

COMPLICATIONS ASSOCIATED WITH GAMMA NAILING A REVIEW OF 439 CASES

P. L. DOCQUIER, E. MANCHE, J. C. AUTRIQUE, B. GEULETTE

We have retrospectively analysed 439 peritrochanteric hip fractures treated in our institution using the Gamma nail, with attention focused on complications.

Intraoperative complications were observed in 15 patients (3.4%), consisting mainly of fractures (1.8%).

Out of 323 fractures (73.6%) followed until radiographic bone healing (mean follow-up of 10 months), 261 (80.8%) healed without a problem.

There were 62 postoperative complications (19.2%) with 37 patients (11.5%) requiring additional surgical procedure. The two most frequent major complications were cut out of the cephalic screw (7.1%) and diaphyseal fractures (3.1%). Other complications included fracture collapse more than 2 cm (1.5%), infection (0.9%), delayed union (0.9%) with one case of nail breakage (0.3%) and persistent pain in 20 patients (6.2%).

All intraoperative fractures, nearly all cases of postoperative cut out of the lag screw and some postoperative diaphyseal fractures can be related to technical errors. Strict observance of the operative technique can decrease per- and postoperative complications.

Keywords : peritrochanteric fractures ; Gamma nail.

Mots-clés : fractures péritrochantériennes ; clou Gamma.

surgical technique and to modification of the nail design (1, 8, 13, 18, 20, 26).

The two major complications reported are intra- or postoperative femoral shaft fractures and cut out of the cephalic screw.

The curve, stiffness and bulk of the Gamma nail have been cited (21) to explain the high rate of fracture. In addition to the nail shape, distal locking may also have contributed to the incidence of shaft fractures (15, 22, 26).

Lag screw cut out may also be attributed to technical errors during surgery and to implant characteristics. The primary cause is related to the positioning of the lag screw within the femoral head. Secondly, the locking of the head screw has been considered to be too rigid, causing jamming of the screw with a potential danger of cutting out through the femoral head (10, 23).

Gamma nailing represents an effective treatment for most peritrochanteric fractures. However this technique demands extensive experience. The goal of the present study was to review the intraoperative and postoperative complications of our first 439 cases and to pinpoint the techniques that may prevent complications associated with the use of the Gamma nail.

INTRODUCTION

The first reports on the use of the Gamma nail have focused on its relatively high complication rates (2, 5-9, 12, 14, 16, 17, 19, 20, 26-31). More recent studies have shown a significant decrease in complication rates thanks to strict observance of

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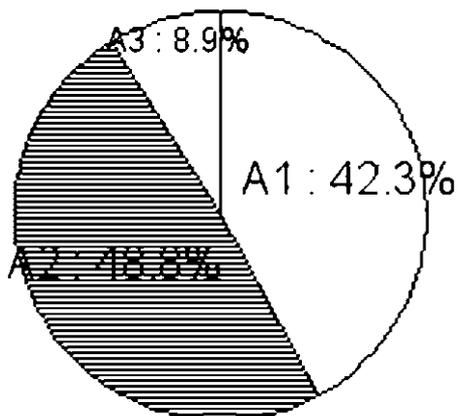


Fig. 1. — AO Classification of peritrochanteric fractures. Of the fractures, 42.3% were simple two-part fractures (A1) whereas 48.8% were type A2 fractures (extension over 2 or more levels of the medial cortex) and 8.9% were type A3 (extension through the lateral cortex of femur).

MATERIAL AND METHODS

Four hundred thirty-nine cases of peritrochanteric fractures treated in our institution with Gamma nailing between 1990 and 2000 were reviewed. The majority of patients were women (77%). The mean age of the patients was 80 years (range : 34 to 102 years). Nine patients had bilateral Gamma nails for successive fractures. Trochanteric fractures were classified as described by the AO group (24) : 42.3 % were simple two-part fractures (AO type A1), 48.8% were type A2 fractures (extension over 2 or more levels of the medial cortex) and 8.9% were type A3 (extension through the lateral cortex of femur) (fig. 1).

In 3 cases (0.7%) the fracture was pathologic. The degree of osteoporosis was determined by the radiographic evaluation of trabecular patterns of the proximal femur (method of Singh) (28) : 88.2% of patients were very osteoporotic (grade 1 to 3 of Singh) and only 11.8% of patients had good bone quality (grade 4 to 6 of Singh) (fig. 2).

Seventy-five percent of the procedures were performed by residents. The operations were carried out under general or spinal anaesthesia with the patient supine on a fracture table with traction using a boot. Closed reduction was performed under fluoroscopic control and checked in anteroposterior and lateral views.

The Gamma nail® (Howmedica International, Zaventem, Belgium) has undergone some changes over the years. In the beginning of our experience the implant

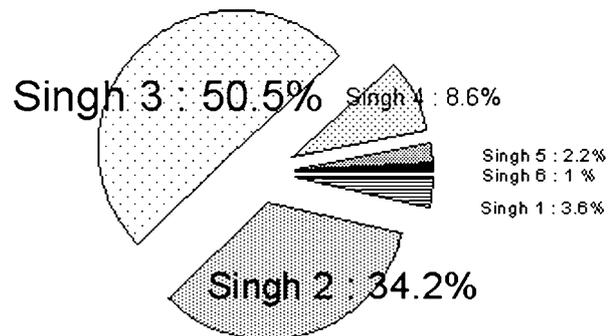


Fig. 2. — Degree of osteoporosis of patients (method of Singh)

The patient population included 88.2% who were very osteoporotic (grade 1 to 3 of Singh), while only 11.8% of patients had good bone quality (grade 4 to 6 of Singh).

used was the standard Gamma nail with a 10° mediolateral curve and a length of 200 mm with a diameter of 12 mm and a lag screw angle of 130°. Double-screw distal locking was systematically performed (126 nails). Starting in 1996, the nail diameter was reduced to 11 mm and only one distal locking screw was inserted (133 nails). The new Trochanteric® Gamma nail with a diameter of 11 mm has been used exclusively since 1998 (180 nails). This implant is 180 mm long and has a 4° mediolateral curve.

Parameters such as reduction quality, osteosynthesis stability, osteoporosis grade, obesity and patient clinical status were taken into account to allow weight-bearing in the early postoperative period. Seventy-seven percent of patients were authorized to bear full weight whereas 23.2% were restricted to toe-touch weight bearing for 6 weeks.

Fifty patients (11.4%) died early in the first postoperative month secondary to general problems (pulmonary, cardiac). Sixty-six patients (15%) were lost to follow-up. Three hundred twenty-three patients (73.6%) were followed until radiographic bone healing with a minimum of 3 months (mean follow-up : 10 months).

The complications were analysed and divided into intraoperative and postoperative. Lag screw positioning within the femoral head was also studied in the coronal and sagittal planes and the tip-apex distance was recorded according to the Baumgaertner method (3, 4). The tip-apex distance is defined as the sum of the distance, in millimeters, from the tip of the lag screw to the apex of the femoral head, as measured both on the anteroposterior and the lateral views, after correction has been made for magnification.

Table I. — Intraoperative complications encountered in the 439 Gamma nailings

	Number	Percentage	Solution to the problem
Total intraoperative complications	15	3.42%	
Displaced diaphyseal fractures	2	0.46%	change of osteosynthesis
Nondisplaced diaphyseal fractures	6	1.37%	delayed weight bearing for 6 weeks
Missed distal locking	3	0.68%	no consequence
Drill bit breakage	2	0.46%	no consequence
Guide pin breakage	1	0.23%	no consequence
Pelvic penetration of the guide pin	1	0.23%	no consequence

Intraoperative complications occurred in 15 patients (3.4%). Only 2 were critical (0.5%) with an impact on the final result.

Differences in tip-apex distance between the cut out group and the uncomplicated group were compared using Student's t test for statistical significance.

RESULTS

Intraoperative complications were observed in 15 of the 439 cases (3.4%) (table I).

Only 2 of these (0.5%) were critical (with an impact on the final result) : two displaced diaphyseal fractures occurred during nail insertion and necessitated change of osteosynthesis (one long Gamma nail and one femoral plate).

Thirteen complications (2.9%) were trivial (without an impact on the final result). Six diaphyseal non-displaced fractures (1.4%) occurred during nail insertion or distal locking and required no specific treatment other than delaying weight bearing for 6 weeks. Three cases of missed distal locking (0.7%) and 2 cases of drill bit breakage (0.5%) had no consequence. One case of guide pin breakage (0.2%) and one pelvic penetration of the guide pin (0.2%) occurred without further problems.

Of the 323 patients followed more than 3 months, 261 (80.8%) healed without problems and required no further intervention.

Postoperative complications were encountered in 62 patients (19.2%) (table II).

The two most frequent major complications were cut out of the cephalic screw (23 cases ; 7.1%) and diaphyseal fractures (10 cases ; 3.1%).

Lag screw cut out led to additional procedures in 13 cases (4.0%) : 2 Gamma renailings, 2 bipolar arthroplasties, 2 total hip arthroplasties, 2 dynamic

condylar screws and 5 simple hardware removals after fracture healing. Another 10 patients were not reoperated because of their general condition, and bone healing occurred with varus malunion.

Of the 10 postoperative diaphyseal fractures (3.1%), four (1.2%) occurred in the early postoperative period (mean = 4 months) ; the fracture line started at the distal locking screw level or at the nail tip level. The other six cases (1.9%) occurred long after surgery (mean = 23 months postoperatively) and the fracture was located distal to the nail. All 10 diaphyseal fractures (3.1%) needed renewed fixation : 5 long Gamma nailing, 1 femoral plating, 1 blade plate, 1 antegrade femoral nailing, 1 less invasive stabilisation system (LISS® Mathys Benelux) and 1 dynamic condylar screw.

Other complications included 5 cases of fracture collapse of more than 2 centimeters (1.5%). No treatment was performed.

Infection occurred in 3 cases (0.9%). One superficial wound infection healed after intravenous antibiotics. One subfascial collection was treated by surgical drainage and antibiotics. In the third case, hardware removal after 9 months and antibiotics solved the problem.

Three cases of delayed union (0.9%) were noted after 6 months with one case of nail breakage (0.3%). This case needed bone grafting and exchange of implant. The other two fractures eventually healed uneventfully.

Finally 20 patients (6.2%) complained of pain (in the inguinal, trochanteric or thigh region). Eleven patients (3.4%) underwent hardware removal whereas 9 patients (2.8%) denied further treatment.

Table II. — Postoperative complications encountered in the 323 patients

	Number	Percentage	Solution to the problem
Bone healing without problem	261	80.80%	
Total postoperative complications	62	19.20%	Further operation in 37 patients (11.5%)
Cut out of the cephalic screw	23	7.12%	Additional procedure in 13 cases (4.0%)
Diaphyseal fractures	10	3.10%	New osteosynthesis in all cases
in the early postoperative period	4	1.24%	
long time after surgery	6	1.86%	
Fracture collapse of more than 2 cm	5	1.55%	No treatment
Infection	3	0.93%	
superficial wound infection	1	0.31%	Intravenous antibiotics
subfacial collection	1	0.31%	Surgical drainage and antibiotic
sepsis	1	0.31%	Hardware removal after 9 months
Delayed union > 6 months	3	0.93%	
nail breakage	1	0.31%	Bone grafting and implant change
later healing uneventfully	2	0.62%	No treatment
Persistent pain	20	6.19%	Hardware removal in 11 patients (3.4%) ; No treatment in 9 patients (2.8%)

Postoperative complications occurred in 62 patients (19.2%). The two most frequent major complications were cut out of the cephalic screw (7.1%) and diaphyseal fractures (3.1%).

Overall, out of these 62 postoperative cases with complications, 37 needed further operations (11.5%) : hardware removal after bone healing was performed in 19 cases (5.9%) whereas additional procedures such as revision of osteosynthesis or bipolar arthroplasty was necessary in 18 cases (5.6%).

DISCUSSION

Our mortality rate of 11.4% at 1 month is in line with those reported in the literature which range from 7 to 22% (25) and 31% for centenarians (11). The advanced age of our population series and poor preoperative clinical status can explain this high rate.

Our global rate of complications is 3.4% intraoperatively and 19.2% postoperatively. In the literature, the reported rates of intraoperative complications range from 2.2% (5) to 10.7% (13), whereas reported global rates of postoperative complications reach 7.2% (18) to 16% (27).

Fracture of the femoral shaft is one of the most frequent intraoperative or postoperative complications identified in other series of Gamma nailing. Three aspects of implant design have been impli-

cated : curve, stiffness and size. The original Gamma nail had a mediolateral curvature of 10° that differed from the trochanter-to-diaphysis angle in an average patient. This shape of the Gamma nail is thought to cause three-point loading across the trochanteric and diaphyseal cortices (27). Therefore stress is concentrated mainly along the medial cortex in contact with the nail curvature and on the nail tip in contact with the lateral cortex, thus exposing the femur to intraoperative and postoperative fractures, even under physiologic loads (27).

Moreover the high implant stiffness (10) also results in a stress rising effect at the nail tip.

Mismatch between implant size and medullary canal diameter, particularly with inadequate reaming and forceful nail insertion (hammer), can create high hoop stresses. This can result in nondisplaced fractures during nail insertion, which may propagate after weight-bearing.

Distal locking problems may weaken the diaphysis (15, 22, 26). This difficulty can be attributed to loosening of the targeting device, forceful use of the distal awl e.g. through use of a hammer, multiple or missed drilling leaving a hole in the cortex, backward movement of the drill sleeve or

excessive tightening of the screw. The distal locking screw diameter (6 mm) may also play a role.

Our intraoperative fracture rate is 1.8%. The two major cases of displaced diaphyseal fractures occurred in the beginning of our experience and were attributed to insufficient reaming and to nail insertion using a hammer. Since 1996 the use of the 11-mm nail and 2-mm overreaming associated with nail insertion by hand only as recommended in the literature (8, 20) considerably reduced this rate. Since 1998 use of the new Trochanteric nail permitted a further decrease in intraoperative complications (only one case since 1997), despite the fact that the majority of operations were performed by residents (learning curve). The decrease in the nail mediolateral curve from 10° to 4° may have played a role.

Postoperative diaphyseal fractures in the literature range from 0% (5, 20) to 12% (27). Our postoperative fracture rate is 3.1% (10 cases). Four cases occurred in the early postoperative period (mean = 4 months) and the fracture line started at the distal locking screw level or at the nail tip and probably resulted from occult microfractures when introducing the nail, from distal locking problems or from a stress rising effect at the nail tip.

The other six cases occurred long after surgery (mean = 23 months) and were located distal to the nail. These fractures were probably secondary to transmission of excessive forces to the unprotected distal femur.

Cut out of the cephalic screw is the second most reported postoperative complication with the primary cause related to positioning of the lag screw within the femoral head. To prevent this complication, it is recommended to center the lag screw in the femoral head on the anteroposterior view within 5 to 10 mm of the subchondral bone. A position in the inferior half is accepted whereas a position in the superior half is not advisable. On the lateral view, the screw should be exactly in the center of the femoral head. Alternatively, a posterior position is tolerated.

In addition, the dynamic locking of the head screw has been considered to be too rigid, causing jamming of the screw (instead of sliding) with a potential danger of cutting out through the femoral

head (17, 18). Our lag screw cut out rate of 7.1% is among the highest reported: 0% (10, 16, 21) to 7.41% (3). Cut out of the cephalic screw was attributed to technical error in the majority of cases (22 of the 23 cases). Only in one case was the position of the cephalic screw optimal on the intraoperative x-ray. The most frequent technical errors were a cephalic screw either too short (43.5%) or too cranial (65%) or a combination of these imperfections. The mean tip-apex distance (3,4) in our cut out group was 33.6 mm (21 to 45 mm) versus 22.1 mm (7 to 45 mm) in the non-complicated group ($p < 0.001$; Student t-test). No significant correlation was found between early weight-bearing and cut out. However in the majority of our 23 cut out cases, the patients had been instructed to avoid weight-bearing because of a lack of confidence regarding the stability of the construct.

Rates of deep infection reported in the literature range from 0% (6, 7, 26) to 3.6% (13). Our rate is 0.9%. Nail fracture is reported at a rate of 0% (6) to 0.5% (7,32) in accordance with our rate of 0.3%. Pain is not considered as a complication in most series, and this explains the lower global complication rates being reported.

Overall, our results are nearly similar to reported rates of complications in the literature except our very high overall revision rate of 11.5%. Reported rates for revision vary from 1.4% (2) to 8% (21), but in numerous studies material removal for pain is not taken into account to calculate the revision rate. Our revision rate decreases from 11.5% to 8.4% if we do not take into account hardware removal for pain.

Gamma nailing is an interesting alternative in the treatment of peritrochanteric fractures allowing early full weight-bearing, with a low infection rate. Strict observance of the recommended surgical technique will avoid most of the complications.

Choice of the new Trochanteric nail (decrease in curvature and length), reduced diameter implant (11 mm), 2-mm overreaming of the femoral canal, manual introduction of the nail (excluding hammer) and meticulous placement of the distal interlocking screw (with one screw only and avoiding excessive tightening of the screw) will decrease intra- and postoperative fractures.

Choice of appropriate length for the lag screw, its good positioning in the femoral neck (with awareness of tip-apex distance) and its dynamic proximal locking will considerably reduce the incidence of screw cut out.

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SAMENVATTING

P. L. DOCQUIER, E. MANCHE, J. C. AUTRIQUE, B. GEULETTE. Complicaties vastgesteld met Gamma nagel. Een studie van 439 fracturen.

Wij hebben een retrospectieve studie uitgevoerd van 439 peritrochanterische heupfracturen behandeld in onze dienst door middel van een Gamma nagel. De nadruk werd op de complicaties gelegd.

Bij 15 patiënten (3,4%) werden er peroperatieve complicaties vastgesteld. Deze bestonden voornamelijk uit fracturen (1,8%).

Van de 323 fracturen (73,6%) gevolgd tot radiografische consolidatie (follow-up van gemiddeld 10 maanden), heelden er 261 (80,8%) zonder enig probleem.

Bij 62 (19,2%) patiënten traden postoperatieve verwikkelingen, hiervan dienden 37 patiënten (11,5%) een heroperatie te ondergaan. De majeure complicaties waren cut out van de cephalische schroef (7,1%) en diafysairefractuur (3,1%). De andere bestonden uit fractuur collaps van meer dan 2 cm (1,5%), infectie (0,9%), pseudarthrose (0,9%) waarvan één nagelbreuk (0,3%) en blijvende pijn in 20 patiënten (6,2%).

Alle peroperatieve fracturen, bijna alle postoperatieve cut out van de cephalische schroef en een aantal postoperatieve femurschaftfracturen kunnen aan technische fouten toegeschreven worden. Het strikt respecteren van de operatietechniek zou kunnen de per- en postoperatieve verwikkelingen verminderen.

RÉSUMÉ

P. L. DOCQUIER, E. MANCHE, J. C. AUTRIQUE, B. GEULETTE. Complications associées au clou Gamma. Une série de 439 cas.

Nous avons analysé rétrospectivement 439 fractures périrochantériennes ostéosynthésées dans notre institution par enclouage Gamma en relevant toutes les complications observées.

Des complications peropératoires ont été observées chez 15 patients (3,4%); il s'agissait surtout de fractures (1,8%). Des 323 fractures (73,6%) suivies jusqu'à consolidation radiologique (suivi moyen de 10 mois), 261 (80,8%) ont guéri sans aucun problème.

Il y eut 62 complications postopératoires (19,2%) avec nécessité de reprise chirurgicale chez 37 patients (11,5%). Les deux complications majeures les plus fréquentes ont été le balayage (cut out) de la vis céphalique (7,1%) et les fractures diafysaires (3,1%). Les autres complications consistent en collapsus fracturaire de plus de 2 cm (1,5%), infection (0,9%), pseudarthrose (0,9%) avec un cas de fracture du clou (0,3%) et douleurs résiduelles chez 20 patients (6,2%). Toutes les fractures peropératoires, presque tous les balayages de la vis céphalique et quelques fractures diafysaires postopératoires sont dues à des erreurs techniques. Le respect strict de la technique opératoire peut diminuer les complications per et postopératoires.