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USE OF TROCHANTERIC NAIL FOR PROXIMAL FEMORAL EXTRACAPSULAR FRACTURES

THESE

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Traitement des fractures extra capsulaires du fémur proximal par le clou Trochantéric

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Résumé

Les fractures extra capsulaires du fémur proximal sont connues pour le risque élevé de morbidité et de mortalité en cas de traitement non chirurgical. Ainsi, le clou Gamma standard a été produit pour garantir une fixation stable de ces fractures permettant par conséquent une mobilisation rapide et en charge des personnes en âge avancé et présentant ce genre de fracture.

Mais il a été reproché à ce type de clou un nombre relativement élevé de fracture per ou post opératoire (environ 17%). Cette complication est liée au design de cet implant. Et, de ce fait, le clou Trochantéric a été créé pour remédier à cette complication en changeant la forme du clou et notamment sa courbure.

Entre juillet 2000 et janvier 2001, 88 patients ont été traités par clou Trochantéric pour une fracture pertrochantérienne et suivis consécutivement dans notre Service. 75 patients, soit 76 fractures, ont pu être évalués cliniquement et radiologiquement durant une évolution de deux ans.

Use of Trochanteric Nail for Proximal Femoral Extracapsular Fractures

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abstract

Proximal femoral extracapsular fractures have shown a significantly high morbidity and mortality rate at 1 year in cases of nonoperative treatment. The standard gamma nail was originally designed to provide stable fixation and allow early mobilization and weight bearing for elderly patients. The design of the standard gamma nail, however, appears to be associated with intraoperative or postoperative femoral shaft fractures in ≤17% of patients, compromising the outcome. The trochanteric nail was developed to overcome the problems encountered with the use of the standard gamma nail. Between July 2000 and January 2001, 88 consecutive proximal femoral extracapsular fractures were treated with a trochanteric nail. Seventy-five patients (76 fractures) were observed clinically and radiographically for 2 years.

Extracapsular femoral fractures represent 65% of proximal femoral fractures,[1] and show a significantly high morbidity and mortality rate. Operative treatment, overall in emergency, reduced 1-year mortality rate and provided better functional results, shorter hospital stay, and greater independence at 6 months after injury.[2-4]

In the past 20 years, several types of sliding hip screws and plates have gained success,[5] and have become choice implants for treatment of most intertrochanteric fractures. These implants were satisfactory for stable fractures, with a reported union rate >90%, but were responsible for 5%-21% of complications (eg, cut-out, metal failure, and secondary fracture displacement in unstable intertrochanteric and subtrochanteric).[6,7] Complications may be the result of the plate lying lateral to the line of load bearing,[8,9] thus telescoping displacement with medialization of the femoral shaft due to lack of lateral support for the proximal fragment, and plate pull-out.[7] These complications occur most frequently in unstable fractures and in the presence of osteoporotic bone.

The standard gamma nail (Stryker Trauma, Kalamazoo, Mich) was introduced to provide a sliding cervical lag screw that would allow controlled fracture impaction and intramedullary fixation in the femoral shaft for more efficient load transfer through the calcar. The standard gamma nail has proven effective in the minimization of surgical trauma, blood

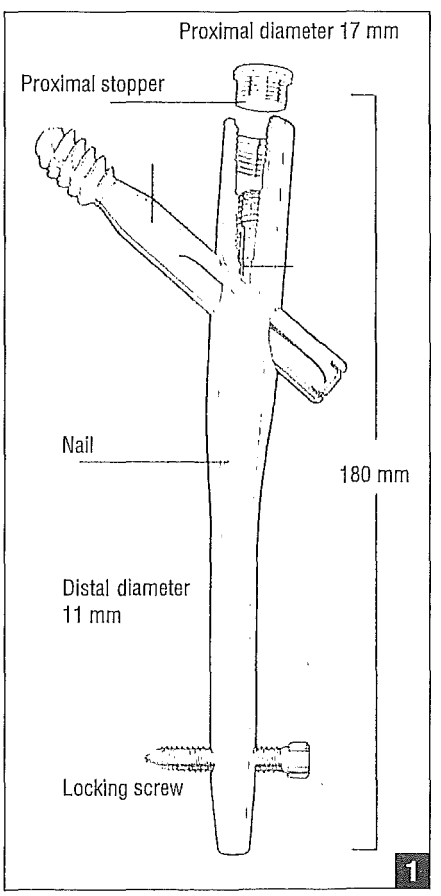

Figure 1: Implant model.

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loss, bone devascularization, and wound complications.[3,10,11] Controlled trials have demonstrated the standard gamma nail's association with intraoperative[11-15] and postoperative[11,12,15-18] femoral shaft fracture at or below the nail tip, with a reported incidence ≤17%.[16] A modified gamma nail, the trochanteric nail (Stryker Trauma), was developed to overcome the problems encountered with the standard gamma nail.

The trochanteric nail (Figure 1) presents a length of 180 mm, a proximal diameter of 17 mm at the trochanteric region, and 11 mm distally. Its principle characteristic is a 4° mediolateral curvature, compared to the standard gamma nail's 10° mediolateral curvature. This lesser valgus angle design provides a better fit and less local load concentration on the medial and lateral cortex at the tip of the nail. Unlike the standard gamma nail, the trochanteric nail locks distally with a single antirotation screw. This last modification is important to avoid distal stress risers, responsible for iatrogenic femoral shaft fractures. This article presents the results of a prospective nonrandomized study of trochanteric nail use in the treatment of 88 extracapsular proximal femoral fractures.

Table 1
Preoperative Patient Data

	No. (%)
No. patients	87
No. hips	88
Age (y)	81 (range: 42-98)
Gender (M/F)	63/24
ASA physical-status score[20] (points)	
1	13 (15)
2	38 (44)
3	27 (31)
4	9 (10)
Prefracture mobility	
Independent	71 (82)
Aided	16 (18)
Residence	
Home	54 (62)
Nursing home	33 (38)
Side of lesion (Left/Right)	35/53
Fracture patterns[19]	
Kyle type I	23 (26)
Kyle type II	25 (28)
Kyle type III	34 (38.6)
Kyle type IV	6 (7)
Stable (Kyle I, II)	48 (54)
Unstable (Kyle III, IV)	40 (46)
Additional injuries*	
Distal radius fracture	1
Contralateral femur shaft fracture	1
Fracture of pubic ramus	1
Mean time from admission to surgery (d)	1.4 (range: 0-4)

**Sustained along with hip fracture.*

Materials and Methods

Between July 2000 and January 2001, patients with intertrochanteric fractures referred to our trauma center were treated with trochanteric nails.

Eighty-eight traumatic extracapsular fractures of proximal femur were treated in eighty-seven patients (63 women and 24 men, average age: 81 years, [range 42-98]).

Anteroposterior (AP) radiographs of the pelvis, and AP and lateral radiographs of the affected hip were taken at admission. Fracture types according to the Kyle classification[19] were as follows: 23 (26%) type I intertrochanteric fractures, 25 (28%) type II, 34 (39%) type III, and 6 (7%) type IV. Each patient's previous walking ability and medical condition was evaluated. Fifty-one (59%) patients had ≥2 pre-existing medical conditions, including cardiac insufficiency, hypertension, pulmonary disease, insulin-dependent diabetes, cerebrovascular accident, malignancy, or dementia. Three (3.4%) patients sustained an additional upper- or lower-extremity injury at the time of their femoral fracture. Patients underwent surgery a mean 1.4 days (range: 0-4 days) after admission, under either general or spinal anaesthesia. The anesthetic risk scoring was assessed according to the criteria of the American Society of Anesthesiology.[20]

Patient data are summarized in Table 1. Preoperatively, an accurate closed reduction was attempted on the fracture table under fluoroscopic control and maintained by traction with a boot. If reduction in the lateral view was not acceptable, the position of the proximal fragment was improved intraoperatively by AP pressure through an anteriorly placed rasp through the same skin incision. Patients received prophylactic antibiotics, 1.5 g second generation cephalosporin, before induction. The procedures were performed by 10 surgeons in the Department of Orthopedic Surgery.

The nail angle was determined by templating the contralateral hip. Values were as follows: 125° in 57 (66%) cases, 130° in 22 (25%) cases, and 135° in 9 (10%) cases. In 3 (3.4%) patients, contralateral hip templating was not possible because of previous surgery (ie, hip arthroplasty, nailing, and plating), and nail angle was estimated before starting surgery after reduction of the fracture under control imaging. The nail was distally locked in all

but one patient with an undisplaced type I fracture.

Tabulated intraoperative data consisted of surgery duration, fluoroscopy time, and intraoperative problems. In 87 cases, intramedullary reaming was performed to 13 mm, and to 12.5 mm in 1 case. The nail was never hammered into the femur; it was pushed gently by hand.

Antithrombotic prophylaxis consisting of low-molecular-weight heparin was administered once per day for 3 weeks postoperatively. Closed suction drainage of the wound was implanted in all patients for 48 hours.

Early (<45 days) and late (>45 days) postoperative complications were recorded. Patients were transferred to armchairs on the first postoperative day. Weight bearing as tolerated was allowed after a mean period of 3 days (range: 2-8 days) depending on the general condition of patients, regardless of the fracture type.

After patients began to ambulate, AP and lateral radiographs of the operated hip were taken to evaluate the position of the implant, distance from the screw tip to the subchondral bone (tip-apex distance),[21] and reduction of the fracture and the neck-shaft angle. At follow-up, presence of pain with a visual analog scale, need for ambulatory aids, and hip range of motion (ROM) were evaluated. Anteroposterior and lateral radiographs of the hip were taken to evaluate neck-shaft angle, changes in position of the screw, cut-out of the implant, and union of fracture. At final follow-up 2 years postoperatively, hip ROM according to Charnley's score, leg-length discrepancies, need for ambulatory aid, gait angle, union of fracture, neck-shaft angle, and presence of cut-out were evaluated.

Table 2
Intra- and Postoperative Patient Data

	No (%)
General anesthesia	34 (39)
Spinal anesthesia	54 (61)
Mean surgery duration (min)	62 (range: 32-80)
Mean fluoroscopic screening time (sec)	29 (range: 4-120)
Intraoperative complications	0
Mean blood transfusions (mL): 52 (68%) patients	1000 (500-2000)
Early postoperative complications	
Hematoma	12
Seroma	8
Sensory deficit in sciatic nerve	1
Urinary tract infections	7
Acute postoperative mental confusion	6
Brochopneumonia	4
Heart failure	3
Renal failure	1
Causes of patient mortality	
Heart failure	4
Renal failure	1
Cerebrovascular accident	1
Chest infection	1
Unknown	2
Total patient mortalities	9 (10)
Mean duration of hospital stay (d)	11.5 (range: 2-38)

RESULTS

Nine (10%) patients aged ≥80 years died within 4 to 6 months after fracture. Three (3.4%) patients were lost to follow-up; it is unknown if they are still alive. The remaining 75 (86%) patients (76 trochanteric nails) met the inclusion criteria of the study with a 2 year follow-up. Of these, 42 (56%) fractures were stable and 33 (44%) were unstable, respectively. Results are summarized in Table 2. The most frequent perioperative complications were surgical wound seroma and hematoma. One patient experienced a sensory deficit of the sciatic nerve due to excessive traction during surgical procedure, and the nerve recovered over a period of 35 days. No cases of superficial or deep wound infection were reported in this series. Fifty-two (68%) patients required perioperative blood transfusion, the average requirement being 1000 mL (range: 500-2000 mL). The mean hospital stay was 11.5 days (range: 2-38 days).

The mean postoperative neck-shaft angle on postoperative radiographs was 129° (range: 140°-122°), compared to 131° (range: 140°-125°) of the other side. The neck-shaft angle in 42 (55%) cases had a mean varus deformity of 2.7° (range: 1°-5°). Seven (9%) patients had a valgus deformity of 3° (range: 1°-6°) and in 27 (36%) patients, neck-shaft was symmetrical to the other side. The reduction was recorded with reference to four categories: 1) anatomical reduction was considered excellent; 2) in a gap between the two main fracture fragments at calcar level, <5 mm as good; 3) 5-10 mm was acceptable; and 4) ≥10 mm was unsatisfactory.

Using these criteria, the quality of reduction was judged excellent in 31 (41%) cases, good in 27 (36%) cases, acceptable in 14 (18%) cases, and unsatisfactory in 4 (5%) cases. Screws were positioned as depicted in Table 3.

The tip-apex distance averaged 18.9 mm (range: 4-35 mm).[21] More specifically, this distance was 8.7 mm (range: 2-17 mm) on AP and 10.2 mm (range: 2-18 mm) on lateral radiographs. By assigning acceptable screw position as inferior or central on the AP view and central or posterior on the lateral view, with a tip-apex distance <23 mm, optimal positioning was achieved in 42 (55%) cases. Forty-four patients had good leg screw position, but 2 patients had tip-apex distances >23 mm. Union

was observed radiographically in 97.4% of cases after an average of 3.2 months (range: 2-7 months) (Figures 2 and 3). Removal of the distal locking screw to dynamize the nail was never required.

Table 3
Intra- and Postoperative Position of Lag Screw

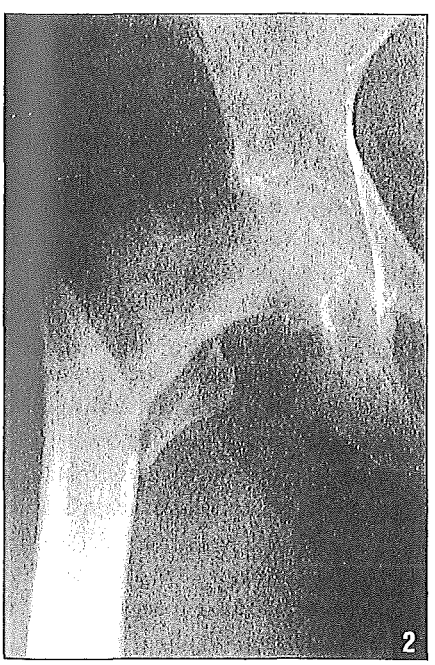
	AP Radiograph No. (%)		
Lateral Radiograph	Inferior	Central	Superior
Posterior	6 (8)	2 (3)	4 (5)
Central	23 (30)	21 (27)	3 (4)
Anterior	7 (9)	8 (11)	2 (3)

Two (2.6%) cases of complete cut-out were noted, representing the only two cases of union failure in this series. In particular, one occurred in a Kyle III fracture following a patient fall and another spontaneously, in a Kyle II fracture, due to extreme osteoporosis. Technical error occurred in both cases, with tip-apex distances >23 mm and uncorrected lag screw position. In one case (traumatic cut-out) tip-apex distance was 32 mm and 39 mm in the other. The position of the screw in the femoral head was superior on the AP view and central on the lateral view, respectively. The last case was a varus fracture type III and intraoperative reduction was such that the lag screw was placed superiorly in the femoral head. The first was treated with trochanteric nail replacement and the other with nail removal and cerclage wiring of the proximal femur. In one case, a proximal protrusion of the cephalic screw was observed without consequence about the fracture union. No occurrence of femoral shaft fracture was found.

At final follow-up, 47 (63%) of the 75 patients were able to walk without assistance, 19 (25%) required one crutch, and 9 (12%) required two crutches or a walker for ambulation. Twenty-eight of 47 patients able to walk presented with stable fractures, and 19 with unstable fractures, respectively. Sixty-six percent of patients with stable fracture, and 57% of patients with unstable fracture were able to walk without assistance at the last follow-up. The main reasons reported for the use of ambulatory aids were unrelated orthopedic problems or patient insecurity in 11 cases, gluteal insufficiency in 6, and pain in 2. Pain, as measured using the visual analog scale, was present in 7 (9%) patients, and was important (7 points) in 1. Pain was most commonly reported in the gluteal region (3 patients); while 2 patients reported pain in the groin, 1 over the greater trochanter, and 1 patient presented with pain in the greater trochanter and gluteal region.

Limb shortening was observed in 11 (14.4%) patients (8 patients with unstable fracture; 3 patients with stable fracture), measuring 5-14 mm. A shoe lift was necessary in 3 patients. Hip mobility was rated between 4 and 6 (mean: 4.6) according to the Charnley score. No difference was observed between stable and unstable patterns. Gait angle measured 7°-15° (mean: 9.4°). Significant rotational deformity was not observed in any patient.

Varus angulation of shaft neck angle was observed in the 69.7% of the cases with a deformity ≤9°. Valgus was present in 12% with a deformity ≤6°. Table 4 summarizes the results of patients evaluated at follow-up.



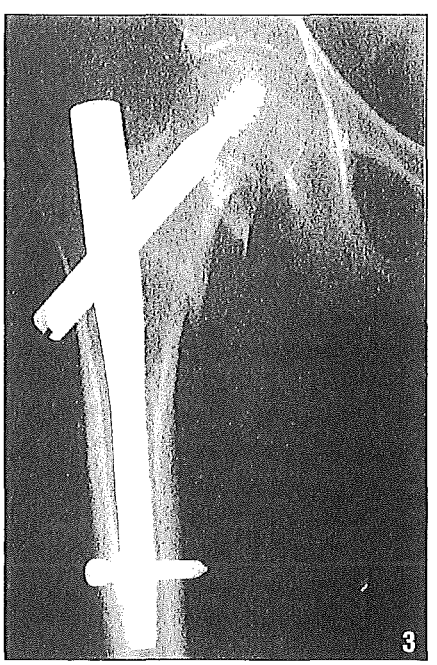


Figure 2: Intertrochanteric fracture Kyle type III. **Figure 3:** Radiograph control 14 months after surgery shows good healing of fracture.

DISCUSSION

The use of standard gamma nails started in 1991. Biomechanical studies have shown intramedullary devices to be superior to plating systems in treating unstable extracapsular fractures of the hip.[8,9] This implant offers several advantages combining a sliding lag screw for controlled fracture impaction and intramedullary fixation in the femoral shaft decreasing the bending moment arm of the loading forces on the implant by 25%-30% as compared with extramedullary devices, with a lower rate of implant failure and cut-out.[22]

The standard gamma nail implant treats very comminuted and unstable intertrochanteric fractures and those with subtrochanteric extension.[23] Controlled trials have shown a number of complica-

tions with the use of standard gamma nails (eg, technical problems,[15] fractures of the nail,[23,24] thigh pain in >10%,[10] and overall intraoperative[11,13-15] and late[11,12,15-18] diaphyseal fractures of the femur reported to range from 0%[10]-17%.[16] Postoperative fractures are serious complications, and usually require revision surgery.

This complication was attributed to insufficient reaming, use of oversized nail, distal interlocking difficulty, and use of hammer to put down the nail.[10,25,26] Otherwise, several studies have shown that by avoiding the use of a hammer and using a nail with smaller distal diameter, femoral shaft fractures were not completely abolished.[27] Fractures around or below the tip of the nail seem to be due to stress risers created by the excessive rigidity of the implant, compressive loads at tip of the nail, and also to a stress shielding phenomenon related to standard gamma nail shape. The 10° valgus of the nail does not match the shape of the femur, and therefore causes 3 point loading over medial cortex in the subtrochanteric region and lateral cortex at the tip of the nail.[14,28] Thus, some authors have suggested limiting the use of standard gamma nails to highly unstable fractures.[18,27,29] The trochanteric nail has been introduced in an attempt to overcome these complications. In the present study, neither post- nor intraoperative diaphyseal femoral fractures occurred among the 75 patients (76 fractures) evaluated at follow-up. The mediolateral 4° curvature of the trochanteric nail does not cause a 3 point loading to the femur, thus reducing the risk of shaft fractures. Moreover, it requires less bone removal for its insertion, and showed an increase in bone to implant contact.[30]

Only two (2.6%) cases of screw cut-out occurred, and these failures were the only complications requiring surgical revision. The percentage of this complication was similar to that of other reports on standard gamma nails.[10] Of these two cut-outs, one occurred after a fall and one spontaneously due to marked osteoporosis. Tip-apex distance in both cases was >23 mm. These results are evidence that the respective tip-apex distance and accurate lag screw positioning in the femoral head are important prognostic factors in preventing cut-out, independent from bone quality.[10]

In the present series, appropriate lag screw placement rate was reported in 55% of cases—most likely due to the relatively low experience levels of surgeons performing the procedures. Only five patients had lag screws in a risk position, such as superior on AP view (3 patients) and anterior on lateral view (2 patients).

The percentage of patients presenting with a varus deformity increased from 55% at the first follow-up to 69.7% in patients reviewed at final follow-up. Fifty-five percent of stable fractures and 88% of unstable fractures, respectively, showed healing in varus position. Moreover, the maximum deformity was 9° at final follow-up and 5° at the first follow-up. Changes occurred within bone, with no observable changes in the metal component. The angle in the nail remained unvaried. This finding may indicate that the bone settled on the femur, confirming the importance of bending force across the proximal femur,

Table 4
Follow-up Data for Patients Treated for Peritrochanteric Fracture

	No (%)	Stable Fracture	Unstable Fracture
Total patients	87		
Deceased	9 (10.3)		
Lost to follow-up	3 (3.4)		
Total available for review	75		
Total hips	76		
Mean follow-up (m)	24		
Mean tip-apex distance (mm)	19.1 (range: 4-39)		
Mean time of fracture consolidation (m)	3.2 (2-7)		
Complete cutting out	2 (2.6)	1 (50)	1 (50)
Reoperation	2 (2.6)	1 (50)	1 (50)
Femoral shaft fracture (beneath the nail)	0		
Union	74 (97.4)	41 (98)	44 (98)
Infection	0		
Patient ambulation			
Independent	47 (63)	28 (55.3)	19 (44.7)
One crutch	19 (25)	5 (26)	14 (73)
Two crutches or walker	9 (12)	1 (11)	8 (88)
Hip pain	7 (9)	2 (28.5)	5 (71.5)
Injured limb shortening; mean (mm): 9 (range: 5-14)	11 (14.4)	3 (27)	8 (73)
Mean Charnley hip mobility score	4.6 (range: 4-6)	4.8	4.4
Mean gait angle	9.4° (range: 7°-15°)		
Varus angulation; mean: 3° (range: 2°-9°)	53° (69.7)	22° (41)	31° (59)
Valgus angulation; mean: 4° (range: 1°-9°)	9° (12)	7° (77)	2° (23)

not only in unstable fractures but also in stable fractures as seen in the results of the present study. No published reports could be found analyzing the shaft-neck angle deformity after intramedullary fixation. No important rotational deformity was recorded in this study. Thigh pain was not an important problem and was observed in only 7 (9%) patients. This differs from other series where standard gamma nails were used and greater percentages of thigh pain were reported.[10] The trochanteric nail is a smaller implant. It generates less stress shielding in the proximal femur and uses only one locking screw instead of two. These characteristics of the trochanteric nail may be responsible for the decrease in percentage of thigh pain. Limb shortening was observed in 14.4% of the patients in the present study, and was important in only 3 patients. This does not differ greatly from other series that used standard gamma nails with or without distal locking.[10,17]

Overall, high mortality rates of these fractures remain a problem in elderly patients. In the present study, 10% of patients died within 4 to 6 months after fracture (average patient age: 81 years). These data are similar to those reported in other studies.[4,10] Often, patients with interthrocanteric fracture are older, in poorer health, and present with comorbid conditions that determine a high mortality[4] by surgery. The results of the present study are evidence of the trochanteric nail's promise as an alternative in the treatment of extracapsular femoral fractures, and its shorter length does not impede in the treatment of highly unstable intertrochanteric fracture.

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