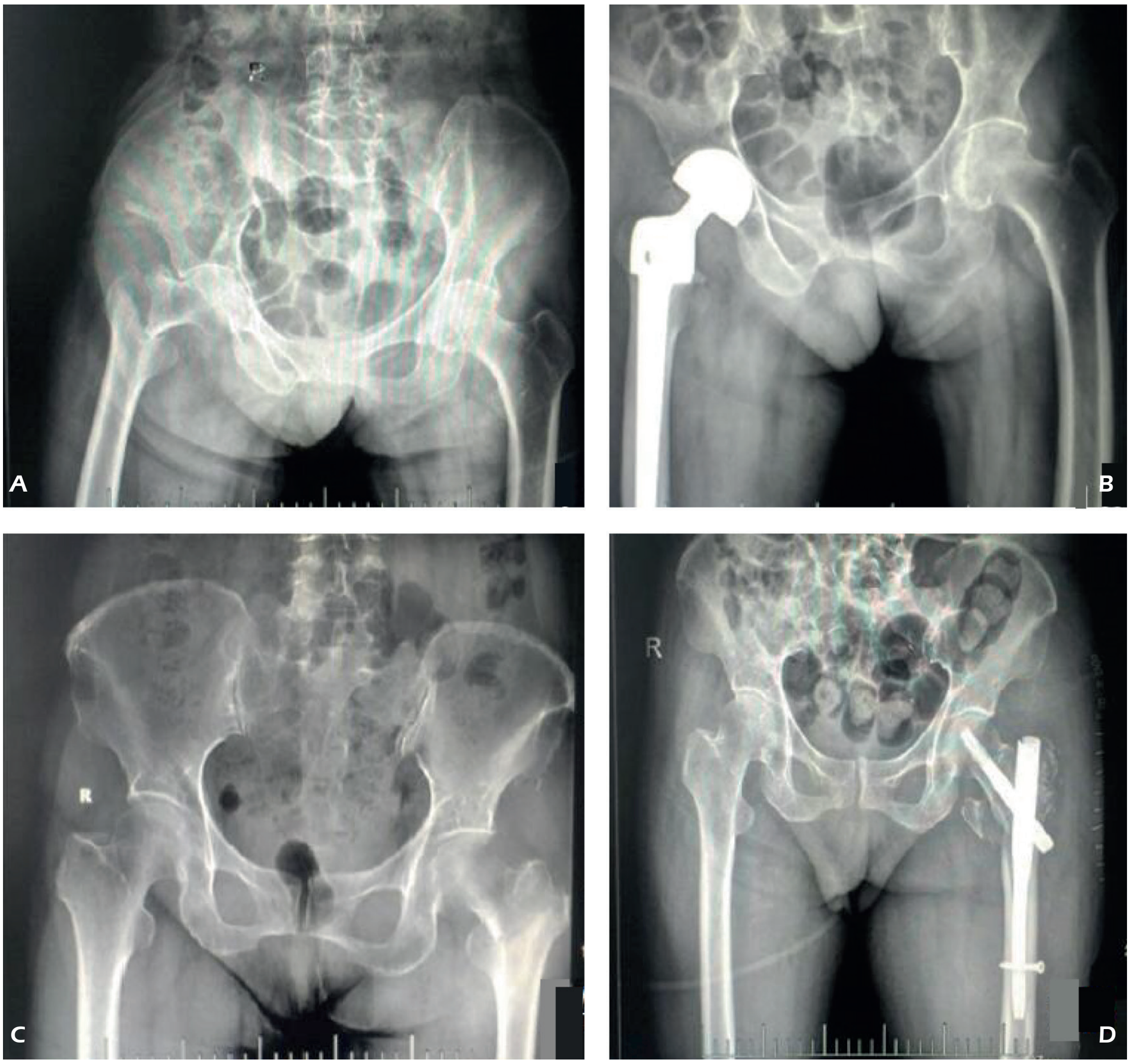

Figure 1. Preoperative and postoperative Schematic diagram for GTF implant and PFNA surgery. **A-B**, GTF implantation. **C-D**, PFNA surgery.

was used for analgesia. Patients were made to wear T-type shoes by diseased limbs. Measures were taken to prevent infection, anticoagulation and thrombosis. Drainage tubes were removed within 24-48 h. Vital signs were monitored. Patients were encouraged to perform early functional exercises, including active flexion and extension of the ankle and foot of the diseased limb, and other functional exercises.

Observational Indicators

The operative time, blood loss, clinical and bone healing times, partial weight and full weight bearing times, Harris hip scores, rate of complications and rate of adverse reactions the of implant material, were compared. The clinical healing criteria were: 1. No local tenderness, 2. No local vertical percussion pain, 3. No local abnormal movement, 4. Showing blurred fracture line through X-ray and continuous callus passing through fracture line, 5. Limbs can withstand the following after lifting by external fixation: the upper limbs can bear a weight of 1.0 kg for one minute if extending forward horizontally; patients can walk for more than 30 m and can last for three minutes without the help of crutches, 6. Observe those without deformations on the fracture within 2 weeks. Bone healing criteria: 1. Achieved clinical healing, 2. X-ray showing: the callus has passed through the fracture line, the fracture line disappeared or nearly disappeared. Harris hip score included degree of pain, life skill, ability to walk, joint deformity and four activity examinations. Higher score indicated better functional recovery. The complications included coxa vara, re-fracture of the proximal end of the femur, osteonecrosis of the femoral head, broken nail, infection, fracture dislocation, loose hip screw, displacement, plate fracture, and no fracture healing. The adverse reactions of implants included local reactions (such as local inflammation, irritation, allergic reaction, tissue proliferation, material corrosion, wearing, biological degradation, and material degradation) and systemic reactions (such as systemic inflammation, allergy, cytotoxicity, coagulation changes, complement activation, tumor formation and immune response). The follow-up was until January 2016, with a mean follow-up of about 18 months.

Statistical Analysis

Statistical Product and Service Solutions (SPSS) 19.0 statistical software (IBM, Armonk, NY, USA) were used for data entry and analysis. Quantitative data are presented as mean ± standard deviation. Independent sample *t*-test was used for comparisons between the two groups. Number of cases or percentage (%) were used to express qualitative data, and χ^2-test was used for comparisons between the two groups. $p<0.05$ indicated that the difference was statistically significant.

Results

Comparison of Operative Time, Blood Loss, Clinical Healing Time and Bone Healing Time

Comparing operative time and blood loss between the two groups, the differences were not statistically significant ($p>0.05$). The clinical and bone healing times in the GTF group were shorter than the in PFNA group, and the differences were statistically significant ($p<0.05$) (Table I).

Comparison of Partial Weight-Bearing Time, Full Weight-Bearing Time and Harris Hip Scores

The partial weight-bearing and full weight-bearing times in the GTF group were significantly shorter than the PFNA group ($p>0.05$). The Harris hip scores within 1 and 6 months after surgery were higher in the GTF group than in the PFNA group ($p<0.05$). By comprising the scores within 12 and 18 months, the differences were not statistically significant ($p>0.05$) (Table II).

Table I. Comparison of operative time, blood loss, clinical healing time and bone healing time.

Group	Operative time (min)	Blood loss (mL)	Clinical healing time (d)	Bone healing time (d)
GTF	75.6±13.2	456.3±33.4	12.4±3.3	25.6±4.2
PFNA	74.3±12.5	427.8±32.9	18.6±3.4	34.7±4.5
t	0.648	0.724	6.529	6.487
p	0.923	0.818	0.034	0.036

GTF: Greater Trochanter of the Femur; PFNA: Proximal Femoral Nail Anti-rotation.

Table II. Comparison of partial weight bearing, full weight-bearing times and Harris hip scores.

Group	Partial weight bearing time (d)	Full weight bearing time (d)	Harris hip score			
			1 month after surgery	6 months	12 months	18 months
GTF	3.6±0.7	17.7±2.8	67.8±5.2	82.6±6.3	86.9±7.2	91.2±7.3
PFNA	8.2±1.5	26.3±2.9	60.5±5.4	75.5±6.4	84.2±7.5	90.6±7.6
t	9.627	7.825	7.201	7.632	0.864	0.732
p	<0.001	0.024	0.027	0.025	0.754	0.668

GTF: Greater Trochanter of the Femur; PFNA: Proximal Femoral Nail Anti-rotation.

Comparison of the Rate of Complications and Rate of Adverse Reactions of Implant Materials

There was 1 case with coxa vara in the GTF group, 1 case with femoral head necrosis, 1 case with infection, 1 case with fracture end dislocation, 1 case with no fracture healing and 1 case with another complication. The total complication incidence rate was 9.8%. In the PFNA group, there were 2 cases with coxa vara, 2 cases with femoral head necrosis, 3 cases with infection, 4 cases with broken nail, loose hip joint screw, displacement or withdrawal, and 1 case with no fracture healing. The total complication incidence rate was 25.5%. In the GTF group, the complication incidence rate was lower than in the PFNA group and the difference was statistically significant (χ^2=4.709, p=0.030). For adverse reactions of implant materials in the GTF group, there were 2 cases with local reactions, 1 case with systemic reaction, and overall incidence rate was 4.9%. There were 6 cases with local reactions in the PFNA group, 3 cases with systemic reactions and the overall incidence rate was 19.1%. In the GTF group, the adverse reaction rate was lower than in the PFNA group and the difference was statistically significant (χ^2=5.443, p=0.020).

Discussion

Currently, there are several surgical methods for treatment of unstable femoral intertrochanteric fractures. The indications are slightly different and the clinical effects have individual merits. This is a dilemma for clinical treatment. A perfect surgical method has yet to emerge. The advantages of PFNA surgery include: 1. The spiral blade is very close to the bone substance, which enhances stability, and prevents both rotation and varus deformity[5]; 2. The large knife face on the hip screw terminal compresses the surrounding bone as much as possible, especially in the case of osteoporosis, and it has a better grip force[6]; 3. The main nail has a 6° transverse section angle, facilitating insertion from the top of the greater trochanter[7]; 4. A locking hole on the distal end made static or dynamic locking possible[8]. PFNA-II has been designed for the anatomical characteristics of the proximal femurs of Asian people, which is advantageous over PFNA-I in surgical operation and fixation stability[9]. Previous studies[10] indicate that, after application of PFNA surgery for treatment of patients with osteoporotic unstable intertrochanteric fracture, during the roughly 6-month follow-up, spiral blade displacement rarely occurred, and 62.4% of patients recovered to the pre-fracture functional status. In a comparative meta-analysis of PFNA and dynamic hip screw, it was shown that PFNA was more advantageous for blood loss[11], operative time, fixation failure rate and rate of complications. In 2014, two randomized controlled studies found that extramedullary fixation was more suitable for unstable intertrochanteric fractures than intramedullary fixation. However, regarding clinical treatment, the study on intertrochanteric fractures was more fragmented, mostly including clinical observations in single centers, small samples or by retrospective contrastive analyses on differences in the effect between the two surgical methods. The ultimate conclusion was slightly weak, and it had limited value for guiding clinical treatment[12,13]. Simultaneously, if carrying out large-sample, blinded and randomized controlled clinical tests, it would be difficult to achieve the groupings according to the relevant ethical blinding methods. The baseline data and biological characteristics of the fractures of patients varied greatly which should be eliminated by larger sample sizes. According to retrospective analysis of GTF implantation and PFNA surgery carried out in our center, comparing the operative time and blood loss, the differences were not statistically significant; the clinical and bone healing times in the GTF group were significantly shorter than the PFNA group; the partial and full weight bearing times in the GTF group were significantly shorter than in the PFNA group; the Harris hip scores within 1 month and 6 months were higher than in the PFNA group; by comparing the scores within 12 months and 18 months, the differences were not statistically significant. In the GTF group, the rate of complications and rate of implant material adverse reactions were lower than in the PFNA group and the differences were statistically significant. The advantages of GTF implantation are that, immediately after bone cement solidification, it can play a role in mechanical fastening so as to achieve mutual convergence of the femur and prosthesis. Next, the force borne by the prosthesis will be uniformly passed to the distal end of the femur from the proximal end, which will make loosening and recurrent fractures difficult from excessive local pressure[14]. Simultaneously, it is conducive to early ambulation, early exercise, and can effectively reduce the incidence of complications of bed rest, but also avoid internal fixation failure from all causes. Its advantages are therefore significant[15]. The disadvantages are that there are more complicated surgical procedures, such as femoral head removal, sequential marrow cavity expansion and cutting reduction. After the reduction is satisfactory, it is necessary to fix the greater trochanter fracture with wire and non-absorbable sutures *via* a tuberosity stem hole. In addition, the bone cement injection and solidification times will also increase the surgical difficulty and time[16]. The incision is also larger, there is more surgical damage to the soft tissue and it can easily lead to bleeding in the marrow cavity when it is expanded.

Conclusions

GTF implantation may be more advantageous in functional improvement and reducing complications compared with PFNA for treatment of unstable femoral intertrochanteric fractures. Clinical randomized and controlled tests can be conducted for further verification by increasing the sample size and prolonging the follow-up time.

Conflict of Interests

The authors declared no conflict of interest.

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