ABSTRACT
Gamma nails have been used extensively for the treatment of proximal femoral fractures. Nail breakage at the level of the aperture of the lag screw is rare. We report 4 such cases mainly associated with a large posteromedial cortex gap and nonunion. The need for adequate reduction to avoid such a complication is emphasised.

Key words: bone nails; equipment failure; femoral neck fractures

INTRODUCTION
Intramedullary nails combined with sliding hip screws are increasingly popular for internal fixation of proximal femoral fractures. Their biological advantages are that the closed technique retains the fracture haematoma and involves less operating time and blood loss. Gamma nails combine intramedullary fixation in the femoral shaft with a sliding screw in the femoral head, allowing controlled collapse of the fracture, while the intramedullary nail acts as a buttress limiting excessive shaft medialisation in unstable pertrochanteric fractures.

Gamma nail breakage at the level of the aperture of the lag screw is rare, and is mainly associated with delayed union or nonunion and premature full weight bearing. We report 4 such cases and discuss their causes.

CASE REPORTS
Case 1
In May 1994, a 42-year-old man presented with a very unstable intertrochanteric fracture with a posteromedial cortical deficit after a motor vehicle accident. Reduction was considered satisfactory, but the posteromedial gap remained after fixation with...
eventually developed cut-out of the femoral head and underwent total hip arthroplasty.

Case 4
In September 2002, a 73-year-old man presented with a painful hip caused by a partial subtrochanteric fracture of the lateral cortex of the right femur. He had metastatic prostate cancer and had undergone radiotherapy for osteolytic lesions in his right humerus and femur 4 months earlier. Prophylactic osteosynthesis with a trochanteric Gamma nail was selected because of his worsening pain and medical history. Nine months later, he reported a painful right hip again caused by nail breakage (Fig. 4). Because of intra-operative difficulty with placement of a long Gamma nail, due to the inadequate grip of the screw in the femoral head, a 130º blade plate was used. At the 10-month follow-up, he was able to walk, fully weight bearing, but eventually died of his disease 3 months later.

DISCUSSION
Although some authors state that intramedullary hip screws have not been shown to be superior to sliding hip screws for the treatment of intertrochanteric hip fractures, they may have selected indications, such as the reverse-obliquity intertrochanteric hip fracture, the intertrochanteric fracture with subtrochanteric extension (requiring a long side plate), and subtrochanteric femoral fractures.

The standard Gamma nails have been biomechanically evaluated in stable and unstable...
The Gamma nails have been shown to transmit decreasing load to the calcar with decreasing fracture stability, so that no strain was put on bone in 4-part fractures with the posteromedial fragment removed. One might expect that the shortened lever arm and intramedullary fixation of the Gamma nail would medialise the load towards the calcar, but in fact the inherent stiffness of the Gamma nail transmits loads to the femur in a fashion analogous to that seen with femoral prostheses.

Good reduction and proper implants are prerequisites for stability in the osteosynthesis of unstable proximal femoral fractures. Gamma nails show a 30% greater load to failure than sliding hip screws. Earlier studies reported no Gamma nail breakage, noting that the greater strength of the Gamma nail may not be necessary for intertrochanteric fractures in a cadaveric model.

Figure 3 Radiographs showing (a) a very unstable intertrochanteric fracture with subtrochanteric extension, (b) fixation using a long Gamma nail, (c) nonunion of the bone and breakage of the lag screw at the level of the aperture at 8 months, (d) the fractured nail, and (e) revision with a sliding hip screw and calcium sulphate bone graft substitute.

Figure 4 Radiographs showing (a) a pathological fracture of the lateral cortex, (b) fixation using a trochanteric Gamma nail, (c) nail breakage, and (d) revision with a 130° blade plate.
Gamma nail breakage

The level of the aperture of the lag screw have been reported since, mainly associated with delayed union or nonunion and premature full weight bearing.

In a series of 2500 Gamma nail fixations, only 4 (0.16%) nails broke, all associated with nonunion and continued weight bearing. Breakage time varied from postoperative month 6 to 15, suggesting fatigue caused by dynamic loading. In a series of 839 patients, 2 fatigue fractures at the cranial aperture of the distal locking holes were reported. In a series of 224 patients, one nail breakage at the level of the aperture of the lag screw was reported. It was a standard Gamma nail, and the manufacturer reported a material failure caused by an eccentric insertion of the lag screw. Two breakages of standard Gamma nails in the same patient were reported. The possibility of septic nonunion or pathological fracture was excluded. There were no signs of fatigue failure in the nail surface and it was decided that weakness at manufacture was the cause. Gamma nails are susceptible to breakage at the weakest point—the lag-screw interface.

In our series, there were 4 breakages out of 412 Gamma nails used. Although nonunion in proximal femoral fractures is uncommon, it may occur in high-energy fractures as in case 1, and those of very old age as in case 2. Both patients were operated on during the early phase of the study and received standard Gamma nails, which are no longer in use. Technical errors, such as wrong placement of the set screw preventing sliding, may also be contributing factors. Patient 3 received a long Gamma nail that was designed to withstand heavy loads. We therefore investigated the surface of the broken nail using photomicrographs taken by scanning electron microscopy (SEM) [Fig. 5]. We examined one of the 2 identical parts surrounding the lag screw in the long Gamma nail. The fracture surface was mainly composed of 2 areas with distinctively different fracture morphologies. In Figure 5, region A was marked by a very brittle fracture pattern in which no large plastic deformations can be observed, whereas region B presented a highly anomalous profile over which large plastic deformations dominate. The fracture appears to have occurred in 2 stages; the breakage occurred with a time lag between the initial cracking and final rupture. The fracture pattern of region A was almost even, with no large surface anomalies; overall a very brittle fracture. This type of failure in metals and alloys corresponds to an overstressing or high-energy fracture, as no initial cracking, or any other defect on the outside surfaces or even pores of the metal bulk can be observed. Further evidence of

![Image](52x193 to 288x716)

Figure 5 Microphotographs taken by scanning electron microscopy showing (a) the left flap (outside) of the fracture surface of the long Gamma nail, (b) and (c) the right flap of the fracture surface A and B (end-region); several striations correspond to crack arrest lines (arrows) formed during the failure process.

fractures, unless these have a subtrochanteric extension. Nevertheless, 8 cases of nail breakage at
the evolution of the rupture and final breakage was seen at the right flap of the fracture surface region B (end-region). The Gamma nail was overloaded by stress or strain causing initial brittle cracking on the left and right sides of the lag screw aperture shaft. Almost half of the implant load-bearing cross-section was cracked and therefore unable to bear loads. The remaining intact cross-section around the lag screw was unable to provide sufficient load bearing. It broke because of high stress (or strain) low cycle fatigue under normal conditions, marked by large plastic deformations. Given the severe instability of the fracture pattern in this obese patient, we should have paid more attention to the posteromedial gap. The absence of any bony apposition in the posteromedial cortex should have necessitated touch-down weight bearing, at least in the early phase of callus formation, to avoid excessive loading of the nail. In patient 4, who had metastatic disease, reduction was considered adequate despite a little varus deformity. Nonetheless, the varus deformity progressed and the fracture did not heal, resulting in nail breakage. Nonunion in metastatic bone pushes the nail material to the limit of its tolerance. The use of a load-bearing device such as the long Gamma nail might have been more appropriate, but breakage of the long Gamma nail has also been reported. Because the proximal parts of the trochanteric and long Gamma nails are the same, their risks of breaking are similar.

**CONCLUSION**

Gamma nails are useful in the treatment of proximal femoral fractures and have a low implant failure rate. Fracture instability may affect the nail breakage rate. When there is a large posteromedial gap with no bony apposition to transfer loads, non-weight bearing is necessary to protect the nail. Although closed reduction and minimally invasive exposure minimise complications such as delayed union and nonunion, prompt revision may be necessary when such complications occur. When the reduction is inadequate with no posteromedial support, it is important that protected weight bearing should continue until callus consolidation.

**REFERENCES**