Original article

Subtrochanteric femoral fractures treated with the Long Gamma3® nail: A historical control case study versus Long trochanteric Gamma nail®

D. Georgiannis*, V. Lampridis, I. Bisinas

424 Military General Hospital, Peripheriaki Odos Efkarpias, PC 56429, Thessaloniki, Hellas, Greece

ARTICLE INFO

Article history:
Received 21 February 2015
Accepted 1st June 2015

Keywords:
Subtrochanteric fractures
Gamma3 nail
Intramedullary nailing
Complications

ABSTRACT

Background: Gamma nail was developed for the treatment of subtrochanteric hip fractures. Despite its advantages over extramedullary devices, gamma nail has been historically related to significant complications (implant breakage, femoral fractures at the tip of the nail). There is limited data to determine if the rate of these complications was minimized by using a new design of the gamma nail. Therefore we performed a case control study between the long gamma3 nail (LG3N) and the long trochanteric gamma nail (LTGN) to assess if: (1) the complication rate in the treatment of subtrochanteric fractures using the LG3N was lower than the one using the LTGN; (2) the reoperation rate was lower after using the LG3N.

Hypothesis: The complication rate after fixation of subtrochanteric fracture of the femur is lower with LG3N than with the LTGN.

Patients and methods: This study prospectively recorded the intra- and postoperative complications of 75 patients with subtrochanteric fractures treated with the LG3N and compared them with those of a historical cohort of 83 patients treated with the LTGN. The two groups were matched regarding age, gender and fracture type. Patients with open, pathological, or impeding fractures were excluded.

Results: Intraoperative complications in the LG3N group were lower (4 cases, 5.3%) compared with those in the LTGN group (9 cases, 10.8%; P = 0.04). The major intraoperative complication encountered with the use of LTGN was fracture of the femur in 3 cases. We encountered in total 9 postoperative complications in LG3N (12%) and 20 in group LTGN (24%). The most frequent complication in both groups was the cut out of the lag screw (3 cases in LG3N and 7 cases in LTGN group). The overall reoperation rate was higher in LG3N group (20.4% vs 10.6%; P = 0.03).

Conclusion: As a result of the improvement of its mechanical characteristics, LG3N has proved a safe and efficient implant for the treatment of subtrochanteric fractures. The new design seems superior to previous generation, giving promising outcomes, reduced mechanical complication rates, and reduced reoperation rate.

Level of evidence: Level III – case controlled study.

* Correspondence author. Tel.: +30 2310 381000; fax: +30 2313 059007.
E-mail address: EVI_DMb45@hotmail.com (D. Georgiannis).

1. Introduction

The long gamma nail (LGN) was introduced in 1992 (HOWMED-ICA – OSTENONICS, Rutherford, USA) and was used for subtrochanteric and combined trochanteric-diaphyseal fractures of the femur with good results [1,2]. The second generation, the long trochanteric gamma nail (LTGN), was introduced in 1997 with modifications of standard proximal diameter of 17 mm, distal diameter of 11 mm and reduced medio-lateral curvature from 10° to 4° [3]. These significantly decreased the rates of complications [4–6]. The latest modification, the LG3N (Stryker Trauma GmbH, Schonkichen, Germany), was introduced in 2003. In comparison with its predecessor, it is narrower proximally (15.5 mm), has a reduced antecurvature radius of R2.0 m of the femoral shaft and the same medio-lateral curvature, but with its apex positioned more distally. The lag screw shape has also been improved in the area of the thread and the cutting flutes at the tip of the screw.

The use of intramedullary devices has been the gold standard of treatment of subtrochanteric fractures in the recent years due to its advantages over extramedullary devices [7]. Despite its advantages, intramedullary nails have been related to significant complications, such as implant breakage and femoral fractures at the tip of the nail,
which eventually require revision surgery [8–11]. However, there is limited evidence specifically evaluating the outcomes following the use of LG3N in the treatment of subtrochanteric fractures.

The present case controlled study was prospectively designed to compare the complication and reoperation rates in the treatment of subtrochanteric fractures using the LG3N with those of a historical cohort treated with the LTGN. The goal of the study was to answer the following questions:

- is the complication rate in the treatment of subtrochanteric fractures using the LG3N lower than the one using the LTGN?
- Is the reoperation rate lower after using the LG3N?

Our working hypothesis was that the LG3N resulted in a lower incidence of intra- and post-operative complications compared to LTGN.

2. Patients and methods

2.1. Patients

Between 2007 and 2010, 75 patients with subtrochanteric fractures, were treated surgically with LG3N (group LG3N) (Fig. 1). The study was a prospective non-randomized study comparing with a historical control group (group LTGN), consisted of 83 patients treated with LTGN (Fig. 2) through the period 2000–2005.

Closed femoral fractures of the subtrochanteric region were included in the study and classified according to Seinsheimer classification [12] (Table I). Exclusion criteria were open and pathological fractures, prophylactic nailing, and fractures treated at the first year after the introduction of both implants in the Department (excluding the learning curve period for the surgeons).

2.2. Methods

All operations were performed by 4 orthopaedic specialists with global knowledge of the principles of intramedullary nailing and experience in the use of gamma nails. The method of treatment was similar to both groups. Patients were positioned supine on traction table and closed reduction of fracture obtained under fluoroscopic control. All LTGN and LG3N used were made of titanium alloy. The entry point was the same for both types of nail. It was first identi-fied 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 a small skin incision, following by fluoroscopic control of the position of the owl. Intramedullary canals were reamed

![Fig. 1. Right femoral subtrochanteric fracture Seinsheimer type III (A) treated with a LG3N (B).](image1)

![Fig. 2. Right femoral subtrochanteric fracture Seinsheimer type III (A) treated with a LTGN. Reduction and lag screw position considered as proper (B). 3 m postop AP radiograph revealed a good outcome with fracture union (C).](image2)
up to 13 mm distally for both nails and proximally up to 15.5 mm and 17 mm for LG3N and TGN respectively. Insertion of the nail was done by hand without any force and without the use of a mallet. Lag screw was inserted at a 130° angle, optimally in a position inferiorly to the neck in the AP plane and centrally in the lateral plane. Distal locking was achieved with free-hand technique. All patients were mobilized with full weight bearing on the first postoperative day.

2.3. Methods of assessment

The primary outcomes collected in the present study were intra- and post-operative complications. Patients’ demographics, mechanism of injury, fracture type, waiting time to surgery, operation time, fluoroscopy time, duration of hospital stay and mortality rate were also recorded as secondary variables. Patients were followed up at 6 weeks, 3 months and 1 year with clinical and radiological assessment. X-rays assessed for fracture reduction and the tip-apex distance (TAD) calculated (maximum follow-up at 3 years).

2.4. Statistical analysis

Statistical analysis using the unpaired student’s t-test and the Fisher’s exact test were applied to evaluate significant differences between the two groups (SPSS, version 11.5, SPSS Inc. Chicago, Illinois, USA). Statistical significance was defined at the 5% (P < 0.05) level. A sample size calculation was done using alpha at 5% and beta power at 80% with a baseline proportion at 20%, the study required 52 cases in each arm to detect a 20% difference in complication rate.

3. Results

The demographic data of the patients, the intra-operative variables and the radiological assessment are shown in Tables 2-4 respectively.

Four complications in group LG3N (5.3%) and 9 in group LTGN (10.8%) were reported intraoperatively (Table 5). The difference between the total number of intraoperative complications in the 2 groups was statistically significant (P=0.04). The major complications encountered with the use of LTGN, were 3 intraoperative fractures of femur. In 2 cases, the fracture was an undisplaced crack of the lateral cortex of the femoral shaft just distally to the tip of nail. These were treated conservatively with non-weight bearing mobilization until callus formation was seen on X-rays. One case of greater trochanter fracture was treated with partial weight bearing mobilization for 6 weeks. No femoral fractures were encountered in the LG3N group.

We encountered in total 9 postoperative complications in Group LG3N (12%) and 20 in Group LTGN (24%) (Table 6). There was significant difference between the 2 groups (P=0.04). The differences

### Table 1
Fracture pattern according to Seinsheimer classification [12].

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Group LG3N (n = 75)</th>
<th>Group LTGN (n = 83)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Undisplaced fractures with less than 2 mm displacement of the fractured fragments</td>
<td>–</td>
<td>–</td>
<td>NS</td>
</tr>
<tr>
<td>II</td>
<td>Two-part transverse or spiral fractures with the lesser trochanter attached to the proximal or the distal fragment</td>
<td>17 (22.66%)</td>
<td>20 (24.09%)</td>
<td>NS</td>
</tr>
<tr>
<td>III</td>
<td>Three-part spiral fractures in which the lesser trochanter is part of the third fragment or butterfly fragment</td>
<td>31 (41.33%)</td>
<td>35 (42.16%)</td>
<td>NS</td>
</tr>
<tr>
<td>IV</td>
<td>Comminuted fractures with four or more fragments</td>
<td>10 (13.33%)</td>
<td>9 (10.84%)</td>
<td>NS</td>
</tr>
<tr>
<td>V</td>
<td>Subtrochanteric-inter trochanteric fractures, including any subtrochanteric fracture with extension through the greater trochanter</td>
<td>17 (22.66%)</td>
<td>19 (22.89%)</td>
<td>NS</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant.

### Table 2
Demographic data.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group LG3N (n = 75)</th>
<th>Group LTGN (n = 83)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>59 (29–74)</td>
<td>62 (48–76)</td>
<td>NS</td>
</tr>
<tr>
<td>Gender ratio F:M</td>
<td>2.5:1</td>
<td>2.8:1</td>
<td>NS</td>
</tr>
<tr>
<td>Fall from ground level</td>
<td>73%</td>
<td>75%</td>
<td>NS</td>
</tr>
<tr>
<td>Road traffic accident</td>
<td>18%</td>
<td>17%</td>
<td>NS</td>
</tr>
<tr>
<td>Fall from height</td>
<td>9%</td>
<td>8%</td>
<td>NS</td>
</tr>
<tr>
<td>Mortality rate (1 year)</td>
<td>18.4% (n = 12)</td>
<td>21.9% (n = 16)</td>
<td>NS</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant.

### Table 3
Intraoperative variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group LG3N</th>
<th>Group LTGN</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting time, hours (mean)</td>
<td>12–58 (24)</td>
<td>10–52 (22)</td>
<td>NS</td>
</tr>
<tr>
<td>Surgical time, minutes (mean)</td>
<td>19–60 (43)</td>
<td>20–85 (48)</td>
<td>NS</td>
</tr>
<tr>
<td>Fluoroscopy time, seconds (mean)</td>
<td>25–65 (34)</td>
<td>27–87 (45)</td>
<td>S (&lt;0.001)</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant; S: significant.

### Table 4
Radiological assessment.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group LG3N</th>
<th>Group LTGN</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiological reduction</td>
<td>18 (24%)</td>
<td>19 (22.9%)</td>
<td>NS</td>
</tr>
<tr>
<td>Anatomic</td>
<td>34 (45.3%)</td>
<td>39 (47%)</td>
<td>NS</td>
</tr>
<tr>
<td>Acceptable</td>
<td>23 (30.7%)</td>
<td>25 (30.1%)</td>
<td>NS</td>
</tr>
<tr>
<td>Poor</td>
<td>18 (12–25)</td>
<td>17 (13–24)</td>
<td>NS</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant; TAD: tip-apex distance.
between the 2 groups for postoperative femoral fractures, nail
breakage, distal screw breakage, loss of reduction and non-union
were not significant. The difference in lag screw cut out com-
pliation was statistically significant (P = 0.03). Femoral fracture
occurred postoperatively in 2 patients of group LTGN, follow-
ing a fall. Both sustained a fracture just distal to the tip of the nail
and were treated with an open reduction and internal fixation. In
two cases, a LTGN failed at the junction of nail with the lag screw, 4
and 6 months postoperatively, due to delayed union. The nails were
revised to DCS and the fractures healed uneventfully 4 months after
revision operation (Fig. 3).

The most frequent complication in both groups was the cut-out
of the lag screw (3 and 7 cases respectively) which resulted in
re-operation in 3 cases of group LG3N (1 total hip replacement and
2 hemiarthroplasties) and in 6 cases of group LTGN (1 total hip
replacement, 3 hemiarthroplasties and 2 DCS) (Fig. 4). The position
of the lag screw was considered optimal (inferiorly in AP/cen-
trally in lateral plane) in 2 out of the 3 failed cases in group LG3N
and in 5 out of the 7 failed cases in group LTGN (P = 0.04). In group LG3N,
loss of reduction was occurred in 2 cases (treated with DCS) and
nonunion in 3 cases of subtrochanteric fracture which were treated
by revision with a LG3N and bone grafting. In group LTGN, nonunion
rate was higher (4 cases) and all were treated with revision nailing
and bone grafting. Loss of reduction occurred in 3 cases, which were
treated with open reduction and fixation with a DHS.

The overall re-operation rate was 10.6% (8 cases) for group LG3N
and 20.4% (17 cases) for group LTGN, as it is shown in Table 7.
The difference of re-operation rates between the two groups was
significant (P = 0.03).

4. Discussion

Our study provides new data regarding the use of LG3N in sub-
trochanteric fractures. The later design seems superior to previous
generations, with reduced intraoperative and postoperative com-
pllication rates.

The main limitation of this study is the use of a historical cohort
as the control group. However, the two groups were matched
regarding the age, gender and fracture type. All the operations
were performed by the same group of experienced surgeons and
the operations within a learning curve period were excluded,
thus we believe that this increases the strength of the study and

Table 5
Intraoperative complications.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group LG3N (n = 75)</th>
<th>Group LTGN (n = 83)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral fracture</td>
<td>–</td>
<td>3</td>
<td>S (P = 0.03)</td>
</tr>
<tr>
<td>Perforation of acetabulum by the threaded guide wire</td>
<td>4</td>
<td>6</td>
<td>NS</td>
</tr>
<tr>
<td>Total</td>
<td>4 (5.33%)</td>
<td>9 (10.84%)</td>
<td>S (P = 0.04)</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant; S: significant.

Table 6
Postoperative complications.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group LG3N (n = 75)</th>
<th>Group LTGN (n = 83)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral fracture</td>
<td>–</td>
<td>2</td>
<td>2.4% NS</td>
</tr>
<tr>
<td>Nail breakage</td>
<td>–</td>
<td>2</td>
<td>2.4% NS</td>
</tr>
<tr>
<td>Lag screw cut out</td>
<td>3</td>
<td>4%</td>
<td>8.4% S (P = 0.03)</td>
</tr>
<tr>
<td>Distal screw breakage</td>
<td>1</td>
<td>1.3%</td>
<td>2.4% NS</td>
</tr>
<tr>
<td>Loss of reduction</td>
<td>2</td>
<td>2.2%</td>
<td>3.6% NS</td>
</tr>
<tr>
<td>Non-union</td>
<td>3</td>
<td>4%</td>
<td>4.8% NS</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>12%</td>
<td>15.6% S (P = 0.04)</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; NS: not significant; S: significant.

Fig. 3. Preop (A) and postop (B) AP radiographs of a subtrochanteric fracture Seinsheimer IV of left femur treated with LTGN. Reduction considered as poor. 4 m postop AP view revealed breakage of the nail (C) which revised with a DCS (D) with good results.
minimized the impact of this limitation. The second limitation is the number of patients withdrew before the final follow-up at one year due to many patients with concomitant illnesses affecting their general health and a mean mortality rate at 1-year of 20.1%. Nonetheless, drop-out rate was comparable between the two groups, minimizing bias in the interpretation of the results, and sample and power calculations confirmed the validity of our results. Finally, comparing our series with the literature was challenging, as subtrochanteric fractures are not well differentiated from the other per trochanteric femoral fractures and there is a lack of studies regarding LG3N in the literature.

Fracture of the femoral shaft is a known complication and in previous studies, up to 8% incidence has been reported for TGN [1,4,6,13,14]. Fracture around or below the tip of the nail seem to be due to stress risers created by the rigidity of the implant and compressive loads at the tip of the nail [3]. In this study, 5 femoral fractures (6.05%) occurred in the historical cohort of LTGN (3 intraoperatively and 2 postoperatively). No fracture of the femur occurred in the LG3N group, which is lower than the results from other studies on G3N, which had a reported incidence of 1% [15,16]. Insufficient reaming or use of a hammer could increase the risk for this complication [1,3]. As we strictly adhered to the original surgical technique and the industrial recommendations, we attributed the lower rate of the femoral shaft fractures to the modifications and improvement of mechanical characteristics of the new design, namely the decreased proximal diameter which requires less reaming and the distally positioned apex of the medio-lateral curvature of the nail which reduces the three-point loading at the femoral shaft [3].

Breakage of the gamma nail at the junction of the nail with the lag screw is reported in the literature with an incidence of up to 5.7% [8,9,16]. In this study, none of the LG3N failed, in contrast with 2 LTGN broken nails (2.4%). It is known that the weak point of this implant is around the insertion hole for the lag screw where the cross-sectional area is reduced by approximately 73%. This is a critical zone where forces coming from the femoral neck are transmitted to the diaphyseal nail [8]. We believe that the decreased incidence of failure of the nail was attributed to the reduction of the lag screw diameter from 12 mm to 10.5 mm. Therefore the aperture is smaller and thus the nail would be thicker in this area and less prone to failure. Delayed union/nonunion at the fracture site was the trigger factor for both the implant failures. The cause of breakage was metal fatigue due to dynamic stress [9,17].

The most frequently occurring complication was the cut-out of the lag screw through the femoral head, 4% and 8.4% in group LG3N and group LTGN respectively. Our results were similar with the results of other studies showing an incidence rate up to 9.72% for the TGN and up to 4% for G3N [1,3,5,6,14,15,18]. Lag screw cut-out has been shown to be dependent on the position of the screw within the femoral head. Optimizing the TAD is critical in preventing fixation failure when using an extramedullary sliding hip screw to fix per trochanteric fractures [19]. A recent study suggests that placement of the lag screw of the gamma nail inferiorly in the AP plane and centrally in the lateral plane (achieving TAD < 25 mm) maximizes biomechanical stiffness and load-to-failure [20,21]. The position of the lag screw was considered optimal (inferiorly in AP/centrally in lateral plane) in 2 out of the 3 failed cases in group LG3N and in 5 out of the 7 failed cases in group LTGN (P = 0.04). In the remainder of the failed cases, the position was considered suboptimal (centrally in AP/centrally or anteriorly in lateral plane). Therefore, we attributed the lower rate of cut out complication to the improvement of lag screw design, especially in the area of the thread and the cutting

<table>
<thead>
<tr>
<th>Data</th>
<th>Femoral fracture</th>
<th>Implant failure</th>
<th>Lag screw cut out</th>
<th>Loss of reduction</th>
<th>Non-union</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group LG3N n = 8 (10.6%)</td>
<td>–</td>
<td>–</td>
<td>3</td>
<td>2 DCS</td>
<td>3 LG3N &amp; graft</td>
</tr>
<tr>
<td>Group LTGN n = 17 (20.48%)</td>
<td>2</td>
<td>ORIF</td>
<td>revision DCS</td>
<td>3 DHS</td>
<td>4</td>
</tr>
<tr>
<td>S (P = 0.03)</td>
<td>1 Biportal</td>
<td>1 Biportal</td>
<td>3</td>
<td>3 LGTN &amp; graft</td>
<td>1 LGTN</td>
</tr>
</tbody>
</table>

LG3N: long gamma3 nail; LTGN: long trochanteric gamma nail; S: significant; ORIF: open reduction and internal fixation; DCS: dynamic compression screw; DHS: dynamic hip screw.
flutes at the tip of the screw. This design offers superior cutting behavior during lag screw insertion, providing very low insertion torque. The thread design also offers excellent grip in the cancellous bone of the femoral head and strong resistance against cut out. The option of the helical blade that exists in other intramedullary devices has improved biomechanical properties and can further decrease the cut out rate [22].

Quality of reduction of subtrochanteric fractures is an important factor that interferes significantly to prevent complications such as cutout, implant breakage and nonunion. Type of reduction frequently obtained with subtrochanteric fracture is rather poor or acceptable than anatomic [1]. Our results regarding quality of reduction were not statistically different between the two groups. They were comparable to results of other studies [23], so we believe that the universally accepted interference of poor reduction to post-operative complications, although still present, was dramatically decreased in our study.

The rate of re-operation after complications with the LG3N was 10.6%, which was higher than the 5.56% rate reported in other study, attributed to inclusion of subtrochanteric fractures only [24]. The rate of implant-related complications that required re-operation after primary use of the LTGN was 20.48%. It is in accordance with previously reported results ranging from 8% to 17.6% [5,13,14,18,24,25].

5. Conclusion

Within the limits of this study, gamma-3 nail has been proved a safe and efficient implant for the treatment of subtrochanteric fractures. Although appropriate reduction is still prerequisite for good results, the new design seems superior to previous generation, giving promising outcomes and reduced mechanical complication and reoperation rates.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References