

Intramedullary Fixation of Subtrochanteric Fractures with Long Proximal Femoral Nail or Long Gamma Nail: Technical Notes and Preliminary Results

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Abstract

Introduction: The objective of this study was to prospectively evaluate the clinical outcome of traumatic subtrochanteric fractures fixed with long proximal femoral nail (PFN) or long gamma nail with particular emphasis on our experience of surgical techniques. **Materials and Methods:** We reviewed the results of 49 consecutive patients who had undergone intramedullary fixation specifically with a long PFN or a long gamma nail for traumatic subtrochanteric fractures in our hospital during a 2-year period from January 2003 to December 2004. The average age of the patients was 53 years. Clinical and radiographic analyses were performed when follow-up was made at 6 weeks, 12 weeks, 6 months, 1 year and 2 years. **Results:** All the 49 traumatic subtrochanteric fractures healed uneventfully except 1 case of delayed union. Walking and squatting ability was completely restored in every case at follow-up examination 6 months postoperatively. Among them, 32 fractures were successfully reduced with traction on a fracture table under fluoroscopy, but cerclage wiring or cable bandage through a small incision was needed in the other 17 cases. The average operative time was 46 minutes (range, 21 to 98). Eighteen Seinsheimer type II fractures were left unlocked distally, and static distal interlocking with 1 bolt was carried out in the other 31 cases. No complications such as cutout or breakage of the implants were encountered. **Conclusions:** This study suggests that long PFN or long gamma nail is a reliable implant for subtrochanteric fractures, leading to high rate of bone union and minimal soft tissue damage. Intramedullary fixation has biological and biomechanical advantages, but the operation is technically demanding. Gradual learning and great patience is needed in order to make this method truly minimally invasive.

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Introduction

Subtrochanteric fractures of the proximal femur have been defined as the fractures involving the area between the lesser trochanter and the isthmus of the femur. Although these fractures are the most difficult to manage in the femur, our improved understanding of the complex biology and biomechanics of the trochanteric region as well as the rapid development of orthopaedic philosophy and implants has led to consensus on the treatment of trochanteric fractures.¹ However, the appropriate implant for the internal fixation of subtrochanteric fractures remains debatable; and a multitude of different intra- and extramedullary devices for their surgical fixation have been advocated.²⁻⁶ The subtrochanteric region of the femur is subjected to many stresses resulting from bending movements and compressive forces generated by body weight and the hip

muscles, thus leading the malunion and nonunion of the fractures and mechanical failure of the implants.^{7,8}

We now report the results of clinical and radiographic follow-up of a series of subtrochanteric fractures treated with long proximal femoral nail (PFN) (AO, Switzerland) or gamma nail (Stryker, Germany). The objective of this study was to evaluate the clinical outcome of traumatic subtrochanteric fractures fixed with PFN or long gamma nail with particular emphasis on our experience with the surgical techniques.

Materials and Methods

A series of 54 consecutive patients with subtrochanteric fractures underwent intramedullary fixation specifically with a long PFN or a long gamma nail in our hospital during a 2-year period from January 2003 to December 2004. Four

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of the 54 patients had pathological fractures from distant metastasis and 1 died of heart disease a month after the index operation, leaving 49 fractures for enrolment in this study. Among them, 38 patients were male and 11 were female. Their age averaged 53 years (range, 22 to 78). Thirty-six fractures were a result of high-energy trauma from traffic accidents, while the remaining 13 were due to low-energy falls. Fifteen of the 36 traffic accident patients had associated injuries such as head, chest and pelvis trauma, or fractures of other sites. According to Seinsheimer's 5-type classification system,⁹ there were 18 type II, 21 type III, 4 type IV and 6 type V fractures in this series of patients.

Implants

Among these 49 patients with subtrochanteric fractures, 18 were intramedullarily fixed with a long PFN and the other 31 with a long gamma nail. The long gamma nail is a second-generation interlocking nail,¹⁰ and the long PFN is basically similar to the long gamma nail in design.¹¹ They all have a larger proximal diameter and a smaller middle and distal diameter, a medial-lateral curvature, an anteversion angle, a large cephalic lag screw inserted in the femoral neck, 2 distal interlocking holes, different lengths and alternate ones for the right or left side. Reaming of the trochanteric region and the femoral isthmus was usually necessary for inserting both the nails. The main differences between these 2 implants are as follows: the long PFN is a solid nail while the long gamma nail is a cannulated one. A second hip screw is inserted parallel to the large lag screw to prevent rotation of the femoral head in the long PFN, while anti-rotation function of the long gamma nail is obtained by inserting a blocking bolt into the proximal canal of the nail. A shorter length of 340 mm was selected in all of the cases because of the smaller stature of our patients as compared with Caucasian patients.

Surgical Techniques

The surgical operations were performed under general or spinal anaesthesia, with the patients set in the supine position on the fracture table. The upper part of the body was curved to the opposite side, with the injured lower extremity adducted as much as possible for the ease of nail insertion. Fractures were reduced under traction and C-arm fluoroscopy. A lateral longitudinal incision of about 3 cm was made superior to the greater trochanter after the top of the greater trochanter was palpated by the surgeon's index finger. The entry-hole on the top of the greater trochanter, usually at the junction of anterior third and posterior two-thirds, was made with a trochar under fluoroscopic monitoring. A guide rod was inserted through this hole into the distal femoral canal, followed by reaming of the femoral isthmus and the proximal fragment. Insertion of the long

PFN or long gamma nail was accomplished manually by the surgeon holding the aiming device, and use of a hammer was forbidden. When closed reduction was not sufficient to insert the guide rod into the distal femoral canal, open reduction and fixation with cerclage wiring or cable bandage would be performed through a small incision at the fracture site. The cephalic lag screw was inserted into the femoral neck with the aid of the aiming device under fluoroscopic control, and then the hip screw of the long PFN or the blocking bolt of the long gamma nail was inserted subsequently. Distal locking of the nails was carried out under C-arm fluoroscopy by freehand technique.

Postoperatively, the patients were encouraged to do active flexion and extension of the hip and knee of the affected side on the first day. Ambulating with crutches but without weight-bearing was started on the third day. Partial weight-bearing was initiated 6 weeks after operation, and full weight-bearing was begun 8 to 12 weeks postoperatively. For the patients with associated injuries, the rehabilitation programme was begun as tolerated. All the patients were asked to come back to the hospital for follow-up at 6 weeks, 12 weeks, 6 months, 1 year and 2 years after their operation and radiographic examination was carried out at each visit.

Results

The average operative time for all the 49 cases was 46 minutes. Thirty-two fractures were successfully reduced with traction on a fracture table under fluoroscopy, and their operative time averaged 32 minutes. Open reduction and fixation with cerclage wiring or cable bandage through a small incision was needed in the other 17 cases, and their average operative time was 69 minutes. None of the 18 type II fractures was locked distally, while static distal locking with only one bolt was performed in each of the remaining cases. Blood loss was minimal, and blood transfusion was not necessary in any case. Perioperative complications such as acute respiratory distress syndrome and deep vein thrombosis occurred in none of the cases. No early or late infection was noted. Walking and squatting ability was completely restored in each case at follow-up examination 6 months postoperatively. No patient complained of limping due to shortening of the affected leg. Pain during walking was reported in 9 cases, but physical examination revealed that the pain was located at the point around the greater trochanter rather than at the fracture site. Radiographic examination showed that the proximal part of the nail had protruded the tip of the greater trochanter too much because of the relative short stature of these patients. It was the friction between the protruded proximal nail and its surrounding soft tissues that had led to the walking pain. As the patients were fixed intramedullarily, their radiographic examination during the follow-up was not focused on the situation of callus formation and bone union rather than the

quality of reduction. All the 49 traumatic subtrochanteric fractures healed uneventfully except 1 case of delayed union (Fig. 1). No complications such as cutout or breakage of the implants, or peri-implant fractures were encountered. Removal of the distal locking bolt for dynamising the nails to improve bone union was not made as it was esteemed unnecessary in any case.

Discussion

Unlike osteoporotic trochanteric fractures, subtrochanteric fractures are usually the result of high-energy trauma and often subjected to significant displacement and great difficulty in close reduction through traction. The high incidence of delayed union, malunion and nonunion of fractures has left conservative treatment, as advocated by DeLee et al,¹² abolished in modern trauma care. Extramedullary fixation with plating has the potential disadvantages of extensive surgical exposure, severe soft tissue damage and blood loss, thus leading to problems of fracture union and implant failure. In addition, the eccentrically plating is prone to fatigue breakage due to their mechanical load-sharing effect.^{2,4,6,13} Recent development in mini-invasive surgery and orthopaedic implants such as mini-invasive percutaneous plate osteosynthesis (MIPPO), locking compression plate (LCP), and less invasive stabilisation system (LISS) are current topics among trauma surgeons worldwide,¹⁴⁻¹⁶ but our preliminary results of application of LISS or LCP through MIPPO technique on subtrochanteric fractures has not been as successful as on fractures of the distal femur or proximal tibia. As great difficulties were often encountered during fracture reduction and plate pre-contouring, open reduction is sometimes inevitable, thus making this technique not truly minimally invasive. Allowing a minimally open approach, intramedullary nailing is closely linked to “biological internal fixation”, in addition to its mechanical benefits over plate fixation.¹⁷ Initially, standard femoral nail was tried in subtrochanteric fractures but the proximal fragments were usually not long enough for stable fixation. The recent development of reconstruction nail, which changes the direction of the proximal interlocking bolts, has greatly expanded the indication of intramedullary fixation for subtrochanteric fractures.¹⁸ Unlike long PFN or gamma nail, the entry point for standard femoral nail or reconstruction nail is not on the tip of the greater trochanter but in the fossa piriformis. The surgical technique of guide wire and nail insertion through the fossa piriformis is much more difficult than that through the laterally shifted entry point, with the patient on the fracture table in supine position. There also exists the risk of split fracture of the femoral neck during the process of entry hole making, reaming, and nail insertion through the fossa piriformis. It was reported that nail insertion through

the fossa piriformis might interrupt the local blood supply, which would be associated with avascular necrosis of the femoral head.¹⁹ Therefore, long gamma nail or long PFN has been increasingly accepted and recommended as the implant of choice for the fixation of subtrochanteric fractures. The advantages of long gamma nail or long PFN for subtrochanteric fractures were well illustrated in our series of patients. In this study, all the 49 cases of traumatic subtrochanteric fractures healed uneventfully except 1 case of delayed union. Walking and squatting ability was completely restored in each case (including the patient with delayed union) at follow-up examination 6 months postoperatively. No complications such as cutout or breakage of the implants, or peri-implant fractures were encountered.

The average operative time in our series of patients was 46 minutes. This is significantly shorter than that reported in other papers.^{10,11} Many authors believed that the long gamma nail or long PFN must be distally interlocked in order to prevent rotational malalignment of the distal fragment, and some of them even recommended that 2 bolts be necessary for distal interlocking.^{10,11} Because radiolucent drill is not available in most hospitals, distal locking is mainly through freehand technique. It is this freehand distal locking that takes a lot of time in the operation and increases the X-ray exposure of the surgeons. We did distal interlocking with only 1 bolt for Seinsheimer type III, IV and V fractures, but never did for type II fractures. Gamma nail and PFN were originally designed for the Europeans, and the 10-mm diameter nail is press-fit with the femoral canal of the isthmus in most cases, owing to the relatively small stature of the people of our country. In addition, aggressive rehabilitation programme including partial or full weight-bearing is usually initiated right after operation under the guidance of professional physical therapists in Western countries. There are no physical therapists specialising in orthopaedic rehabilitation in most hospitals in our country. On the other hand, as much more attention has been paid on the result of X-ray appearance after operation than on rehabilitation by the patients themselves and complications of implant failure are deemed great problems by the patients, surgeons are hesitant to encourage early rehabilitation and weight-bearing. We believe that delayed partial weight-bearing after surgical operation and the relative narrow canal of the femoral isthmus might decrease the complications such as rotational malalignment, limb shortening and implant failure in this series, even if no distal interlocking or distal interlocking with only 1 bolt was performed. Meanwhile, operative time was spared and X-ray exposure was diminished. We also realise that the key for the success of the operation depended on the correct determination of the entry point. Under fluoroscopic monitoring, the entry point must be on top of the greater



Fig. 1A.



Fig. 1B.



Fig. 1C.

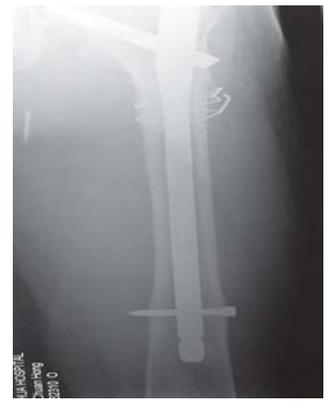


Fig. 1D.

A. A type IIIa subtrochanteric fracture.

B. The fracture was not reduced satisfactorily after open reduction through a small incision and cerclage wiring. C and D, 6 months and 2 years after operation respectively, the fracture did not achieve complete union.



Fig. 2A.



Fig. 2B.

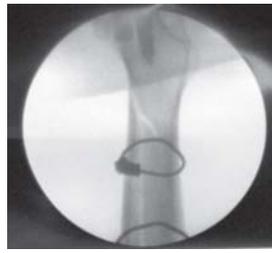


Fig. 2C.

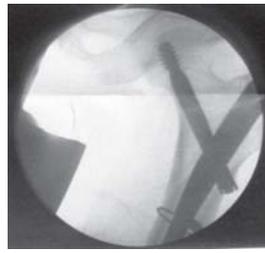


Fig. 2D.



Fig. 2E.

A. A type IIa subtrochanteric fracture with long spiral fracture line.

B and C. Open reduction through a small incision with cable bandage was done before nail insertion. The correct entry point was the tip of the greater trochanter in anteroposterior view, and along the centre of the femoral canal in lateral view.

D and E. The lag screw was close to the femoral calcar and reached the subchondral bone 5 to 10 mm below the articular cartilage in anteroposterior view, and in the centre of the femoral neck in lateral view.



Fig. 3A.

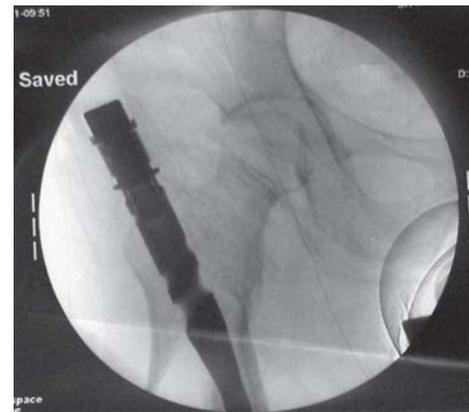


Fig. 3B.

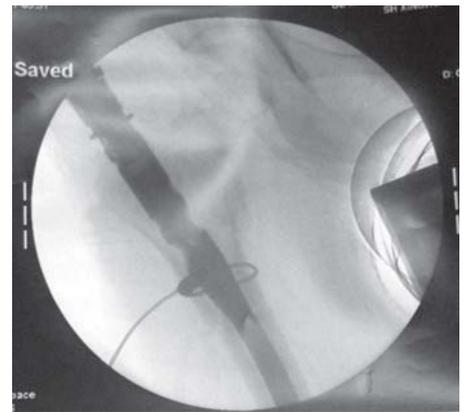


Fig. 3C.

A. A type IIc subtrochanteric fracture.

B. The fully inserted nail blocked reduction.

C. The cable was tightened after the nail was withdrawn slightly, and the fracture was anatomically reduced before the nail was fully inserted.

trochanter in anteroposterior view and in line with the centre of the femoral canal in lateral view (Fig. 2). It was this correct entry-point location that took a large proportion of time and X-ray exposure during our operations. If the entry point shifted a little bit laterally, the lateral cortex of the greater trochanter could be easily shaved off during reaming of the femoral canal. On the other hand, if the entry point shifted medially, the awl might slip into the fossa piriformis. Nowadays, extramedullary fixation with dynamic hip screws or other plates has been adopted for all kinds of trochanteric fractures in many hospitals in our country. We believe the main reason for this is that the importance of correct entry point is not understood. Confidence was lost owing to the shaving-off of the lateral cortex of the greater trochanter during the initial attempt to carry out intramedullary fixation, so gamma nail or PFN was totally abandoned in the end.

The abundant muscles around the subtrochanteric region usually cause significant displacement of the fractured fragments, leading to great difficulties in close reduction under traction. Sometimes open reduction through a small incision at the fracture site is inevitable. We found the fractures that needed open reduction were always those with long spiral oblique fracture lines. All the 18 cases with open reduction in our series had long oblique spiral fracture lines. Although open reduction was notorious for nonunion, we had only 1 case of delayed union (Fig. 1). In this case, the superior fragment had obvious abduction and flexion displacement following nail insertion. Cerclage wiring through a small incision was made in an attempt to reduce the fragment but in vain due to blockage of the large upper part of the nail. Although this patient had excellent walking and squatting ability, the fracture gap could still be seen at 2-year follow-up examination. In another similar case, a stronger cable bandage was used instead of cerclage wiring. As soon as the distal thinner part of the nail was inserted into the femoral canal of the distal fragment, the cable was tightened, the fracture was anatomically reduced, and the nail was finally completely pushed into place (Fig. 3). Six months after operation, the patient got satisfactory bone union. Based on the experiences of these 2 cases, it is suggested that open reduction and cable bandage through a small incision may be performed before long gamma nail or long PFN insertion in the cases with long spiral fracture lines and unsatisfactory reduction under traction (Fig. 1).

The complication of cutout was often reported in the literature when trochanteric fractures were treated with standard PFN or gamma nail,²⁰⁻²² or subtrochanteric fractures were managed with long PFN or long gamma nail.^{10,11} Fortunately, such complications did not occur in any of our 49 patients. A few reasons, we believe, account for the satisfactory results of the study. First, subtrochanteric fractures usually occur in relatively young patients without

osteoporosis after high-energy trauma, while cutout is often noted in old patients with osteoporotic fractures. Second, this complication is closely related to the position of the lag screw. We recommend that the lag screw of gamma nail or PFN should be placed in the lower part of the femoral neck close to the femoral calcar, with screw tip reaching the subchondral bone 5 to 10 mm below the articular cartilage in anteroposterior view. In lateral view, it should be placed in the centre of the femoral neck (Fig. 2). There, the lag screw will be definitely placed in the area of best bone quality. In addition, cutout is also related to the timing of weight-bearing. In this study, partial weight-bearing was not initiated until 6 weeks after operation in all of our patients to allow preliminary callus formation to substantially decrease the load the screw would need to sustain.

There were some limitations in our prospective longitudinal study. First, there was no control group such as dynamic hip screw or other types of internal fixation method to serve as a comparison to the surgical technique being investigated. Secondly, we did not use an accepted outcome measure instrument such as the Harris Hip Score or SF-36 to present our results. The evaluation of the patients' ability to squat and walk with no limp for assessing outcome was also a crude method. But assessment for bony union with serial radiographs in our study was acceptable, and the major merit of this study was our emphasis on the use of this technique in the Asian patients and small but important changes in techniques and rehabilitation protocols that lead to a favourable outcome.

Conclusions

Long PFN or long gamma nail is a reliable implant for subtrochanteric fractures, leading to high rate of bone union and minimal soft tissue damage. Intramedullary fixation has biological and biomechanical advantages, but the operation is technically demanding. Gradual learning and great patience is needed in order to make this method truly minimally invasive.

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