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Original Article

Analysis of complications of intertrochanteric fracture treated with Gamma 3 intramedullary nail

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Abstract: Whether Gamma 3 fixation system is suitable for all intertrochanteric fractures is inconclusive. This paper analyzed the surgical complications of Gamma 3 intramedullary nail in the treatment of intertrochanteric fractures. Methods: A total of 186 cases were enrolled in the study including 115 males and 71 females. The surgical operations were performed in all cases and Gamma 3 intramedullary nail was inserted in medullary cavity. Results: Anti-rotation screw displacement into the intermuscular space of inner thigh occurred in 1 case, lateral femoral wall defect in 3 cases; refracture of proximal femur shaft during the Gamma 3 nail inserting into the medullary cavity occurred in 5 cases and fractures with a gap or malalignment in closed reduction of A3 type in occurred 6 cases. Fracture union occurred in 3-4 months postoperative. Recovery situations of all patients were evaluated based on Harris scoring system 6 with an average of 87 points. There are indications and shortcomings in the treatment of intertrochanteric fracture with Gamma 3 intramedullary nail. Conclusion: Understanding the surgical indications, standardizing the operation and upgrading skills are the key points to ensure operation successful, reduce complications and improve clinical outcomes.

Keywords: Gamma 3 fixation system, intertrochanteric fractures, complications, Harris scoring system

Introduction

Around 30% of the hip fractures occurring worldwide are occurred in Asian populations, most notably occurred in China. The incidence rate of hip fractures continued increasing year by year [1]. Intertrochanteric fractures constitute one of the most common fractures of the hip, which occurred mainly in elderly people with osteoporosis [2]. Faced with increasing incidence of intertrochanteric fractures due to an ageing population, clinically urgent problem is how to reduce the mortality rate, and shorten the time in bed and fix fractures through minimal trauma. The invention is also concerned with a method for the fixation and stabilization of a bone fracture utilizing said apparatus [3, 4].

Gamma 3 nail is one of the most acceptable fixation apparatus to treat intertrochanteric fractures, which is more suitable for early postoperative ambulation due to weight-bearing axis closer to the hip, and the lever arm shortened by about 25% compared to steel plate with advantages of reduced complications, reliable fixation, minimally invasive and significantly improving patients' quality of life after injury [5]. However, whether Gamma 3 fixation system is suitable for all intertrochanteric fractures is inconclusive. Small negligence on clinical operations often leads to unsatisfactory fracture fixation, which is one of the main reasons limiting its wider application [6].

In this study, we analyzed the surgical complications of Gamma 3 intramedullary nail in the treatment of intertrochanteric fractures and explored its indications, and how to reduce complications and improve the clinical outcomes.

Methods

Patients and ethnic consideration

A total of 186 cases were enrolled in our study, including 115 males and 71 females aged 45~89 years (mean 67.00 ± 5.26 years). All cases were classified into 9 types according to

Table 1. Incidence and stability of intertrochanteric fractures of different types

AO/OTA type	Case number (%)	Stability (%)
31-A1-1	9 (4.8)	80 (43.1)
31-A1-2	32 (17.2)	
31-A1-3	3 (1.6)	
31-A2-1	36 (19.3)	
31-A2-2	57 (30.6)	106 (56.9)
31-A2-3	16 (8.6)	
31-A3-1	11 (5.9)	
31-A3-3	7 (3.7)	
31-A3-3	15 (8.3)	
Total	186 (100)	

AO/OTA classification [7] including 9 cases of type A1.1; 32 cases of type A1.2; 3 cases of type A1.3; 36 cases of type A2.1; 57 cases of type A2.2; 16 cases of type A2.3; 11 cases of type A3.1; 7 cases of type A3.2 and 15 cases type A3.3.

All enrolled patients were fresh fractures patients and pathological fractures were excluded (**Table 1**). The causes of injury included 142 falling cases, 35 traffic accident cases and 9 cases of fall from a height. Of these patients, 127 cases were accompanied with diabetes, heart, brain, lungs and other internal diseases.

This study was approved by an Institutional Review Board of Tianjin Hospital and was conducted in accordance with good clinical practice, all applicable regulatory requirements and the guiding principles of the Declaration of Helsinki. Written informed consent was obtained from all subjects prior to admission to the study.

Preoperative preparation

A series of examinations were performed including liver function, kidney function, routine blood and urine examinations and ECG. Blood pressure and blood sugar should be controlled at normal or near-normal levels. Patients who accompanied with cardiovascular and cerebrovascular diseases were operation procedure was consulted by their physicians. The tolerance of anesthesia and surgery and whether accompanied by osteoporosis as well as the extent were also assessed. All patients received supracondylar traction after admission. Pathological fractures were excluded through X-ray (pelvic anteroposterior and lateral position of the affected hip) and CT examinations.

Surgery procedure

All patients took supine position, and the affected limbs were placed in orthopedics traction bed and received epidural anesthesia. According to shift degree and stability of fractures after traction, temporarily fixation with 2.5~3.5 mm k-wire was performed. After satisfactory fixation was achieved under the monitor of C-arm X-ray fluoroscopy, a longitudinal incision was made in the 2~4 cm proximal to greater trochanter tip (incision length determined according to the degree of obesity). To touch the tip of the greater trochanter after longitudinally separating the abducens, make a hole in the middle-inner 1/3 point of its top and insert the guide pin in medullary cavity. Gamma 3 intramedullary nail produced by Stryker Company is selected. The diameter of proximal fragment of Gamma 3 main nail is 15.5 mm, distal fragment 11 mm, and the length is 180 mm. Ream was not performed in elderly patients. And 21 cases of elderly patients were given intraoperative blood transfusion due to low preoperative hemoglobin. After the surgery, the active and passive activities or CPM functional exercise of the limb were started. The ambulation time and weight bearing were decided according to conditions of incision and the presence of osteoporosis. Harris scoring system was used for recovering evaluation.

Results

General surgery information

The operations were performed 3~12 days after patients admitted to the hospital (average 6 days). Average operating time was 50 min (30~100 min) with average loss of blood of 200 ml (100-300 ml). Patients were discharged from hospital 3~16 days after surgery. Patients ambulated 9~56 days after surgery and weight-bearing was about 10~15 kg.

Intraoperative complications

Anti-rotation screw displacement into the intermuscular space of inner thigh occurred in 1 case (**Figure 1A**), lateral femoral wall defect in 3 cases (**Figure 1B**), refracture of proximal

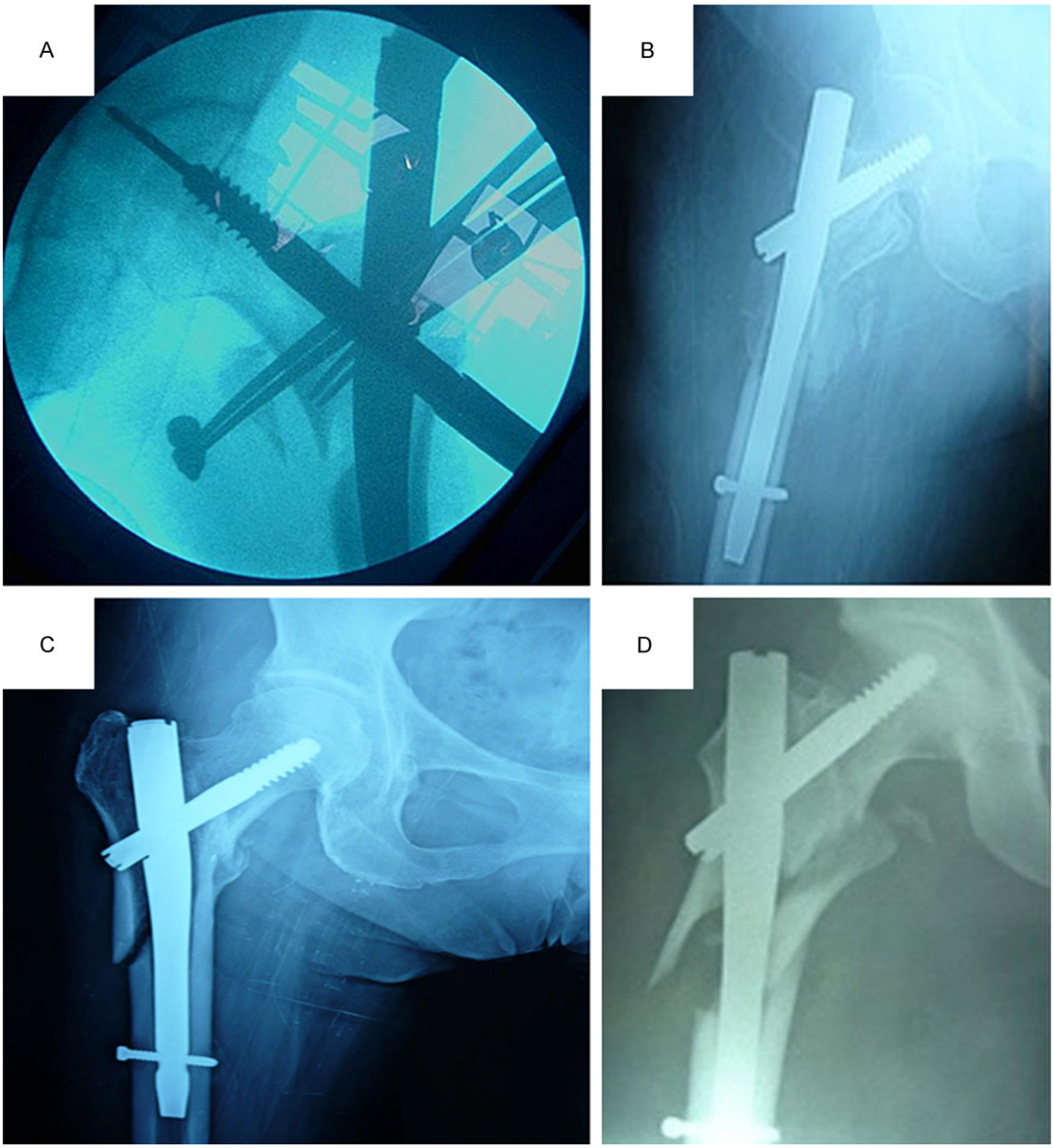

Figure 1. Intraoperative complication. A. Anti-rotation screw displacement into the intermuscular space of inner thigh; B. Lateral femoral wall defect; C. Subtrochanteric fracture caused by Gamma 3 nail inserting into the medullary cavity in the treatment of intertrochanteric fracture; D. Malalignment of subtrochanteric fracture.

femur shaft during the Gamma 3 nail inserting into the medullary cavity occurred in 5 cases (**Figure 1C**) and fractures with a gap or malalignment in closed reduction of A3 type in occurred 6 cases (**Figure 1D**).

Postoperative complications

Fracture re-displacement occurred in 5 cases (**Figure 2A**), cut-out of lag screws occurred in 3 cases (**Figure 2B**), refracture of distal femoral shaft in locking screw point in 1 case (**Figure 2C**). We included incidence and stability of intertrochanteric fractures in **Figure 2D**.

Follow-up and management

Fracture union occurred in 3-4 months postoperative. Recovery situations of all patients were evaluated based on Harris scoring system [8]

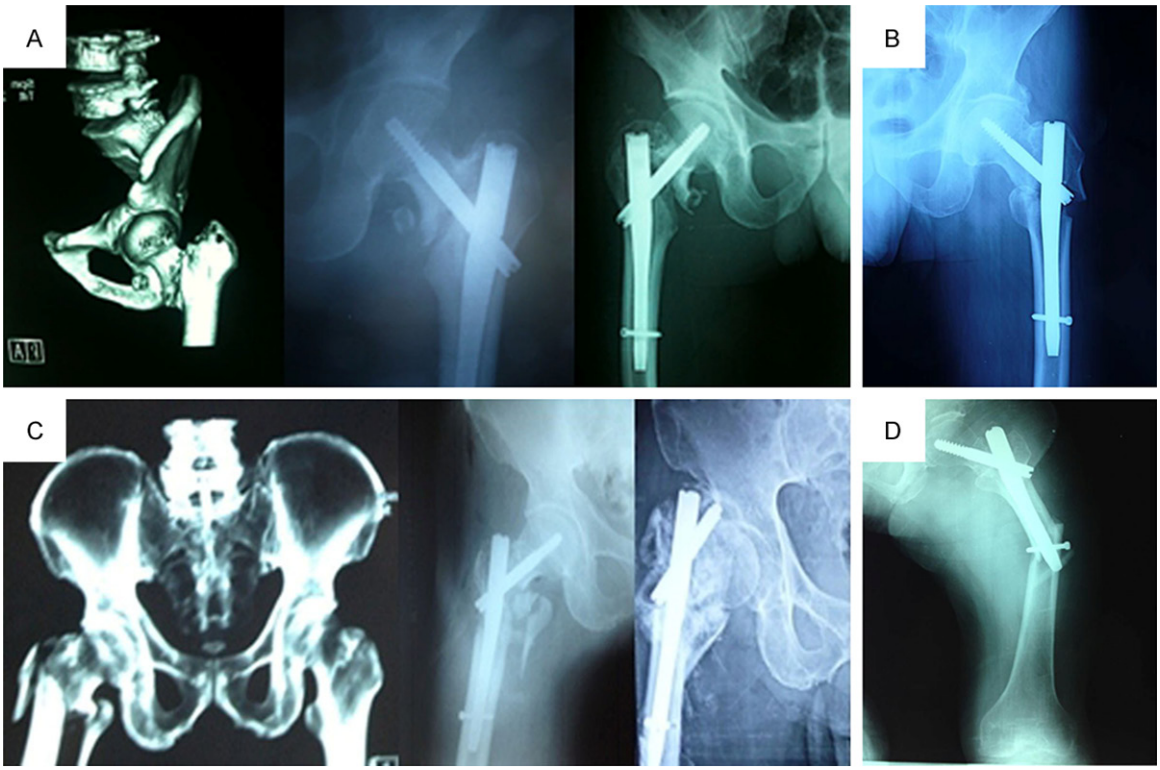

Figure 2. Postoperative complications. A. Re-displacement of irreducible intertrochanteric fracture(three dimensional image preoperatively, 1 week after surgery, re-displacement one months after surgery); B. Displacement of type A3.2 fracture 1 week after surgery; C. Cut-out of lag screw, preoperational, post operation and 10 months postoperatively; D. Fracture in the locking nail point.

with an average of 87 points. Taking screws intraoperatively was performed in anti-rotation screw dropping off cases. The time in bed of patients was prolonged in the cases of refracture of femur shaft during the Gamma 3 nail inserting into the medullary cavity, fractures with a gap or malalignment in closed reduction of A3 type, postoperatively fracture re-displacement and cut-out of lag screws. They achieved union for a maximum of 4 months. In one case of cut-out of lag screw, the lag screw affected the hip joint activity and the patient felt pain 5 months after surgery. The internal fixation was removed ten months after surgery and the affected limb was 3 cm shortened than the well one. The patients with lateral femoral wall defect achieved union, but presented with reduced muscle strength while walking and limp of different degrees.

Discussion

All three cases of cut-out of lag screw in our study belong to type 2.3. The causes of cut-out include non-anatomical reduction of fractures, lag screw placement not ideal, complex fracture type and design of internal fixation devices [9]. Gamma 3 lag screw's thread is a reverse one and has a greater area of holding the femoral head which transforms the cutting force into pressure with good cutting- resistance capacity [10]. For patients suffered from cut-out of lag screw in our study, locking screw had different degree of loose while lag screw cutting out posteriorly and laterally, which indicated that Gamma nail fixation system was stable as a whole. Then we assumed that the main reason for cut-out of lag screw is obvious osteoporosis because all patients were aged from 75 to 83 years and bone densitometry of hip showed T value less than -3.5SD and TAD value less than 20 mm. Therefore, it is believed that for those elderly patients with osteoporosis, short Gamma 3 intramedullary nail is insufficient in anti-rotation capabilities and application of long intramedullary nail for strengthening remote locking should be a critical factor to prevent cut-out of lag screw.

Said described a kind of irreducible intertrochanteric fracture in 2005 [11], which is desig-

nated type A1 and is characterized by fracture ends comminuted not seriously, part of less trochanter located in the distal of fracture line and long wedge-shaped fracture fragment in proximal femur. It belongs to stable fracture. Fracture re-displacement occurred in two patients of type A1.1 in our study which is similar to the irreducible fracture described by Said. The patients, who aged 40 to 50 years, were injured by great violence, high fall and heavy pound injury leading to large fracture displacement. Fracture re-displacement occurred in two weeks indicating that the pressure and holding force of lag screw in the head and neck of femur are insufficient. For this type of fracture, application of fixation system with greater pressure such as DHS, maybe have better results.

Gotfried [12] proved that the integrity of lateral femoral wall is extremely important to fixation of unstable fractures. In fracture of type A3.2, the entry point of lag screw located in 1.5~2.5 cm under the lateral femoral muscle ridge of great trochanter, which aggravated the damage of lateral femoral wall, and leading to fixation force of intramedullary nail on great trochanter reducing. Three patients experienced lateral displacement of the greater trochanter after surgery and the time in bed was prolonged. Drilling of lag screw can also increase the damage of lateral femoral wall which is not conducive to early ambulation and fracture union [13, 14]. Therefore, from the perspective of protecting the lateral femoral wall, lag screw should be carefully selected.

Gamma 3 anti-rotation screws can prevent rotation or inward shift of lag screw [15] and there is a dedicated protection sleeve used for installing anti-rotation screw. However, surgeons often ignore the protection measure leading to anti-rotation screw going into the intermuscular space of inner thigh.

The diameters of aiguilles used for reaming are different for proximal and distal fragment of Gamma 3 nail because the diameters of them are 15.5 mm and 11 mm respectively. In three cases of lateral femoral wall defect, one case is due to proximal aiguille reaming to the femoral shaft and another two cases is attributable to the entry point biased towards the lateral causing the cortex of bone excessively thin.

Since reaming of the proximal fragment easily causes lateral femoral wall defect [16], the intramedullary nails are directive inserted without reaming in some elderly patients, considering their relatively larger medullary cavity which leads to cleavage of narrow place of femoral shaft during the Gamma 3 nail inserting into the medullary cavity in five cases in our study. Nowark et al. [17] reported that femoral shaft fracture can also occur in the course of prosthesis implant accounting for 8.8 per cent in 105 patients and men to women ratio was 13:1. Therefore, properly reaming is necessary for post-menopausal women with severe osteoporosis.

Because femoral shaft has an anterior arch at an angle, under the circumstances of nail not going well and the remote sight apparatus not securely installed, repeated drilling is needed to ensure the locking screw going into the screw hole which results in intensity of distal femoral cortex reducing [18]. In addition, nail tail is closer to locking hole in Gamma 3 which can cause local stress concentration. The two points above-mentioned lead to femoral shaft fracture in the region of nail tail. Bhandari [19] also pointed out that treatment of proximal femoral fracture with Gamma 3 caused 3% femoral shaft fractures. Especially for older women patients, if remote locking is difficult, it will be not considered so as to reduce the likelihood of fracture.

Subtrochanteric fractures are designated type A3 which is characterized by long oblique fracture line in the coronal plane and proximal fractures dislocating poster laterally and closed reduction is difficult. The lag screw positioning device of Gamma 3 is designed according to anatomical reduction with a fixed angle. If this kind of fracture fails to achieved anatomical reduction, intramedullary nail placement is difficult to meet the standards, it is hard to select correct entry point and adjust front rake of lag screw and some complications such as cut-out of lag screw in the femoral head, fracture nonunion and breakage of internal fixation easily appear [20, 21]. Some of the previous reduction methods such as Hoffman retractors, spherical top rod, bone circular needle and reduction forceps may aggravate the dissection of periosteum soft tissue to some extent and are difficult to maintain fracture alignment

[22]. In our experience, minimally invasive fixation with wire rope in later period achieved satisfactory fracture alignment and nail placement.

Conclusion

There are some limitations in this study, for example, the number of cases with complications is small and a large sample study is expected. Surgical operations were performed by different surgeons and there are deficiencies in surgical standardization and proficiency. In addition, the analysis of cases is based on experience of the authors and is biased inevitably. Despite the above limitations, our study demonstrate that Gamma 3 fixation system is suitable for intertrochanteric fractures; The doctors should fully understand the surgical indications, standardize the operation and upgrade skills, these are the key points to ensure operation successful, and also they are keys to reduce complications and improve clinical outcomes.

Disclosure of conflict of interest

None.

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