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ORIGINAL ARTICLE

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Long gamma nail in the treatment of subtrochanteric fractures

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Abstract *Introduction:* The purpose of our study was to retrospectively evaluate the clinical and radiological results of subtrochanteric fractures treated with a long gamma nail (LGN). The LGN has been the implant of choice at our level-1 trauma center since 1992. *Materials and methods:* Over a period of 7 years, we have treated 90 consecutive patients with subtrochanteric fractures. In order to evaluate the clinical and radiological outcomes, we reviewed the clinical and radiographic charts of these patients followed for a mean time of 2 years (range 13–36 months). *Results:* We found no intra- or perioperative complications nor early or late infection. Clinical and radiological union was achieved at a mean of 4.3 months in all of the patients (range 3–9 months); in 24 cases (30%) the distal locking bolts were retrieved in order to enhance callus formation and remodeling as a planned secondary surgery. Three patients (3.3%) needed unplanned secondary surgery for problems related to the nailing technique. Two mechanical failures with breakage of the nail were encountered due to proximal varus malalignment, of which one was treated with exchange nailing and grafting and the other one by removal of the broken hardware, blade-plating, and bone grafting. One fracture below a short LGN was treated by exchange nailing. *Conclusions:* The minimally invasive technique and simple application of the LGN lead to a low percentage of complications in these difficult fractures after a relatively short learning curve. The biomechanical properties of this implant allow early mobilization and partial weight-bearing even in patients with advanced osteoporosis.

Keywords Subtrochanteric fracture · Long gamma nail · Femur

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Introduction

The key to the successful treatment of subtrochanteric fractures is the restoration of the most physiologic anatomy of the proximal femur. These fractures are known to be difficult to treat [3, 13], and a multitude of different intra- and extramedullary devices for their surgical fixation have been advocated in the past.

Plating requires large exposures with possible biological and biomechanical complications, and is technically demanding and time-consuming [7, 13, 15]. Intramedullary devices enable the surgeon to treat these fractures with a minimally invasive technique [3, 5, 7, 13] and have better biomechanical properties than extramedullary devices in the presence of these unstable fracture patterns [20].

In this study, we retrospectively analyzed the results of one teaching hospital with the use of the long gamma nail (LGN; Stryker-Trauma, Germany).

Patients and methods

Between February 1992 and March 1999, 90 consecutive patients suffering from traumatic subtrochanteric fractures underwent internal fixation with the LGN at the University Hospital of Lausanne. Sixty-five patients were women and 25 men. Their average age was 56 years, ranging from 24 to 84 years. Sixty-four fractures were due to high-energy trauma, while a simple fall was the cause in the remaining 26 patients. Pathological fractures were not included in this series. Thirty-four of the 90 patients had severe associated medical problems or injuries (Table 1). Subtrochanteric fractures were classified using the Seinsheimer Classification [24] (Table 1).

Fifteen different surgeons in varying stages of training performed the surgical procedure.

Implant and operative technique

After medical clearance, preoperative antibiotics were given to every patient. Surgery was performed in each case on a fracture table with condylar traction. The LGN used is a second-generation interlocking nail with a proximal diameter of 17 mm and a middle and distal diameter of 11 or 12 mm. The LGN is not a straight nail but has a medial-lateral curvature of 4°. Alternate LGN exist for the right and for the left side. A different length can be chosen, ranging from 340 mm to 440 mm in 20 mm steps. Different angles exist for the cephalic lag screw (125°, 130° or 135°), which has a diameter of 12 mm, depending on the neck-shaft angle as measured on the uninjured hip, or fluoroscopically after reduction of the fracture. If closed reduction was not possible due to the typical dislocation of the proximal fragment tilting into varus, anteflexion, and external rotation, open reduction and temporary fixation with a reduction forceps or cerclage wire were performed. For distal locking, two screws can be used to statically lock the nail.

Table 1 Preoperative data of 90 patients with subtrochanteric femoral fractures

Number of patients	90
Number of hips	90
Age (year)	56 (24–84)
Gender (M/F)	65/25
Fracture patterns:	
Seinsheimer type II	26
Seinsheimer type III	34
Seinsheimer type IV	17
Seinsheimer type V	13
Associated morbidities:	
Polytrauma	10
Osteomalacia	6
Neurological affection	4
Diabetes mellitus	5
Cardiovascular disease	9

Table 2 Types of long gamma nail used

Nail diameter	11 mm	49 patients	60%
	12 mm	41 patients	40%
Nail length	320 mm	20 patients	24%
	340 mm	16 patients	15%
	360 mm	17 patients	19%
	380 mm	18 patients	20%
	400 mm	19 patients	22%
Neck-shaft angle for cephalic screw	125°	29 patients	32%
	130°	38 patients	42%
	135°	23 patients	26%
Distal interlocking	1 bolt	5 patients	6%
	2 bolts	85 patients	94%

The entry point is first identified by palpation with the surgeon's index finger at the tip of greater trochanter, at the junction of the anterior third and posterior two-thirds, through the small, maximally 50 mm skin incision, followed by fluoroscopic control of the position of the target device before manual insertion of the guide rod. Using front-cutting drills, the shaft is reamed usually up to 13 mm (range 12.5–14 mm), while the trochanteric region is usually reamed up to 17 mm (range 15.5–18 mm). Insertion of the nail is done by hand without any force and specifically without the use of a mallet. Through a second short incision, the cephalic lag screw is inserted with the aid of the radiolucent targeting device and under fluoroscopic control after drilling with the step drill over the guidewire. Distal locking bolts are inserted using a targeting device mounted onto the fluoroscopy machine as a rule, because the freehand technique with the radiolucent AO drill is not allowed in our department to decrease exposure of the surgeons' hands to radiation.

In 85 patients (94%), standard distal interlocking with two screws took place, while in the remaining 5 patients one single bolt for distal interlocking was esteemed sufficient (Table 2).

Postoperatively, the patients were allowed early ambulation from the second day on with partial weight-bearing of 20 kg unless associated injuries or the general condition provided contraindications. This weight-bearing regimen was chosen because of the frequent instability of these fractures and to harmonize and simplify postoperative procedures. All patients received a deep vein thrombosis prophylaxis consisting of low molecular weight heparin (LMWH) followed by oral administration of coumarin for 6 weeks. Patients were clinically and radiographically followed by eight different surgeons, under supervision of the same senior surgeons, until fracture healing occurred. This was defined by painless weight-bearing and radiological callus formation on three cortices (Fig. 1). All of the patients were thereafter followed annually for up to 3 years.

No functional score was assessed, but all younger patients were able to at least walk independently.

Fig. 1a–c Images in a 35-year-old man who was involved in a car accident. Preoperative X-ray AP view (**a**), after healing (**b**), and after nail removal (**c**)

Results

Operative time varied between 58 and 115 min with a mean of 82 min. The mean fluoroscopic radiation time was 29 s (range 40–120 s). A closed surgical reduction was performed in all cases except 11. In these 11 patients, open reduction and cerclage wiring were necessary because of the impossibility of achieving an acceptable reduction by closed means and/or major instability with secondary displacement after open reduction. In 5 patients, the distal interlocking was technically demanding and took more than 45 min. We used two different diameters of nail, five different lengths with three different angles for the cephalic screw (Table 2).

No perioperative complications like severe hypoxia with fat embolism syndrome or acute respiratory distress syndrome due to the fracture or intramedullary nailing were found.

Neither early or late infection nor superficial or deep venous thrombosis was seen in our study group. Although all of the patients received blood thinners, no hematoma requiring drainage developed.

One single author reviewed all of the radiographs. Reduction was judged to be good in 52% of the cases, fair in 28%, and poor in 20% (good: less than 5 mm of fracture diastasis between main fragments, fair: 5–10 mm of fracture diastasis, and poor: more than 10 mm of fracture diastasis). The introduction point of the nail was ideal (on the tip of the greater trochanter) in 28 patients (31%), and the tip-apex distance (TAD) was on average 10 mm (range 4–27 mm) as defined by Baumgaertner and Solberg [4]; in particular, only 5 patients (5%) presented with a TAD of more than 25 mm.

Planned secondary surgery was undertaken in 24 patients (26%) at an average of 11 weeks after the index operation (range 10–15 weeks). In these patients, the distal interlocking bolts were removed under local anesthesia in an outpatient situation to successfully accelerate callus formation and callus remodeling.

Unplanned revision surgery was necessary in three patients (3.3%). In 2 patients, an implant failure with fracture of the LGN was encountered, treated once with exchange nailing and autologous grafting and once with hardware removal, blade plating, and homologous bone grafting. In one patient, a fracture just below an overly short LGN led to an exchange nailing. Uneventful healing of the fractures followed all of these revision surgeries.

Radiologically, we encountered one cutting-out of the cephalic screw; due to the age of the patient and her diminished mobility, no revision was indicated.

All of the fractures healed at a mean time of 4.3 months (range 3–9 months). After an initial time of partial weight-bearing (20 kg) for 10–90 days, the patients were bearing full weight after a mean of 40 days.

Clinically, the most frequent complication was leg shortening, which occurred in 31 patients (34%): 16 mm on average, with a maximum of 20 mm.

Discussion

Conservative treatment of subtrochanteric fractures as mentioned by DeLee et al. [9] is no longer an option in modern trauma care. Our improved understanding of the complex biomechanics of the subtrochanteric region as well as the development of ever better and more appropriate devices have led to improved results in the treatment of these often difficult fractures. A multitude of different intra- and extramedullary devices exist to deal with these fractures. On the extramedullary side, the most widely used implants are the 95° condylar blade plate [15, 18, 26]; the dynamic hip screw [17, 19, 21], the dynamic condylar screw [6, 23, 28], and the Medoff sliding plate [16]. All of these extramedullary implants have the potential disadvantage of extended soft-tissue damage with accompanying blood loss, difficulties in reduction, increased surgical time, nonunion, malunion, implant rupture, or pulling-out [6, 11, 13, 23, 28, 29].

Intramedullary devices have been shown to be biomechnically superior by different authors [5, 11, 26, 30, 31] because of unloading, due to its central position in both the medial and lateral cortex. Another important benefit of closed intramedullary nailing is the elimination of the absolute requirement of reconstitution of the medial cortex at the time of surgery [29].

Intramedullary devices of different generations are currently being used. First-generation nails without a cephalic screw are indicated for subtrochanteric fractures without any extension of the fracture into the piriformis fossa. In the presence of an extension of the fracture to the starting point of a first-generation nail, high rates of failure and complications have been described [7, 12, 15].

Second-generation nails or cephalomedullary nails, with the proximal interlocking screw in the femoral head, have been shown to have fewer limitations concerning proximal extension of the fracture (e.g., piriformis fossa) and have thus found an important place in the treatment of complex intertrochanteric and subtrochanteric fractures [1, 11, 12, 22, 25]. The LGN [2, 10, 11, 13] with its entry point through the tip of the greater trochanter circumvents the issue of piriformis comminution.

Although some articles [14] concluded that closed reduction of complex fractures of the proximal femur is difficult and anatomic reduction is required when reconstruction nails are being used, we have encountered only two (2.2%) implant failures. Failures of extramedullary and intramedullary devices in combination with varus deformity are well known [24, 27]. Careful attention has to be paid to the initial reduction and placement of the nail as varus malpositioning of the fracture or over distraction will significantly increase the risk of painful nonunion, deformity, and subsequent implant failure. In our series, the two implant failures were due to an unsatisfactory reduction of the neck-shaft angle with remaining varus malreduction. In order to prevent potential malalignment and these known possible complications, we performed open reduction and preventative cerclage wiring in 6 patients, with an uneventful postoperative outcome.

Some authors like Buchholz and Brumback [8] have mentioned the risk of secondary posterior displacement of the nail through the fracture site in the presence of proximal extension of the fracture. We did not encounter such a problem as we introduced the guidewire as well as the nail in a standardized fashion and under fluoroscopic control at the tip of the greater trochanter.

In 30% of our patients, planned secondary surgery was done to enhance fracture healing by interfragmentary compression. These numbers are higher than those reported in other series, such as Hotz et al. [13] with 16% and Barquet et al. [3] with 6%. We do believe that the distal dynamisation by removal of the distal locking bolts is a minor, low-demand procedure, which can be performed on an outpatient basis under local anesthesia. We have not encountered any problems related to this secondary procedure, especially no distal malrotation after dynamisation, probably due to the fact that this procedure was always performed later than 10 weeks after the index operation.

One fracture occurred below a short LGN. The tip of the nail was 12 cm above the knee joint line. It seems that the stress generated by the tip of the implant has the same characteristics as the traditional standard gamma nail or prosthesis, and care has to be taken to choose a nail of sufficient length. After exchange nailing with a longer LGN, the healing of the fracture was uneventful.

We noted only one cutting-out of the cephalic screw in our series with a TAD of 22 mm. Our mean TAD was 10 mm (range 4–27 mm), and our very low cut-out rate confirms the results of Baumgaertner and Solberg [4] who describe a significantly augmented risk of cutting-out of the cephalic screw if placed with a TAD above 25 mm.

Of major concern is the shortening of the operated limb, which occurred in 34% of our patients. As in other studies [2, 13], shortening was evaluated only clinically as we think that standardized radiographic measuring is technically difficult and imprecise and that clinical measuring in a standardized fashion is precise enough. This proportion is similar to that reported by Alvarez et al. [2] of 38% but higher than those found in other series [3, 13], probably due to our aggressive distal dynamisation protocol to augment interfragmentary compression. On the other hand, we judged that it was not always possible to achieve perfect anatomic reduction through noninvasive measures and that this is not a necessity, as mentioned by Dubrana et al. [10]. Loss of leg length has been described by other authors [3, 13] and is a known problem in the treatment of subtrochanteric fractures and generally well supported if the discrepancy does not exceed 2 cm.

In our series, we did not find a relation between implant failure and loss of reduction because of osteopenia. Like Alvarez et al. [2], we think the LGN provides enough stability to allow fracture healing and early ambulation with protected weight-bearing.

Protected weight-bearing was our standard postoperative regimen even though other series [13] described immediate full weight-bearing with a low complication rate. Although the LGN is mechanically strong enough to support rapid full weight-bearing, we tried to limit it. Postoperative weight-bearing status was standardized at our institution due to the variety of different surgeons, reductions, physiotherapists, and patients.

Our clinical series definitively shows that the use of the LGN leads to good results in the treatment of subtrochanteric fractures. In accordance with Hotz et al. [13] and Dubrana et al. [10], we maintain that the benefits of the LGN are its minimally invasive technique, its easier use in comparison to extramedullary implants, and the possibility of immediate partial weight-bearing. In order to reduce possible intraoperative complications, it is of the greatest importance to follow some simple guidelines. The use of the fracture table is mandatory to achieve a good reduction before starting the actual procedure. During the actual surgery, the entry point of the nail should be exactly on the tip of the greater trochanter, the distance from the joint space to the tip of the cephalic screw should be not more than 25 mm, and the introduction of the nail should be achieved manually and never by the use of a mallet. If closed reduction is not satisfactory, varus malalignment should not be accepted, and open reduction and temporary or definitive interfragmentary wire fixation should be used. The LGN is our implant of choice for subtrochanteric fractures, and the surgery is today performed by residents under supervision of more experienced teaching surgeons.

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