THE GAMMA NAIL FOR PERITROCHANTERIC FRACTURES

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The Gamma nail was designed to treat unstable intertrochanteric and subtrochanteric fractures. The device was developed after cadaver studies and has been used clinically since February 1985 in a total of 421 patients. The results in 123 patients treated by the third version of this design are reported.

The Gamma nail transmits weight closer to the calcaneus than does the dynamic hip screw and it has greater mechanical strength. A semi-closed operative technique is used, with an average duration of operation of 35 minutes and little blood loss. Distal locking screws can be used to maintain rotational stability, and can be inserted without the use of an image intensifier.

Results showed satisfactory fracture union with little loss of position, even in comminuted fractures. Operative complications were few, but included fractures of the base of the greater trochanter. The most important postoperative complication, seen in one case, was fracture of the shaft of the femur at the distal end of the nail, but this healed well after re-nailing.

Unstable intertrochanteric and subtrochanteric fractures are difficult to fix and can present problems in management (Esser, Kassab and Jones 1986; Bergman et al 1987; Chang et al 1987). The most common current method of fixation uses a large screw in the femoral head secured to a plate on the lateral aspect of the upper femur. This has the disadvantage that the plate is lateral to the line of load-bearing. Any defect in the medial cortex of the femur, due to imperfect reduction, comminution or a metastasis, means that a varus stress will be applied to the fixation with every weight-bearing step. This may cause cutting-out of the screw from the head of the femur (Davis et al 1990) or failure at the nail–plate junction or of the screws securing the plate to the bone (Waddell 1979; Amis, Bromage and Larvin 1987).

The use of the Zickel nail meets some of these objections, but it is difficult to insert and has its own complications, such as fracture of the base of the greater trochanter. The Gamma nail was accordingly developed in an attempt to overcome some of these problems.

DESIGN AND DEVELOPMENT

The Gamma nail has three main components: an intramedullary rod passed down the upper shaft of the femur, a screw passed through a hole in the proximal part of the rod and inserted into the head, and a set screw which prevents rotation of the main screw. It was designed for semi-closed insertion.

A prototype was produced after wax studies had been made of the shape of the femoral canal in eight cadavers, and was tested on other cadavers.

Mark-1 design. After some modifications the mark-1 version (Fig. 1a) was used in 100 patients. The results were, in general, satisfactory but there were three main complications:

1) fracture of the greater trochanter, caused by excessive medial curvature of the implant;
2) late coxa vara deformity due to disengagement of the shoulder of the hip screw; and
3) external rotation deformity caused by rotation of the rod within the femoral shaft.

Mark-2 design. The implant was accordingly modified:

1) the medial curvature of the nail was reduced;
2) the shoulder of the hip screw was extended proximally; and
3) the facility to use distal locking screws was added (Fig. 1b).

The distal locking screw was used for spiral subtrochanteric fractures, to control the length and rotation of comminuted fractures, and for disparity between the diameter of the nail and femur producing poor control of rotation. Another modification to the hip screw allowed an increase in fracture compression, helping to prevent its penetration through the head of the femur. This second-generation nail was used in 19 pilot centres throughout Europe (Bridle et al 1991).

Mark-3 design. The results of these clinical studies led to further modifications: the nail was shortened by 20 mm, to 200 mm, and nails of three distal diameters, 12, 14 and
The evolution of the Gamma nail. The mark-1 design (A) had a greater angle and the shank of the femoral neck screw was narrower (arrow). Mark 2 (B) had a smoother curve and a uniform shank diameter. It was longer (220 mm) and had provision for distal interlock. Mark 3 (C) was similar to the previous version but was shorter (200 mm) and had a universal set screw.

16 mm, were provided. The third version of the nail has been in use since May 1988 (Fig. 1c), and the first 123 cases treated in this way are reported.

**PATIENTS AND METHODS**

We treated operatively a total of 156 patients with intertrochanteric or subtrochanteric femoral fractures at the Royal Halifax Infirmary from May 1988 until January 1991. During this period 25 intertrochanteric and eight subtrochanteric fractures were treated by other methods, when expertise in the use of the Gamma nail was not available. The mean age of those treated by the Gamma nail was 80.1 years (19 to 100). There were 100 women and 23 men with a follow-up of at least one year. Intertrochanteric fractures were classified according to Jensen (1980), and had the distribution shown in Figure 2. Two intertrochanteric fractures were pathological and one subtrochanteric fracture was in Pagetic bone. Details of all patients were recorded prospectively including blood loss, drainage and transfusion required. The duration of image intensification was monitored. Patients were reviewed at six weeks, three months, six months and one year after injury, with clinical and radiographic assessment of the progress of healing and of complications.

**Operative technique** (Halder et al 1991). The fracture is reduced on an orthopaedic table by traction and internal rotation of 10° to 15°, with the limb in a neutral or a slightly adducted position to allow access to the greater trochanter. A small incision is made over the tip of the greater trochanter which is broached at the correct site, using a double-action drill over a 3.2 mm guide wire passed as far as the lesser trochanter. The femoral shaft is then reamed with a flexible reamer until the cortex is engaged. Care is required not to over-ream in patients with porotic bone. The proximal end of the femur as far as the lesser trochanter is reamed to 17 mm to accommodate the proximal part of the nail. A Gamma nail with shaft diameter about 2 mm less than the final reamer is selected, assembled on the jig and inserted by hand until the lowest part of the hip screw hole is seen on the image intensifier to be level with the lesser trochanter or the inferior border of the neck. During the introduction of the nail the jig is kept parallel to the floor or in slight retroversion. A small lateral incision is then made at the level of the introducer hole of the hip screw in the jig and deepened to bone. A soft-tissue guide sleeve followed by a guide wire is inserted.

The position of the guide wire is then checked on anteroposterior and lateral views. If it is unsatisfactory the guide wire is removed and the nail partially withdrawn...
for adjustment of rotation and re-insertion. When the
position of the guide wire is satisfactory a cannulated
drill is passed over it to reach the subchondral bone of
the femoral head. A hip screw of appropriate length is
then introduced and locked by a set screw.

When distal locking screws are required they are
introduced in a similar manner.

A spiral subtrochanteric fracture which cannot be
reduced by a closed technique is managed by open
reduction and circumferential wiring before a Gamma
nail is inserted in the usual way. Provided that the
postoperative radiograph shows adequate reduction and
a satisfactory nail position, patients are allowed to walk
with full weight-bearing as soon as comfort permits.

RESULTS

The mean follow-up of 123 patients was 21.7 months (12
to 31), and details of these are shown in Table I. The
duration of the operation, image intensifier time, and
operative blood loss are given for the three types of
fracture in Table II, as is the use of distal locking screws.
Subtrochanteric fractures took longer, required more
image intensifier time and bled more than intertrochan-
teric fractures.

The radiological results in 71 cases are shown in
Table III. There were no fatigue fractures or implant
failures. Thirty-eight fractures healed with no loss of
position. In 22 patients there was axial as well as lateral
compression at the fracture site, but no subtrochanteric
fracture showed shortening of more than 4 mm. Apart
from one case of nonunion, there was satisfactory healing
in all cases, including those with severely comminuted
fractures (Fig. 3).

The main intra-operative complications were small
iatrogenic fractures of the base of the greater trochanter

<table>
<thead>
<tr>
<th>Table I. Details of 123 patients treated by Gamma nailing</th>
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<tbody>
<tr>
<td>Fracture</td>
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<tr>
<td>Age (years ± sd)</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Mental status</td>
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<tr>
<td>Normal</td>
</tr>
<tr>
<td>Impaired</td>
</tr>
<tr>
<td>Walking</td>
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<tr>
<td>Unaided</td>
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<tr>
<td>Stick</td>
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<tr>
<td>Frame</td>
</tr>
<tr>
<td>Unable</td>
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<tr>
<td>Source of admission</td>
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<tr>
<td>Own home</td>
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<tr>
<td>Old people's home</td>
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<tr>
<td>Nursing home</td>
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<tr>
<td>Hospital</td>
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<th>Table II. Operative details for 123 patients treated by Gamma nailing</th>
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<tr>
<td>Intertrochanteric</td>
</tr>
<tr>
<td>Age (years ± sd)</td>
</tr>
<tr>
<td>Duration of operation (mins ± sd)</td>
</tr>
<tr>
<td>Image intensifier (mins ± sd)</td>
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<td>Blood loss (ml ± sd)</td>
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<td>Distal screws (number of cases)</td>
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<table>
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<tr>
<th>Subtrochanteric</th>
<th>Total</th>
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<tbody>
<tr>
<td>Stable</td>
<td>10</td>
</tr>
<tr>
<td>Unstable</td>
<td>2</td>
</tr>
<tr>
<td>Subtrochanteric</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
</tr>
</tbody>
</table>

| No change in position | 11 | 17 | 10 | 38 |
| Compression by 1 to 4 mm | 5 | 15 | 2 | 22 |
| Fracture of greater trochanter | 0 | 3 | 0 | 3 |
| Varus angulation | 1 | 2 | 0 | 3 |
| Screw cut-out | 0 | 1 | 1 | 2 |
| Postoperative shaft fracture | 0 | 1 | 1 | 2 |
| Nonunion | 0 | 1 | 0 | 1 |
Comminuted combined intertrochanteric and subtrochanteric fracture, showing fixation by a Gamma nail using a closed technique and distal locking screws to maintain rotation and length.

during operation. These were seen in three cases, but did not influence healing because the femur was adequately immobilised by the implant. There was a mild coxa vara deformity in three cases.

In two cases the hip screw cut through the femoral head superiorly: one was after revision from a previous pin and plate; the other was in a pathological fracture due to a metastasis from carcinoma of the breast. Two patients sustained postoperative fractures at the lower end of the prosthesis. One had penetration of the anterior cortex of the femur during operation; the other fell out of bed at six weeks and sustained a spiral fracture of the femur. Both were treated by the insertion of a long version of the Gamma nail with good results (Fig. 4). There were no cases of deep infection, and two superficial infections settled with oral antibiotic therapy. The postoperative mortality was high, as expected in this age group of patients, 12.2% within one month and 30.1% within one year, and there was the usual range of medical complications including pneumonia, congestive heart failure, deep-vein thrombosis and myocardial infarction.

DISCUSSION

For peritrochanteric fractures of the femur pin and plate fixation (Bannister and Gibson 1983; Esser et al 1986) has been replaced by a variety of dynamic compression screw plates. These give satisfactory results in most stable fractures, but in unstable fractures, where the postero-medial fragment has not been reduced anatomically, there is impaction with shortening of the neck of the femur (Templeton and Saunders 1979; Chang et al 1987; Davis et al 1990). This shortens the leg and reduces the lever arm of the hip abductors. Most of the body-weight is transmitted down the calcar, and a plate supporting either nail or screw must be some distance lateral to the weight-bearing line. It is therefore under considerable tension (Esser et al 1986; Chang et al 1987; Friedl et al 1987). An intramedullary device is very close to the calcar, subject to less tension, and is more stable.
Intramedullary devices such as the Enders nail (Kuo-
kanen, Korkala and Lauttamus 1986; Waddell, Czitrom and Simmons 1987; Sernbo et al 1988) and the Zickel
nail (Ashby and Anderson 1977; Bergman et al 1987)
have been tried but technical difficulties make their use
uncommon (Waddell 1979; Ross and Kurtz 1980).

The Gamma nail allows semi-closed fixation of these
fractures, facilitating union without major changes in
proximal femoral anatomy. Some comminuted fractures
(Jensen types 4 and 5) showed an increased tendency to
varus deformity, but in most cases there was no
subsequent displacement even in very porotic bone.
In some cases, marked comminution and poor bone quality
resulted in excessive compression at the fracture and
mild varus deformity.

Stability can be achieved without anatomical reduc-
tion of the posteromedial comminuted fragment, and
distal locking provides control of rotation in unstable
fractures, especially the difficult subtrochanteric spiral
type (Fig. 3). The distal screws can be inserted without
the use of image intensification.

In the 123 cases reported, complications were few,
the commonest being fracture around the greater
trochanter, which did not influence the course or final
outcome. To minimise this and other complications
during the learning phase and in patients with porotic
bone, the following considerations are important (Bridle

1) Exact placement of the guide wire. It must enter the
greater trochanter at the junction of its anterior third and
posterior two-thirds, just lateral to its tip.
2) Special care in the presence of abnormal or excessive
curvature of the femoral shaft.
3) No attempt to correct malaligned drill holes before
inserting distal screws.
4) Selection of a nail 2 mm narrower than the reamer.
5) Correction of rotational alignment of the nail by partial
withdrawal and re-introduction, not by twisting it in the
engaged position.

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