GAMMA NAILS AND DYNAMIC HIP SCREWS FOR PERITROCHANTERIC FRACTURES

A RANDOMISED PROSPECTIVE STUDY IN ELDERLY PATIENTS

K. S. LEUNG, W. S. SO, W. Y. SHEN, P. W. HUI

From the Prince of Wales Hospital, Hong Kong

The Gamma nail was introduced for the treatment of peritrochanteric fractures with the theoretical advantage of a load-sharing femoral component which could be implanted by a closed procedure. We report a randomised prospective study of 186 fractures treated by either the Gamma nail or a dynamic hip screw.

Gamma nails were implanted with significantly shorter screening times, smaller incisions, and less intra-operative bleeding. The Gamma nail group had a shorter convalescence and earlier full weight-bearing, but there was no significant difference in mortality within six months, postoperative mobility, or hip function at review. More intra-operative complications were recorded in the Gamma nail group, mainly due to the mismatching of the femoral component of the nail to the small femurs of Chinese people. Use of a smaller modified nail reduced these complications.

We conclude that with careful surgical technique and the modified femoral component, the Gamma nail is an advance in the treatment of peritrochanteric fractures.

The early operative treatment of peritrochanteric fractures in geriatric patients is now accepted practice and numerous versions of a sliding nail-plate system (Lentz 1986) are the most widely used implants. Complications are, however, still common (Doherty and Lyden 1979; Matthews, Sonstegard and Dumbleton 1981; Wolfgang, Bryant and O'Neill 1982; Manoli 1986; Amis, Bromage and Larvin 1987; Tronzo 1987; Simpson, Varty and Dodd 1989; Davis et al 1990).

Problems include the need for considerable dissection and the lateral fixation of the side plate. The Gamma nail (Howmedica International, Staines, Middlesex, England) was introduced to provide a sliding lag screw and intramedullary fixation in the femoral shaft. This medialises the femoral component of the fixation and also enables insertion by a semi-closed procedure. The theoretical advantages of minimising the surgical trauma, allowing guided impaction and decreasing the lever arm of the loading force are clear.

We report the results of a randomised prospective

study which compared the use of Gamma nails and dynamic hip screws in elderly patients with trochanteric fractures.

PATIENTS AND METHODS

All patients over 65 years of age with peritrochanteric fractures were included, recording their premorbid mobility, medical diseases, and social background. Fractures were classified as peritrochanteric or intertrochanteric with or without subtrochanteric extension. Purely subtrochanteric fractures were excluded. Fracture stability was assessed by the methods of Evans (1949) as modified by Jensen (1980b).

Our treatment protocol for elderly patients with hip fractures included the routine investigation of arterial blood gases, haemoglobin levels, renal function, electrocardiography and chest and pelvic radiography. Any medical problems were treated with the help of physicians and anaesthetists, so that surgery could be carried out as soon as possible. All patients had prophylactic intravenous cefazolin.

Operative technique. Operation was under either general or spinal anaesthesia, with the patient in the supine position on a traction table. An accurate closed reduction (Leadbetter 1933) was done under fluoroscopic control, and maintained by traction with a boot. Slight lateral flexion of the trunk was used to gain better access to the greater trochanter.

Fixation was randomly assigned according to the sequence of admission: dynamic hip screws were inserted by a standard technique (Regazzoni et al 1985) and

K. S. Leung, MD, FRCS, Senior Lecturer and Consultant in Traumatology
W. S. So, FRCS, Senior Medical Officer
W. Y. Shen, FRCS, Lecturer
P. W. Hui, PhD, Scientific Officer
Department of Orthopaedics and Traumatology, Prince of Wales Hospital, Shatin, New Territories, Hong Kong.

Correspondence should be sent to Dr K. S. Leung.

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Fig. 1

Determination of the anteversion of the femoral neck by percutaneous insertion of Kirschner wire.

Fig. 2

The handle of the nail mount is kept parallel to the Kirschner wire in the coronal plane during insertion of the Gamma nail. Inset shows the ideal position of the lag screw in the inferior half of the femoral neck.

Gamma nails by a method slightly modified from that recommended by Grosse and Taglang (1990).

Gamma nailing. With an image intensifier giving a lateral view, a 2 mm Kirschner wire is passed percutaneously, anterior to the femoral shaft and parallel to the axis of the femoral neck (Fig. 1). This shows the anteversion angle, ensuring the correct position of the lag screw in the femoral head and neck.

A 6 to 8 cm incision is made, centred just above the tip of the greater trochanter, and the medullary canal is entered by a reamer guide. The medullary cavity of the shaft is then reamed to 1 mm larger than the diameter of the intended nail, with over-reaming of the trochanteric region by 2 to 3 mm in a stepwise manner. The selected nail is mounted and passed into the femoral canal without hammering, keeping the handle of the mount parallel to the Kirschner wire (Fig. 2). When the nail is in the

correct position, the corresponding targeting device is assembled on the nail mount, the lateral cortex of the femur is perforated by the awl and the lag screw guide wire is inserted through its centring sleeve until its tip reaches the subchondral bone of the femoral head. The guide wire should be placed in the inferior half of the head and neck in the frontal view and centrally in the lateral view. The track for the screw is then prepared by the triple reamer, and the screw inserted to 5 mm from the subchondral line. The set screw is then positioned. Distal locking of the nail is indicated for unstable fractures; these screws can be inserted with the same targeting device.

Immediate mobilisation with full weight-bearing is started as soon as the patient's general condition allows. Discharge from hospital was when independent walking was possible with or without walking aids. Patients were reviewed and radiographed at six weeks, three months and six months after the operation.

Assessment. Our assessments included the ease of operation, its duration, the total duration of radiographic screening and the intra-operative blood loss. The last was calculated from the number of units of blood transfused multiplied by the difference in haemoglobin levels before and after operation less the volume of postoperative drainage. This calculation assumed that the average volume of blood per unit transfused was 350 ml and that 500 ml of blood loss caused a 1 g decrease in haemoglobin level.

Clinical assessments included postoperative walking ability, hip function, fracture healing and the implant and bone interactions. Sliding of the lag screw was measured on serial films using the method described by Doppelt (1980), with minor modifications for the Gamma nails.

Statistical analysis. Statistical analysis was performed by PWH, who had no part in the treatment of the fractures. Patients were considered in two subgroups; those with stable and those with unstable fractures. Within each group, patients with dynamic hip screws were compared with those fixed with Gamma nails.

Student's *t*-test was used for variables measured on an interval scale and the Wilcoxon rank-sum test for those on an ordinal scale. For data on a nominal scale, we used either a chi-square test or Fisher's exact test. The difference between two treatments is considered to be statistically significant when $p < 0.05$.

RESULTS

Of the 225 peritrochanteric fractures treated during the period of study, 12 were in patients who died within four weeks (Table I), and 28 in those who died within six months (Table II). These exclusions left 185 patients with 186 fractures followed up for six to 12 months. The average follow-up for 93 dynamic hip screws was 6.8 months and for 93 Gamma nails 7.5 months. Details of

Fig. 3

Fracture of the lateral cortex during insertion of the nail in a stable trochanteric fracture. Distal locking was always performed after such a fracture.

Fig. 4

Jamming of the nail in both planes (arrows); this prevents the positioning of the lag screw in the inferior half of the femoral neck.

the patients are given in Table III, showing no significant differences between the two groups.

Assessments of the differences at operation are shown in Table IV. The Gamma nail required shorter screening time and shorter incisions for both stable and

unstable fractures, with less intra-operative blood loss for unstable fractures. There were no significant differences in the duration of the operations, or in the opinions of the surgeons on the ease of the procedure.

The results of the final clinical assessments are given in Table V, and show that the only significant difference was the time to full weight-bearing, which was shorter for stable and unstable fractures after Gamma nails. In both groups the figures for loss of one level of mobility were similar as were those for walking either independently or with aids, or inability to walk. Patients treated by Gamma nails noted pain in the thigh during the first three months but this decreased dramatically after the fracture healed and there was no difference between the two groups at the final assessment.

Radiological healing was similar for both groups (Table VI), with one case of nonunion in the Gamma nail group and no significant difference in the incidence of varus displacement of the proximal fragments. Sliding of the lag screw was slightly more frequent in the Gamma nail group but the difference was not significant.

Complications. Intra-operative complications are shown in Table VII; the Gamma nail group had a significantly higher incidence, mainly of problems unique to this method. These included fractures of the lateral cortex (Fig. 3) during insertion, which required distal locking even in stable fractures, jamming of the Gamma nail which sometimes prevented the ideal positioning of the lag screw (Fig. 4), and occasionally failure of distal locking which delayed the time to full weight-bearing.

The incidence of postoperative complications was similar in both groups, but of different patterns (Table VIII). Two patients treated by Gamma nails had femoral shaft fractures below the tip of the nail within three months, both due to a fall at home. In both cases fixation was revised with a shorter, smaller Gamma nail, Ender nails and cerclage wire.

DISCUSSION

Proximal femoral fractures are common in the elderly and more are seen with the increase in the ageing population (Wallace 1983; Zain Elabdien et al 1984; Lthje 1985; Lizaur-Utrilla et al 1987; Leung 1989; Cummings, Rubin and Black 1990; Rockwood, Horne

Table I. Early postoperative mortality in 225 patients treated for peritrochanteric fracture of the femur

	Gamma nail (n = 113)	Dynamic hip screw (n = 113)	Total
Chest infection	2	3	5
Heart failure	2	0	2
Renal failure	2	2	4
Aspiration	1	0	1
Total	7 (6.3%)	5 (4.5%)	12 (5.3%)

Table II. Postoperative mortality within six months of operation in 225 patients treated for peritrochanteric fracture of the femur

	Gamma nail (n = 113)	Dynamic hip screw (n = 113)	Total
Chest infection	2	3	5
Heart failure	1	4	5
Renal failure	4	1	5
Cerebrovascular accident	1	2	3
General debilitation	4	3	7
Unknown	1	2	3
Total	13 (11.6%)	15 (13.3%)	28 (12.4%)

Table IV. Operative details of 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)	p-value
Mean timing of operation Days after fracture (SD)	2.0 (1.27)	2.2 (2.27)	* > 0.05
Mean duration of screening in seconds (SD)			
Stable fractures	30.41 (2.87)	48.47 (5.02)	* < 0.0377
Unstable fractures	41.90 (10.39)	71.91 (15.22)	* < 0.0009
Mean duration of operation in minutes (SD)			* > 0.05
Stable fractures	32.3 (2.05)	48.4 (2.84)	
Unstable fractures	42.9 (9.78)	53.2 (10.92)	
Mean blood loss in ml (SD)			
Stable fractures	765.2 (644.78)	1157.86 (609.66)	* 0.069
Unstable fractures	837.85 (497.17)	1012.29 (477.18)	* 0.047
Mean length of incision in cm (SD)			* 0.0001
Stable fractures	8.9 (1.63)	15.9 (1.63)	
Unstable fractures	8.9 (1.01)	15.5 (1.68)	
Ease of operation			† > 0.05
Stable fractures			
Easy	8 (26.7%)	4 (20.0%)	
Usual	21 (70.0%)	15 (75.0%)	
Difficult	1 (3.3%)	1 (5.0%)	
Unstable fractures			
Easy	15 (23.8%)	12 (16.4%)	
Usual	42 (66.7%)	54 (74.0%)	
Difficult	6 (9.5%)	7 (9.6%)	

* Student's *t*-test

† Wilcoxon rank-sum test

and Cryer 1990). Early operative treatment reduces both mortality and morbidity (Laskin, Gruber and Zimmerman 1979; Ceder, Lindberg and Odberg 1980; Nue Møller et al 1985; Pillar et al 1988), giving the best chance of early independence, and reducing the risks of prolonged bed rest.

Sliding nail-plate systems have given good results for both stable and unstable trochanteric fractures (Ecker, Joyce and Kohl 1975; Doppelt 1980; Jensen, Sonne-Holm and Tøndevold 1980; Waddell 1980; Herrlin et al 1989), with reported complication rates of 3% to 15%. Their strength is adequate for the physiological load of

Table III. Details of 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)	p-value
Sex (M:F)	25:68	30:63	* > 0.05
Mean age (year) (SD)	80.86 (8.41)	78.27 (9.46)	† > 0.05
Side of fracture (l:r)	57:36	50:43	* > 0.05
Pre-morbid mobility			‡ 0.052
Independent	58 (62.4%)	44 (47.3%)	
Aided	34 (36.6%)	44 (47.3%)	
Chair/bed bound	1 (1.0%)	5 (5.4%)	
Anaesthesia risk			‡ > 0.05
Grade 1	15 (16.1%)	10 (10.7%)	
2	47 (50.5%)	42 (45.2%)	
3	23 (24.7%)	38 (40.9%)	
4	8 (8.7%)	3 (3.2%)	
Admitted from			* > 0.05
Home	74 (79.6%)	64 (68.8%)	
Institution	19 (20.4%)	29 (31.2%)	
Fracture pattern (Evans)			* > 0.05
Stable	30 (32.3%)	20 (21.5%)	
Unstable	63 (67.7%)	73 (78.5%)	

* chi-square test

† Student's *t*-test

‡ Wilcoxon rank-sum test

Table V. Postoperative details of 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)	p-value
Mean duration of hospital stay in days (SD)			
In acute hospital			* > 0.05
Stable fractures	9.2 (6.43)	10.7 (6.27)	
Unstable fractures	9.5 (3.38)	9.6 (4.46)	
In convalescent hospital			
Stable fractures	17.7 (11.97)	15.4 (10.86)	* > 0.05
Unstable fractures	15.9 (8.2)	19.1 (10.34)	* 0.06
Mean time to full weight- bearing in weeks (SD)			
Stable fractures	1.3 (0.88)	1.9 (0.89)	* 0.0453
Unstable fractures	1.2 (0.64)	1.7 (0.76)	* 0.0009
Postoperative mobility			
Stable fractures			† > 0.05
Independent	12 (40%)	8 (40%)	
Aided	11 (36.7%)	11 (55%)	
Chair/bed bound	7 (23.3%)	1 (5%)	
Unstable fractures			† > 0.05
Independent	22 (34.9%)	23 (31.5%)	
Aided	36 (57.1%)	42 (57.5%)	
Chair/bed bound	5 (8.0%)	8 (11%)	
Hip range of movement mean total in degrees (SD)			
Stable fractures	124.5 (64.34)	154.4 (18.96)	* 0.0501
Unstable fractures	152.9 (29.53)	151.8 (17.23)	* > 0.05
Pain in hip			‡ > 0.05
Stable fractures	8 (26.7%)	5 (25%)	
Unstable fractures	14 (22.2%)	27 (40%)	
Pain in thigh			‡ > 0.05
Stable fractures	4 (13.4%)	5 (25%)	
Unstable fractures	7 (11.1%)	3 (4.1%)	

* Student's *t*-test

† Wilcoxon rank-sum test

‡ Fisher's exact test

Fig. 5

The intramedullary placement of the femoral component of the Gamma nail shortens the moment arm of the force.

Fig. 6

The standard (D) and the modified (M) femoral component of the Gamma nail. The length of the modified nail is 160 mm, the distal diameter is 11 mm and the mediolateral angle is 7°.

normal gait (Kaufer, Matthews and Sonstegard 1974; Jensen 1980a; Larsson, Elloy and Hansson 1988). Complications such as superior cutting-out are related to the position of the lag screw (Doherty and Lyden 1979; Manoli 1986; Simpson et al 1989; Davis et al 1990). Penetration of the lag screw is due to its failure to slide (Matthews et al 1981; Simpson et al 1989), and the rare lateral pulling-out of the side-plate is caused by the varus

moment acting on the screws (Matthews et al 1981; Wolfgang et al 1982; Amis et al 1987).

The Gamma nail attempts to combine the advantages of a sliding lag screw with those of intramedullary fixation while decreasing the moment arm as compared with that for a sliding nail-plate system (Fig. 5). It can be inserted by a closed procedure which retains the fracture haematoma, an important consideration in fracture healing (McKibbin 1978; Latta, Sarmiento and Tarr 1980) and reduces both exposure and dissection.

We have shown, after satisfactory randomisation, that the final functional results in the two groups of patients are very similar, with equivalent reductions in mobility and very similar limb function and healing of the fractures.

The insertion of the Gamma nail was accomplished through a significantly shorter incision and with much less dissection, in particular with no need to reflect the vastus lateralis. The advantages of closed fixation have been shown for diaphyseal fractures (Kempf, Grosse and Beck 1985; Klemm and Börner 1986; Wiss et al 1986; Browner and Cole 1987; Zuckerman et al 1987; Brumback et al 1988), and the decrease in surgical trauma certainly reduces intra-operative blood loss. The minimal dissection preserves tissues and decreases the chance of infection, allowing significantly earlier rehabilitation and a shorter hospital stay. There is less need for frequent use of the image intensifier, minimising the radiation hazards to patients, surgeons and operating theatre personnel. Although only 10% of the operations were rated difficult in both groups it should be noted that most of the surgeons were very much more familiar with the use of the dynamic hip screw.

These technical advantages of the Gamma nail are not reflected in the final outcome: mortality within the first six months in these old and fragile patients is determined by many other factors (Miller 1978; Jensen and Tøndevold 1979; Ceder, et al 1980; Dahl 1980; Wolfgang et al 1982; Ceder, Strömquist and Hansson 1987; White, Fisher and Laurin 1987).

There were more intra-operative complications in the Gamma nail group; most were related to the intramedullary component of the nail in the small Chinese femur. An anthropometric study of the Chinese femur (Leung 1991) provided data for the modification of the femoral component (Fig. 6) to one which has a length of 160 mm, a distal diameter of 11 mm and a mediolateral angle of 7°. Comparison of early results in 41 trochanteric fractures fixed with the modified nail, with those for the standard nail, showed a significant decrease ($p < 0.05$) in the intra-operative complications (Table IX).

Of the postoperative complications, fracture of the femoral shaft was unique to the Gamma nail group. This could be due to the stress riser created by the rigid implant inside the usually osteoporotic proximal medullary canal. The femoral component of the standard nail in the small Chinese femur caused impingement of the

Table VI. Postoperative radiography in 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)	p-value
Fracture healing			
Stable fractures			* 0.0582
Healed	27 (90%)	19 (95%)	
Healed with < 10° varus displacement	2 (6.7%)	1 (5%)	
Nonunion	1 (3.3%)	0 (0%)	
Unstable fractures			* > 0.05
Healed	58 (92.1%)	68 (93.2%)	
Healed with < 10° varus displacement	5 (7.9%)	5 (6.8%)	
Mean sliding of lag screws in mm (SD)			† > 0.05
Stable fractures	6.86 (10.16)	4.88 (3.65)	
Unstable fractures	6.55 (5.8)	5.61 (5.88)	

* Wilcoxon rank-sum test

† Student's *t*-test**Table VIII.** Postoperative complications of 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)
Infection	1	3
Superior cutting-out	2	3
Fracture of shaft	2	0
Shortening (> 20 mm)	3	2
External rotation	2	1
Varus displacement (> 10°)	2	2
Percentage	12.9	11.8

Fisher's exact test, $p > 0.05$ **Table IX.** Comparison of intra-operative complications between standard and modified Gamma nails

	Standard nails (n = 93)	Modified nails (n = 41)
Fracture of lateral cortex	3	0
Fracture displacement by nail insertion	2	1
Jamming of nail	3	0
Failure of distal locking	3	1
Drill breakage	1	0
Failure of reduction	1	0
Percentage	14	4.9

chi-square test, $p < 0.05$

tip of the nail (see Fig. 4). This may also explain the high incidence of early thigh pain, relieved by fracture healing, when the load is taken by bone. It seems advisable to use the narrowest possible nail and to avoid excessive reaming of the femoral canal. The use of the modified

Table VII. Intra-operative complications of 185 patients (186 fractures) treated for peritrochanteric fracture of the femur

	Gamma nail (n = 93)	Dynamic hip screw (n = 93)
Failure of reduction	1	2
Fracture of lateral cortex	3	2
Drill breakage	1	2
Jamming of nail	3	0
Operative fracture displacement	2	4
Failure of distal locking	3	0
Percentage	14.0	10.8

chi-square test, $p = 0.048$ **Table X.** Comparisons of postoperative complications between standard and modified Gamma nails

	Standard nails (n = 93)	Modified nails (n = 41)
Wound infection	1	1
Superior cutting-out	2	0
Varus displacement (> 10°)	2	1
External rotation	2	0
Shortening (> 20 mm)	3	0
Shaft fracture	2	0
Percentage	12.9	4.9

Fisher's exact test, $p = 0.095$

nails seemed to eliminate these complications, reducing the postoperative complication rate to 5% (Table X).

Conclusions. The potential advantages of the Gamma nail are clear in these already compromised patients.

We have shown that the final outcome is similar to that after the use of the dynamic hip screw, but is achieved with less surgical trauma, less screening time, less blood loss and earlier rehabilitation. With the modified nail and careful operative procedures, uniformly good results can be obtained. The ease of implantation and the possibility of early weight-bearing even after very complex fractures mean that the new technique shows considerable promise.

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