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*Case report*

# Implant failure of long Gamma nail in a patient with intertrochanteric-subtrochanteric fracture

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## Introduction

Fractures of the trochanteric region in the femur are common in the elderly, and many devices have been developed to fix these fractures, the most widely used being the numerous versions of the sliding nail plate system. The Gamma nail was developed with a theoretical advantage in load shearing due to its short lever arm, and successful use of this implant has been reported.[1–3] The long Gamma nail (Stryker Trauma, Geneva, Switzerland) was introduced to widen the indication of the Gamma nail for the treatment of more unstable fractures, such as bifocal, subtrochanteric and diaphyseal fractures.[1,4–6] Because of its material strength, design, and mechanical advantage,[3,7] implant failure of the Gamma nail has been thought to be rare. There have been only 11 cases in six articles describing implant failures of the Gamma nail.[2,8–12] All cases revealed nonunion or re-fracture, and all but two cases required revision surgery. These two cases also revealed varus deformity. We present a rare case of implant failure of the long Gamma nail, which became evident at the second operation to remove implants after bony union without late deformity. We obtained consent for publication of this case report from the patient.

## Case report

A 63-year-old man suffered a traffic accident with an automobile while riding a motorcycle and was brought to our hospital by ambulance in October 1998. Radiographs showed an Orthopaedic Trauma Association classification of fracture 31-A2.3,[13] Seinsheimer classification type V,[14] intertrochanteric-subtrochanteric fracture of his right femur (Fig. 1). The fracture was fixed internally with a 130° angle long Gamma nail and cerclage wires 8 days after the injury. On the postoperative radiographs, reduced anteversion of the proximal fragment and imperfect reduction of the lesser trochanteric fragment were noted. The Garden alignment index in the anteroposterior (AP) view was 154°.[15] A lag screw was inserted through the fracture site. The position of the lag screw was in the center part of the femoral head in both AP and lateral views (Fig. 2). Weight-bearing was restricted for 3 months using a long leg brace, and the patient was allowed partial weight-bearing after 3 months, when bridging callus was visible on the radiographs. Full weight-bearing was allowed after 5 months. Radiographs at 1 year 9 months after operation showed bony union with neither late varus deformity nor sliding of the lag screw (Fig. 3A,B). The Garden alignment index in the AP view was 152°.[15] Breakage of the distal interlocking nails, which was not suggested by the radiograph at 1 year 6 months after operation, was now suspected (Fig. 3C), but there was no evidence to indicate breakage of the intramedullary nail, such as an angler deformity, lateral displacement, or a fracture line of the nail (Fig. 3D,E). Removal of the implants was performed 1 year 10 months after the operation, and breakage of the intramedullary nail at the insertion point of the lag screw was found during the operation. The distal portion of the intramedullary nail could not be removed because we did not expect the breakage and thus had not prepared the special instruments needed to remove a fractured intramedullary nail (Fig. 4). The patient refused further surgery to remove the distal portion of the intramedullary nail and returned to full activities of daily living.

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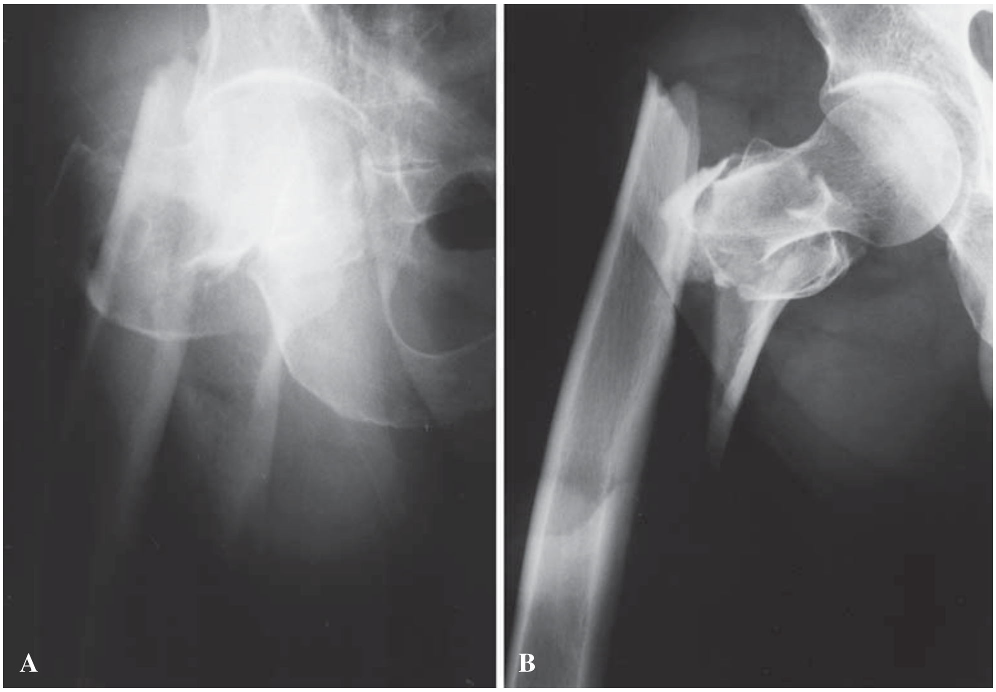


**Fig. 1.** Radiographs showed an OTA classification 31-A-2.3, Seinsheimer classification type V intertrochanteric-subtrochanteric fracture of the right femur. **A** Anteroposterior view. **B** Lateral view

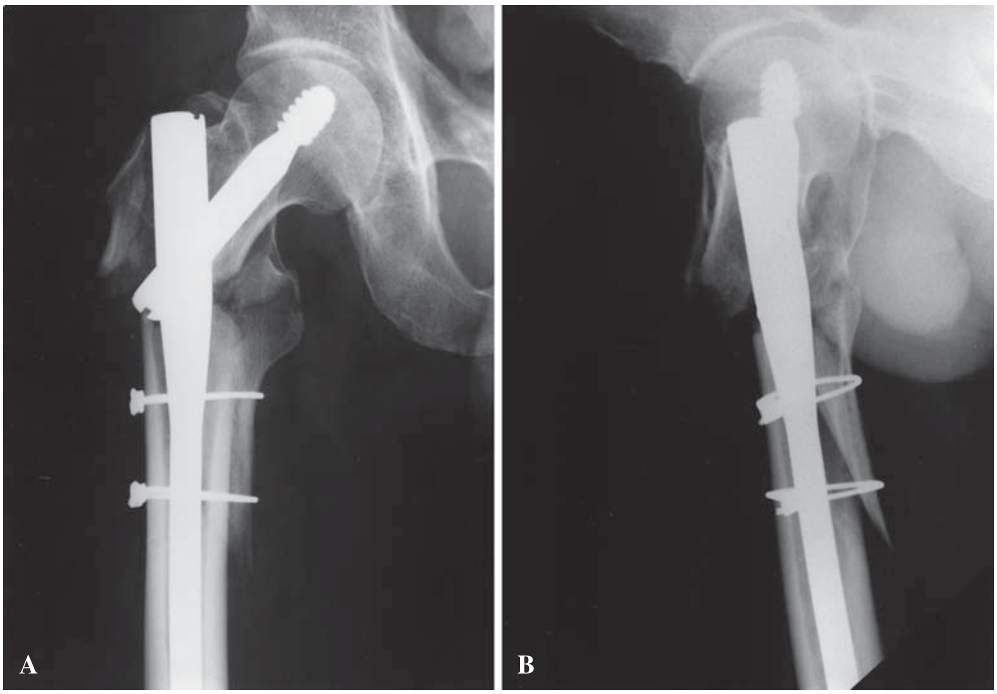


**Fig. 2.** Postoperative radiographs showed reduced anteversion position of the proximal fragment and imperfect reduction of the lesser trochanteric fragment. The position of the lag screw was the center part of the femoral head in anteroposterior (**A**) and lateral (**B**) projections

### Macroscopic, scanning electron microscopic, and mechanical analysis of fractured nail

The long Gamma nail was fractured horizontally at the level of the insertion hole for the lag screw. The Vickers hardness test (JIS Z 2244) showed 388 HV (standard range 340–420 HV). The Rockwell hardness test (JIS Z 2245) showed 39.2 HRC (standard range 34.4–42.7). Tensile strength was 1269 MPa (standard range 1100–1350 MPa). Fatigue limit was 620 MPa (standard range 540–670 MPa). These mechanical tests revealed the nail to be within the normal range of wrought high nitrogen stainless steel (ISO5832-9).

The macroscopic view of the fractured surface showed a larger shear lip in the posterior portion than in the anterior portion (Fig. 5). There was pronounced

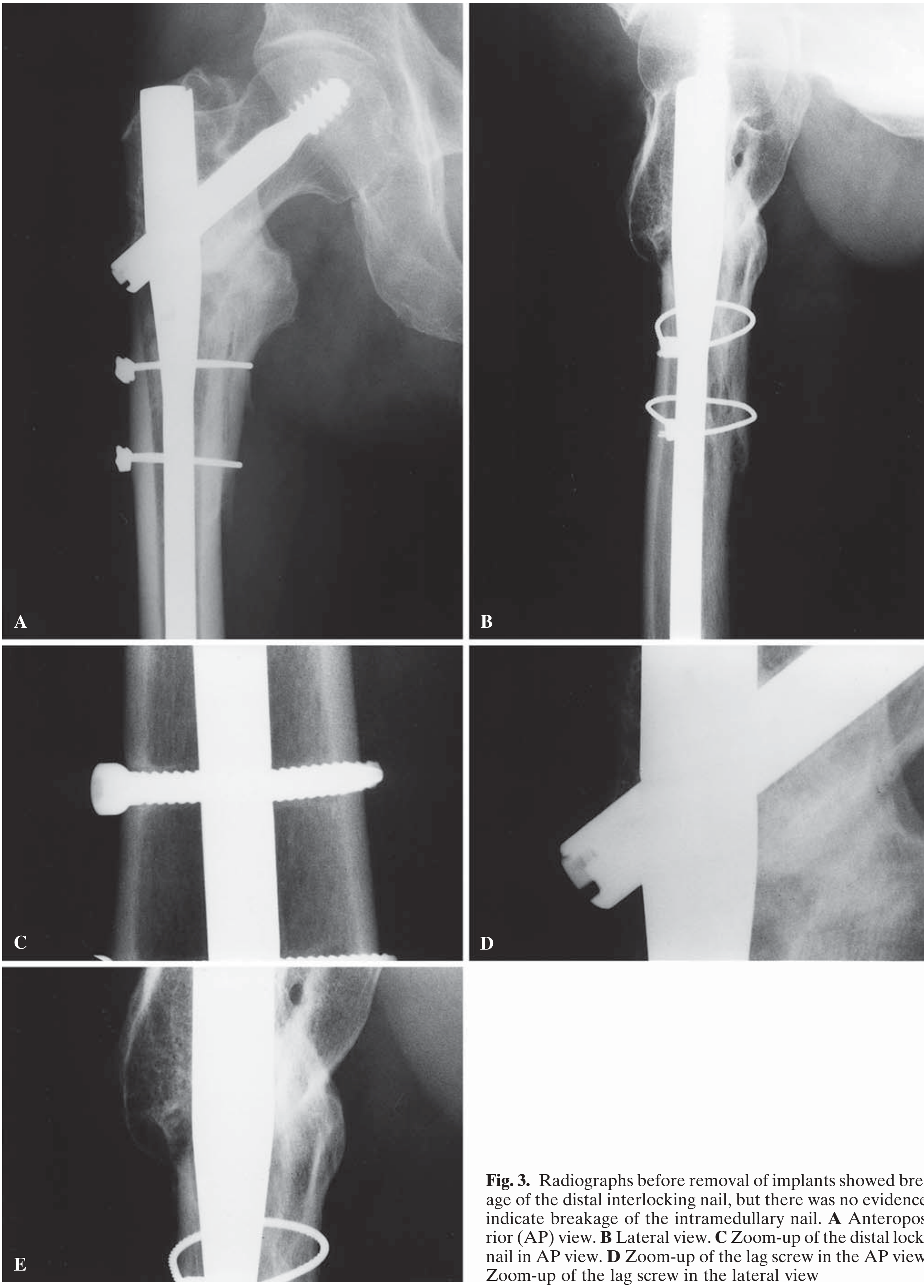


**Fig. 3.** Radiographs before removal of implants showed breakage of the distal interlocking nail, but there was no evidence to indicate breakage of the intramedullary nail. **A** Anteroposterior (AP) view. **B** Lateral view. **C** Zoom-up of the distal locking nail in AP view. **D** Zoom-up of the lag screw in the AP view. **E** Zoom-up of the lag screw in the lateral view

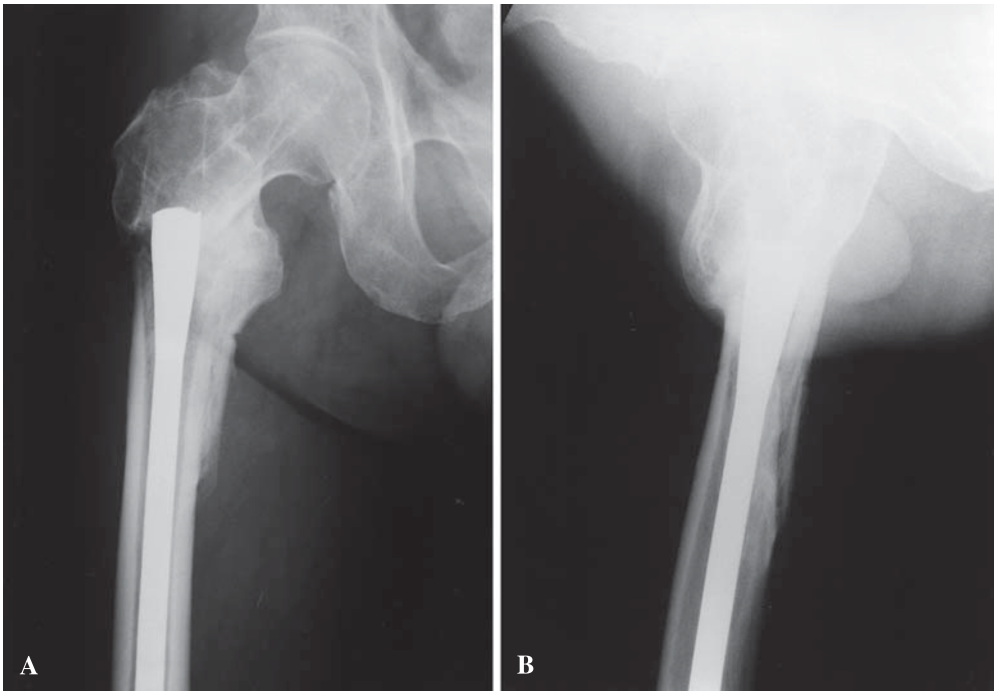


**Fig. 4.** Radiographs after removal of implants showed the remaining distal portion of the nail. **A** Anteroposterior view. **B** Lateral view

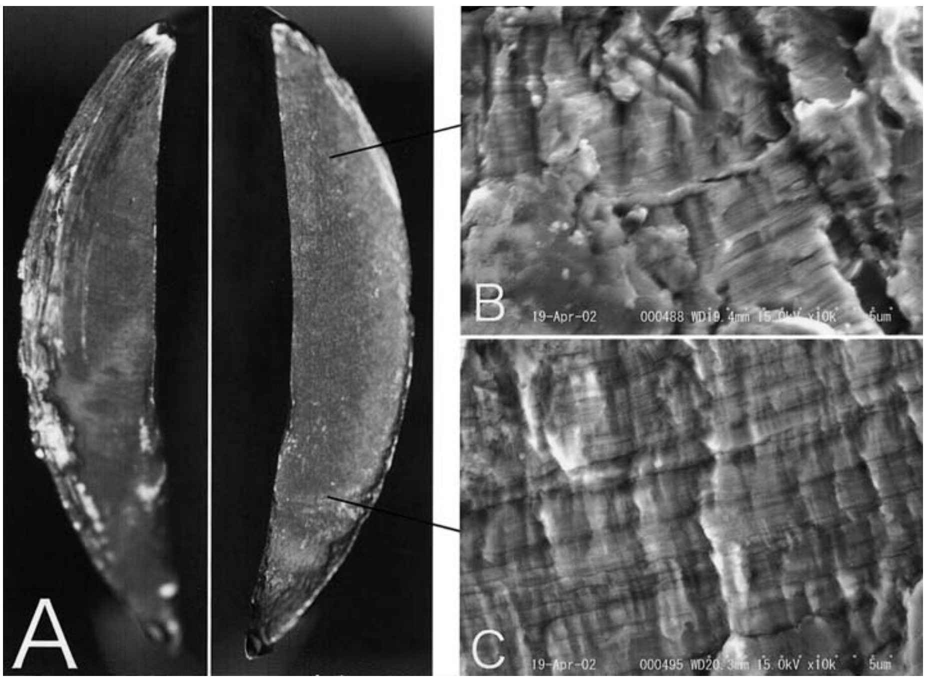


**Fig. 5.** Macroscopic and microscopic views of the retrieved implant. **A** Macroscopic view of the retrieved implant showed the horizontal fracture of the nail. *Top*: lateral side of nail. *Bottom*: medial side of nail. *Right*: anterior side of nail. *Left*: posterior side of nail. This figure indicates the site where the scanning electron microscopic study (SEM) was performed. **B, C** SEM images of the fractured surface showed typical striation

damage to the shear-lip, which suggested prolonged massive axial loading to the already failed implant. Scanning electron microscopic (SEM) images of the fractured surface showed typical striation, with the interval of striation becoming larger from the lateral side to the medial side of the nail (Fig. 6). The interval of striation of the posterior portion was wider than that of the anterior portion the same distance from the lateral corner. These findings suggest that the failure initiated from the anterolateral corner and spread to the anteromedial corner. After the anterior portion completely fractured, a fatigue crack may have occurred at the posterolateral corner and spread to the posteromedial corner, and nail then failed completely. There was no void, which is a fusion defect of material due to the manufacturing process,[12] which might have led to an initial failure mechanism; and there was no crack as a result of trauma due to inserting of the lag screw by force.[8]

## Discussion

Complex fractures of the proximal femur involving the subtrochanteric region are challenging injuries for the orthopedic surgeon. The sliding nail plate system requires large exposures with the related risk of soft tissue damage. The recently developed minimally invasive percutaneous plate osteosynthesis may diminish the size of skin incisions and preserve soft tissue; however, reports on this technique have shown the difficulties with reduction, the significant technical demand, and the incidence of mechanical complications.[16] The long Gamma nail was developed to manage these challenging fractures as a modification of the Gamma nail,[4–6,17] which has superseded the sliding nail plate system for treating intertrochanteric fractures, and has shown efficacy in the treatment of intertrochanteric fractures[1–3,8] and osteotomy.[18] The long Gamma nail also allows treatment of pathologic fractures in the trochanteric area by means of stable fixation; and simultaneously, intramedullary nailing protects diaphyseal pathological fracture due to metastasis.[4,17,19,20] The complications of the Gamma nail were diaphyseal, lateral cortex, and subcapital fractures; cut-out or back-out of the lag screw; shortening of thigh length; and superficial or deep infection, among others. Implant failure of the device has been rare. In the recent literature, the incidence of intraoperative fracture of the shaft was reported to be decreased because of the modification of implant design and the improvement of surgical technique.[1,3,21,22]

The reported incidence of implant failure of the Gamma nail is 0%–0.4% in multicenter studies,[2,3,8,10] and there has been only one case report of implant failure of the long Gamma nail.[11] There have been only 11 cases of implant failure in six articles that have described use of the Gamma nail.[2,8–12] Van den Brink and Janssen reported four cases of implant failure including two pathological fractures.[10] Zafiropuolos and Platt reported a single case involving repeated implant failures of the Gamma nail, whose fracture was united by valgus osteotomy and bone graft using a kind of sliding nail plate system.[12] Wozack et al. reported three implant failures, two of which were with the long Gamma nail.[11] Randle et al. reported a case of implant failure of the nail for fixation of an impending pathological fracture, which was united by valgus osteotomy and bone graft using a 95° angle blade plate.[9] In these reports, the nails were broken at the level of the insertion hole for the lag screw. Zafiropuolos and Platt pointed out that the weak point of the Gamma nail was around the insertion hole for the lag screw, where the cross-sectional area is reduced by approximately 73%.[12] The other breakage site was the insertion hole for the distal interlocking screws reported by Gaebler et al.[8] and Wozack et al.[11] All three cases in their report required revision surgery. There have been no instances of implant failure of the Gamma nail without nonunion or re-fracture.

The reason for breakage of the nail in the present case was unclear. The strength of the nail just after implantation was assumed to be normal because, in the SEM study, there was neither a void nor a crack, which occurs as a result of trauma due to insertion of the lag screw by force.[8] Concerning the type of fracture, the stress to the implant increases in accordance with the grade of the instability of the fracture. The present case sustained an unstable subtrochanteric fracture, but the long Gamma nail was developed for these unstable types[17]; therefore, the type of fracture might not be responsible for the implant failure. As for the operative procedure, there were some factors that may have caused implant failure. (1) Open reduction was necessary. (2) The lag screw was inserted through the fracture site. (3) The reduction was insufficient (reduced anteversion and varus deformity). We speculated that the process of implant failure was as follows. Repetitive stress during daily activities may have caused fatigue failure or the preceding stage of fatigue failure of the nail at the weak point; however, the increasing mechanical strength of the fracture site withstood the stress so as not to be re-fractured despite the nail fracture. The exact time when implant failure occurred could not be defined because the serial radiographs up until removal of the implants showed no evidence of implant failure, and the patient had no complaints. The most possible time of failure was the period of removal of the lag screw, which might have produced shearing stress at the lag screw hole of the nail. The present case might have suffered re-fracture if early weight-bearing had been allowed; fortunately, he obtained bony union.

We caution that when the Gamma nail is used for fixation of unstable fractures around the trochanteric region an adequate waiting period before full weight-bearing and careful observation are necessary to avoid re-fracture and implant failure.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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