

CASE REPORT

Successful Revision with INTERTAN for a Blade Cut Through in PFNA Fixation: A Case Report

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Background: Implant cut-out or cut-through remains a common cause of cephalomedullary nail failure and patient morbidity following surgical treatment of intertrochanteric femur fractures. In patients not suitable for conversion to total hip arthroplasty, which can involve long operation times and substantial blood loss, as well as a higher risk of periprosthetic fracture and dislocation postoperatively, revision with another internal fixation is an alternative option. If the femoral head can be preserved as much as possible to avoid eventual joint replacement while the internal fixation failure is solved, the quality of life of patients will be significantly improved.

Case Presentation: This current case describes a successful clinical use of a salvage procedure that allows the surgeon to avoid joint arthroplasty using INTERTAN to solve internal fixation failure caused by cut-through of Proximal Femoral Nail Antirotation-II (PFNA-II). Four years after closed reduction and internal fixation of the right femur, the patient had immobilizing right hip pain and mobility disorder. X-ray examination revealed contraction of the neck of the right femur and cut-through of the helical blade of the PFNA-II. After the revision operation, he recovered well and presented no grown pain or discomfort in weight-bearing. Conventional radiographs at 1-year follow-up showed a healed fracture, with no implant migration.

Conclusion: Main nail exchange and revision with INTERTAN can be considered a salvage procedure in selected cases to revise a failed fixation with PFNA, which solves internal fixation failure as well as preserves the femoral head.

Key words: Implant cut-through; INTERTAN; PFNA-II; Revision

Introduction

Intertrochanteric (IT) fracture, predisposed by aging and poor health status, accounts for more than 60%–70% of hip fracture cases with an annual mortality rate of 15%–20% among elderly patients, resulting in high health and economic burden as well as challenges for nursing management.^{1,2} Most IT fractures can be treated successfully with contemporary surgical techniques and internal fixations; however, clinical failures still occasionally occur, with reported data from 0.5% to 56%, due to unfavorable fracture patterns, poor bone quality, or suboptimal position of internal fixation devices.³ It may bring marked pain and functional disability.⁴ Hip replacement is still the mainstay of

salvage for IT fracture fixation failure.⁵ However, it remains somewhat defective due to potential problems, including postoperative soft tissue balance, offset reconstruction and joint dislocation.⁶ Therefore, the quality of life of patients with internal fixation failure can be effectively improved by adequately evaluating their condition and promoting fracture healing while preserving their femoral head as much as possible to avoid eventual joint replacement.

Herein, we report a case of IT fracture in a patient who subsequently developed failed internal fixation. Revision with the intramedullary nail was performed successfully instead of hip replacement, providing new inspiration for revision surgery due to failed internal fixation of IT femoral fracture.

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Case Presentation

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This patient was a 60-year-old male with a history of several orthopaedic surgeries. He had undergone closed reduction internal fixation (CRIF) for a left femoral neck fracture in October 2010 and recovered well. He also had osteoporosis, hypertension, and hyperlipidemia. The patient developed obvious pain in the right hip after a fall in 2016 and was diagnosed as a type 31-A1.2 intertrochanteric femoral fracture according to the AO/OTA Fracture and Dislocation Classification Compendium (Figure 1A,B). Then he received CRIF on a traction table using a Proximal Femoral Nail Antirotation-II (PFNA-II)TM by DepuySynthes (Pennsylvania, USA) of the right femur. The implant had a length of 170 mm, a diameter of 10 mm, and a nail-blade angle of 135-degrees. Postoperative recovery was good. The patient was allowed to partially weight bear 6 weeks after the

surgery with a walker and crutches, and did not transition to full weight bearing until 3 months postoperatively. Two years after (2018), he complained about immobilizing right hip pain without an obvious cause, then the pain worsened and mobility disorder occurred in March 2020. Radiographic work-up of the hip joint showed that the helical blade of the PFNA-II cut through the femoral head (Figure 2A,B).

Physical examination revealed medial and lateral tenderness of the right femur (+), axial percussion pain of the right lower limb (+), and mild limitation of adduction, abduction, flexion, and extension activities of the right lower limb due to pain. There was no swelling in the bilateral lower limbs. X-ray examination revealed contraction of the neck of the right femur and cut-through of the helical blade of the PFNA-II; callus formatted around the fracture line. Additionally, a dual-energy X-ray absorptiometry scan (DXA) showed that the L2-L4 bone mineral density (BMD) was 0.969 g/cm² and the T-score was - 1.5. Trabecular bone score (TBS) of L2-L4 was 1.246. The bone turnover indexes

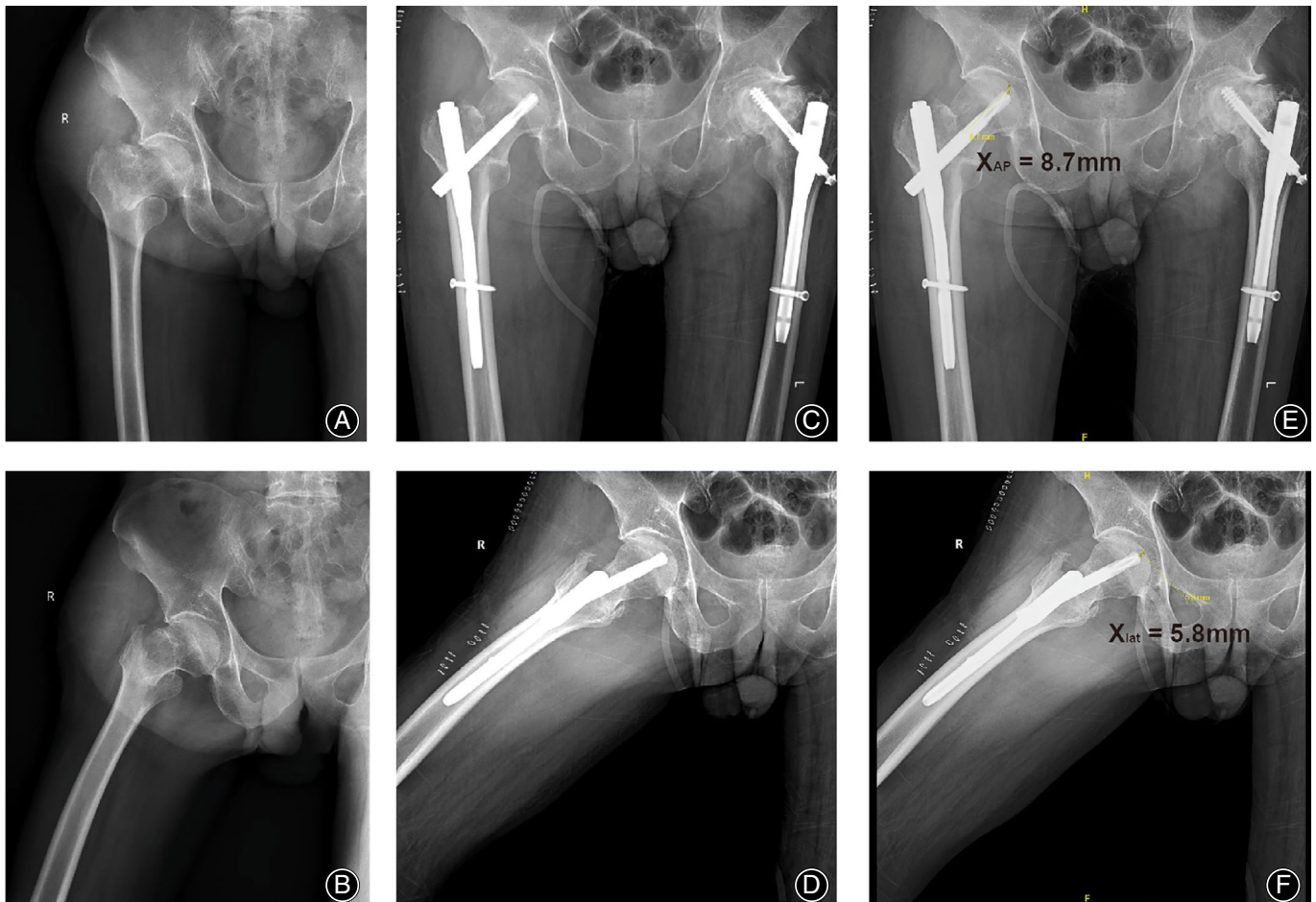


Fig. 1 Radiographs before and after the first operation. (A, B): preoperative lateral and anteroposterior X-ray of the right hip joint shows right femoral intertrochanteric fracture; (C, D): lateral and anteroposterior X-ray after closed reduction and internal fixation with PFNA-II; (E, F): the tip-apex distance (TAD) in AP (8.7 mm) and lateral (5.8 mm) view after the first operation, and final TAD is addition of both the values (14.5 mm)

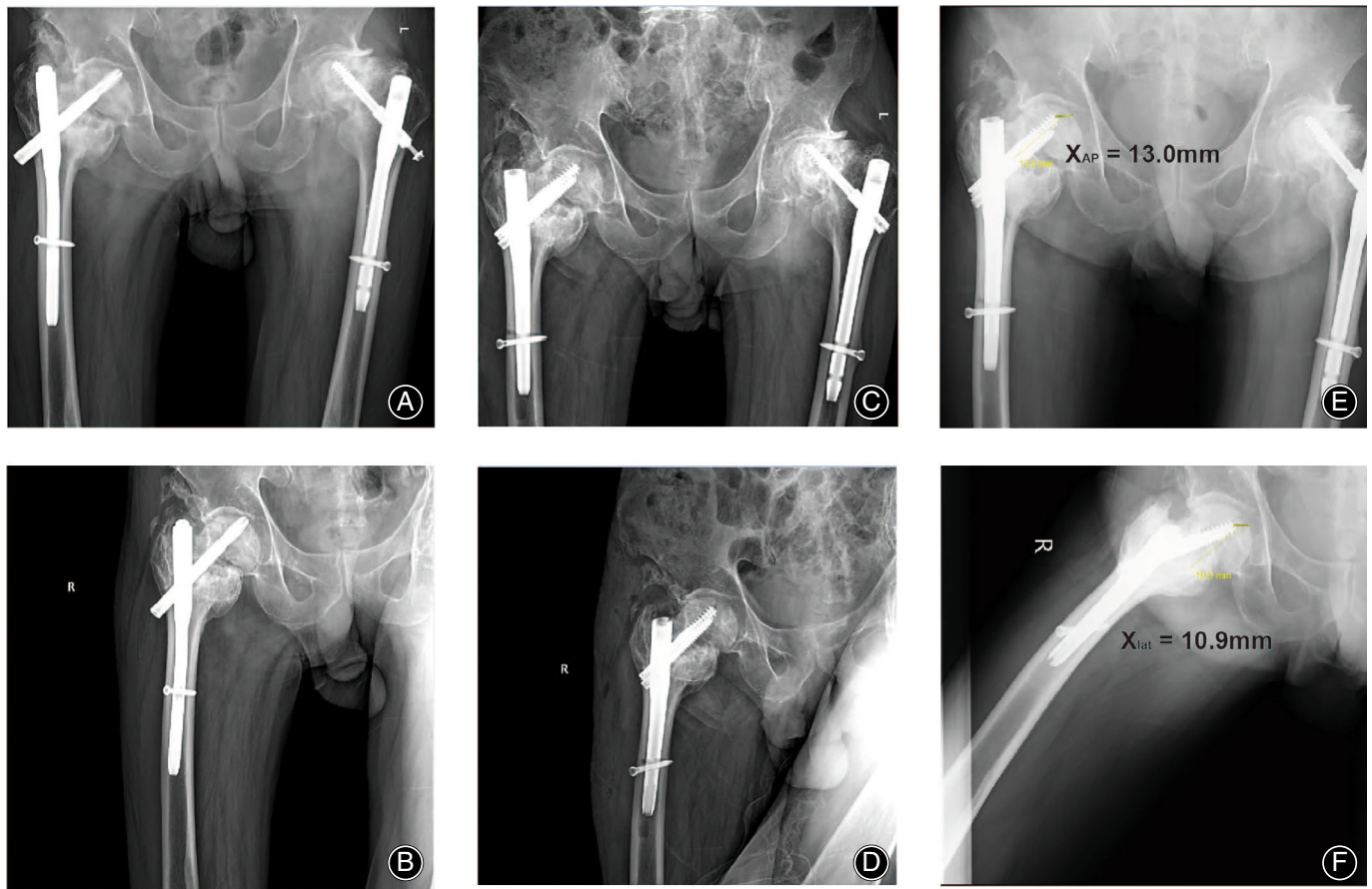


Fig. 2 Radiographs before and after the revision operation. (A, B): preoperative lateral and anteroposterior X-ray of the right hip joint shows cut-through of the helical blade of the PFNA-II; (C, D): lateral and anteroposterior X-ray after revision with INTERTAN; (E, F): the tip-apex distance (TAD) in AP (13.0 mm) and lateral (10.9 mm) view after the first operation, and final TAD is addition of both the values (23.9 mm)

were as follows: type I collagen carboxyl terminal peptide (β -CTX) 0.35 ng/mL (0.21–0.44 ng/mL), and type I procollagen amino-terminal peptide (PINP) 29.6 ng/mL (15.1–58.6 ng/mL).

Considering that the patient is in obvious pain and unable to walk due to a cut-through of the helical blade of the PFNA-II, surgical treatment was recommended. The BMD of our patient was 0.969 g/cm² (T-score –1.5) and the TBS score was 1.246. There was obvious callus formation at the fracture end; meanwhile, no signs of avascular femoral head necrosis (AVN) were observed. After a careful preoperative assessment, this patient was proposed to be performed on for the removal of original internal fixation and revision with an intramedullary nail of Smith + Nephew's INTERTAN™ nail (Tennessee, USA). Intraoperatively, the main nail was replaced with a longer intramedullary nail (180 mm) and the original blade was removed. Anteversion angle of the intramedullary nail was reduced, then the interlocking derotation and compression screw cephalomedullary nail were inserted from the new passage. The patient recovered well after surgery (Figure 2C,D). Full weight-bearing

was established 3 months after the revision operation. At 1-year follow-up, he presented no pain or discomfort on weight-bearing. Conventional radiographs showed a healed fracture, with no implant migration (Figure 3).

Discussion

The IT fracture is a common type of hip fracture carrying 1-year mortality up to 36%.⁷ Since the clinical introduction of PFNA by the AO group in 2004 and PFNA-II (Asian version) in 2008, this type of cephalomedullary nail with a single head–neck helical blade were commonly used in unstable pertrochanteric and IT fractures in geriatric patients.⁸ Biomechanical study proved that the helical blade system showed a significantly increased stability of fracture fixation.⁹ However, helical blade perforation through the femoral head may occur, thus bringing severe complications.^{10–12} Relative sharp head, hammer-in, large circumference contact area, and compact cancellous bone of the helical blade make it more likely to move axially, cutting through the femoral head. Cut-through after internal fixation can also be raised by fracture type, fracture reduction and

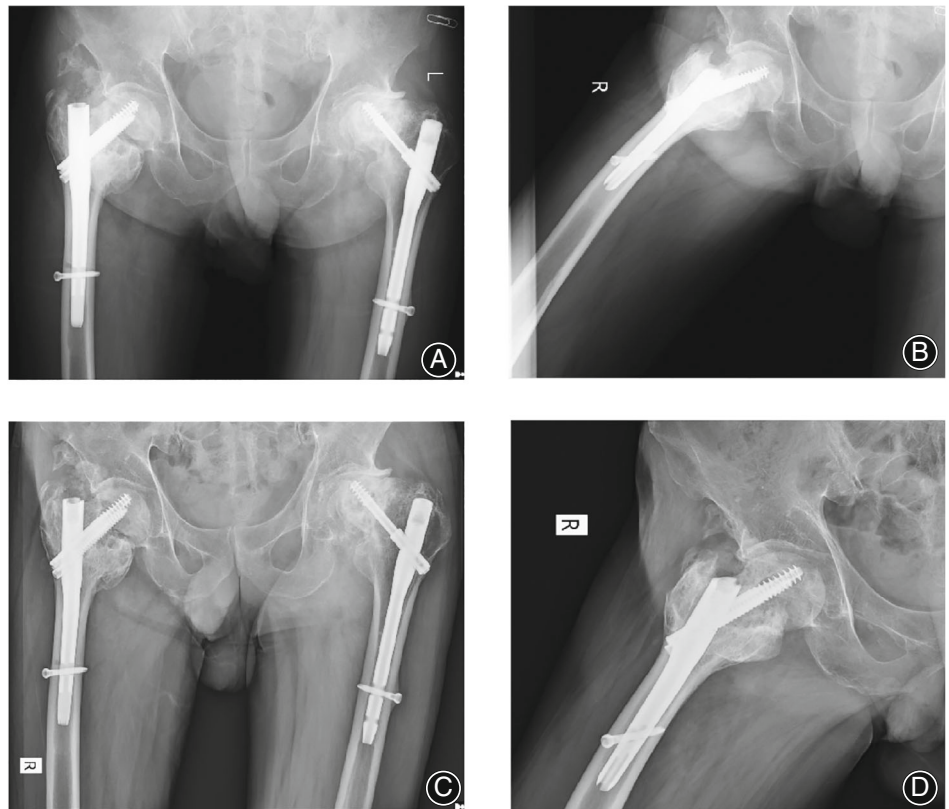


Fig. 3 Follow-up X-rays (lateral and anteroposterior views). (A, B): 3 months after revision surgery, callus formation at the fracture end with the INTERTAN in good position 3 months later; (C, D): a healed right intertrochanteric hip fracture 1 year after revision surgery

lag-screw position in the femoral head. Thus, finding out how to solve this kind of cut-through problem is essential for orthopaedic surgeons.

The reasons for the failure of our patient's postoperative internal fixation were mainly considered from the following aspects. First, there were risk factors for internal fixation failure, as the patient had osteoporosis (T-1.5; TBS 1.246) as well as several histories of fractures. Secondly, the characteristics of PFNA, including relative sharp head, hammer-in, large circumference contact area and compact cancellous bone may cause failure, cut-out, and cut-through of internal fixation. Studies have reported that penetration rate ranges between 0.6% and 3.6%, and appropriately enlarged blade tip-apex distance (TAD) to between 20 and 25 mm is excellent, which may play a great role in avoiding its medial migration and perforation postoperatively.¹³ However, the TAD of our patient was only 14.5 mm after the first operation, which may be another risk factor for PFNA cut-through (Figure 1E,F).

Total hip arthroplasty (THA) is considered the most common option to salvage fixation failure in IT fractures.¹⁴ Nevertheless, some patients may be unsuitable for conversion to THA, as it is faced with long operation times and substantial blood loss, as well as a higher risk of periprosthetic fracture and dislocation postoperatively. Internal fixation exchange and revision with INTERTAN fixation may be an alternative.

Considering the following aspects, we did not choose a hip replacement. The patient's BMD was -1.5 , not severe

osteoporosis. Moreover, the TBS value was 1.246, indicating that the bone trabecular microstructure of the patient was only partially damaged (1.200–1.350), not severely damaged (≤ 1.200). Radiological examination showed obvious callus formation and sufficient bone mass at the fracture end without an obvious bone nonunion or large amount of bone resorption. In addition, the femoral head showed no obvious necrosis, such as atrophy and collapse, but the femoral neck had a certain degree of shortening. Therefore, it was considered that the cut-through of the patient was caused by osteoporosis, partial bone absorption and structural characteristics of the spiral blade itself, which was easy to perforate. Given the absence of necrosis of the femoral head, hip replacement is not the optimal choice for our patient. Revision with internal fixation can address internal fixation failure while avoiding potential complications associated with THA. So, we decided to perform revision surgery with INTERTAN. A 170-mm main nail of PFNA was replaced with a 180-mm intramedullary nail to increase the overall stability of the internal fixation system. INTERTAN has a unique design of two cephalocervical screws that interlock and allow controlled linear intraoperative compression of the intertrochanteric fracture, which can strengthen the grip force and anti-rotation effect.

The conventional blade removal process of PFNA is well described in the removal guide from Depuy Synthes.¹⁵ Based on the original surgical approach, the end cap and distal locking bolt, anti-rotation blade, and main nail were

removed in sequence. Finally, the internal fixation needs to be checked for integrity and fracture damage. It is important to note that the greater trochanter area and the entry point of helical blade is a high stress area where osteophyte proliferation is often severe and therefore osteotomes are often required to expose the end of the blade.¹⁶ When the INTERTAN is placed, the guide pin is inserted under fluoroscopy along the original entry point of the nail to avoid additional bone destruction. The main nail, lag screw, and proximal interlocking screw are placed sequentially. During the nail placement, TAD and nail position need to be considered to obtain a good internal fixation and prevent the internal fixation from failing again.

In the position of the nail, the initial placement in our case is in the center-center zone according to the Cleveland system.¹⁷ Since removing the screw blade would cause a certain degree of internal bone defect in the femoral head, placing the INTERTAN screws below the original nail path would easily cause insufficient upper support, leading to internal fixation failure again. Moreover, upward blade implantation needs drilling of the lateral cortex, further damaging the integrity of the lateral femoral cortex and the stability of internal fixation. Therefore, the new nailing path can be renovated in front and rear of the original nailing path. Baumgaertner et al. reported that the cut-out rate in anterior zone was about 15%, compared with 11% in the posterior zone.¹³ So, we decided to place screws in center-posterior zone according to the Cleveland system, to prevent the internal fixation failure as much as possible. Postoperative X-ray showed TAD was 23.9 mm, within the optimum range (Figure 2E,F). Anti-osteoporosis treatment with vitamin D, calcium, and desomumab started postoperatively. Three months after the operation, examination showed good internal fixation and callus formation at the fracture end (Figure 3A,B). One year later, follow-up showed a good range of motion of the hip joint and no obvious pain in walking and loading. X-ray showed healing of the fracture (Figure 3C,D).

Previous reports suggested that bone cement could strengthen the screw holding of internal fixation.^{18,19} However, in our case, cement is prone to leak into the hip space from where the spiral blade penetrates, increasing the risk of necrosis of the femoral head. So, this operation did not use bone cement to strengthen internal fixation after comprehensive consideration. Postoperative follow-up also confirmed that INTERTAN provided sufficient stability even without cement reinforcement.

There are several limitations to this report. It is a single-case report with the associated limitations of retrospective follow-up of a single patient. Furthermore, this case is a surgical procedure based on the patient's bone condition and the surgeon's clinical experience, and no systematic evaluation strategy to quantitatively evaluate these patients to determine whether to use joint replacement or revision with internal fixation. So, more cases need to be studied.

In conclusion, when a patient with IT fracture encounters failure of internal fixation, the cause of failure should be analyzed comprehensively, and a suitable surgical method should be selected according to the patient's condition. Revision with internal fixation can be selected in appropriate cases whose osteoporosis are not severe and whose femoral head show no obvious necrosis. Carefully selecting the nail entry area during the procedure, controlling the TAD value in the appropriate range (20–25 mm), administering anti-osteoporosis treatment after surgery, and paying strict attention to weight-bearing time should be integrated in the revision surgery to achieve a good recovery and to avoid further internal fixation failure.

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Author Contributions

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors. All authors are in agreement with the manuscript. H.Z.† and X.M.† are co-first authors of this manuscript. *Conceptualization*, H.Z.†, J.Z.; *Methodology*, H.Z.†, X.M.†; *Validation*, H.Z.†; *Formal Analysis*, X.M.†; *Data Curation*, X.M.†; *Writing—Original Draft*, X.M.†; *Writing—Review & Editing*, H.Z.†; *Visualization*, X.M.†; *Supervision*, J.Z.; *Project administration*, H.Z.†, J.Z.; *Funding acquisition*, J.Z.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Statement

The study was approved by the Institutional Review Board of Peking Union Medical College Hospital, Beijing, China. The patient provided written informed consent.

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