

Exchange Nailing as Revision Surgery for Post-operative Non-union of Atypical Femoral Fractures: A Case Report and Treatment Strategy

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Learning Point of the Article:

Exchange nailing and the use of opposite side IMN were useful for the revision of post-operative non-union of atypical femoral fractures with lateral bowing.

Abstract

Introduction: Atypical femoral fractures account for only 0.5% of femoral shaft fractures, but delayed union or non-union occurs in 50% of atypical femoral fractures accompanied by femoral lateral bowing. Such fractures are difficult to treat.

Case Report: The case was an 84-year-old woman. She was diagnosed post-operative non-union of atypical femoral fracture. We planned a revision surgery for post-operative non-union of the atypical proximal femoral fracture. A two-dimensional template was used to simulate the intramedullary nail (IMN). Due to the advanced femoral lateral bowing deformity, a mismatch with the nail was noted when the unaffected femur was used to construct the template. When the opposite side nail was used as a template, the nail was aligned with the medullary canal, and the tip of the nail coincided with the center of the medullary canal; hence, the opposite side nail was chosen. Radiographical assessments of healing of the fracture confirmed callus formation and complete bone union 3 months and 1 year after the operation, respectively.

Conclusion: We found that exchange nailing as revision surgery for post-operative non-union of atypical femoral fractures combined with an IMN on the opposite side was useful.

Keywords: Alendronate, femoral fracture, osteoporosis, revision surgery.

Introduction

Bisphosphonates (BPs) play an important role in the treatment of osteoporosis. BPs inhibit the bone remodeling process and improve bone mineral density and mechanical properties [1]. Meanwhile, the use of BPs for a long term has been reported to cause femoral shaft fractures and subtrochanteric femoral fractures [2]. The American Society for Bone and Mineral Research (ASBMR) has published a definition of atypical femoral fractures in 2010 and its revised edition in 2014 [3]. Not only BPs but also Asian race are an increasingly recognized risk factor for AFFs [4]. Delayed or incomplete union occurred in 50% of BP-induced atypical femoral fractures after treatment with intramedullary nails (IMNs) [5]. Prasarn et al. have reported that the treatment of atypical femoral fractures is

difficult because it is often associated with non-union and implant fractures [6]. They reported on stress fractures of the femoral shaft after total knee arthroplasty has also described involvement of femoral shaft bowing deformity and bilaterality. Treating severely bowed femurs in atypical femur fractures were difficult. No established strategies of revision surgery are available. Here, we report a case of a severely bowed femurs in atypical femoral fracture associated with the long-term use of a BP, in which non-union after the treatment with an IMN was successfully revised by exchange nailing.

Case Presentation

The case was an 84-year-old woman. She had undergone total knee arthroplasty for osteoarthritis 3 years before. She had been

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Author's Photo Gallery



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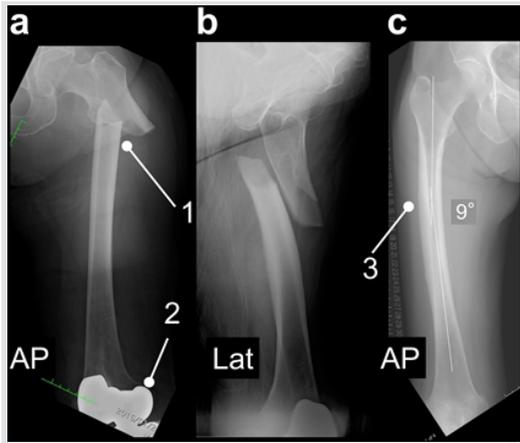


Figure 1: Pre-operative radiograph of the femoral fracture. (a) Anteroposterior radiograph. (b) Lateral radiograph. (c) Anteroposterior radiograph of the right side. 1: Hypertrophic lateral cortex. 2: Femoral component of total knee. 3: Hypertrophic lateral cortex of the right side.

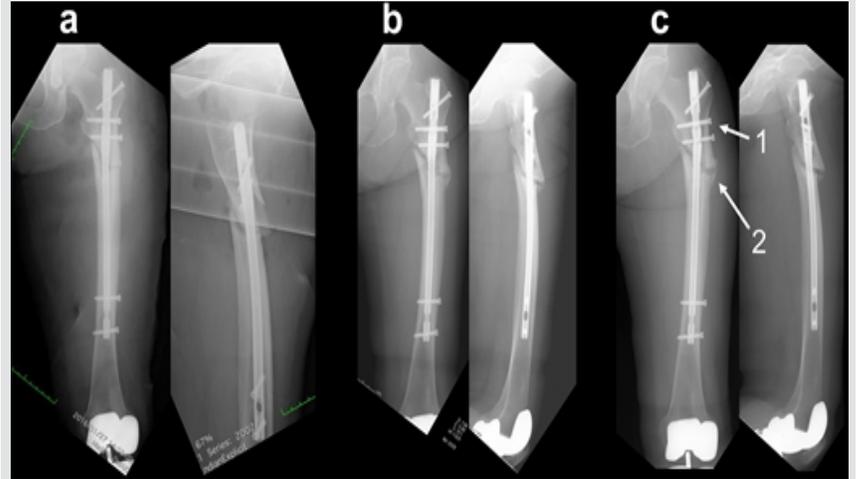


Figure 2: (a) Post-operative radiographs. (b) Eleven-month follow-up. Radiographs showing bridging callus of the fracture site. (c) Thirteen-month follow-up. 1: Main nail breakage (white arrow). 2: A displaced lateral femoral wall (white arrow).

using oral alendronate (35 mg) tablets once a week for 7 years for the treatment of osteoporosis. She fell after she felt a pain in her right thigh while walking and consulted a local doctor. A radiographic examination revealed a non-comminuted oblique fracture at the subtrochanteric level of the left femur (Fig. 1a, b). In addition, the hypertrophic lateral cortex or subperiosteal hypertrophy was observed in the fractured part (Fig. 1a: 1). The hypertrophic lateral cortex or subperiosteal hypertrophy was also observed in the unaffected femur, which was laterally bowed by 9° (Fig. 1c: 3). Her fracture fulfilled four major and three minor ASBMR diagnostic criteria for atypical femoral fractures (Fig. 1). The previous doctor had performed a surgery using an antegrade IMN, long Gamma 3 nail (diameter, 10 mm; length, 280 mm, Stryker, Schonkirchen, Germany). Retrograde IMNs were not indicated because she had undergone total knee arthroplasty (Fig. 1c: 2). A sufficiently long IMN could not be used because the IMN interfered with the cortical bone due to femoral lateral bowing (Fig. 2a). The patient was referred to us 12 weeks postoperatively. Oral alendronate was discontinued. Instead, the patient consented to empirical therapy with teriparatide at 20 µg/day, which is a dose approved for the treatment of osteoporosis. Oral alendronate was discontinued because BPs inhibit the bone remodeling process. We expected that teriparatide would promote bone union. Instead of oral alendronate, teriparatide was administered at a daily dose of 20 µg, which is its therapeutic dose for osteoporosis. However, bone union was not observed even 11 months after surgery, and thus, a diagnosis of nonunion (hypertrophic nonunion) was made (Fig. 2b). The intensity of femoral pain increased during walking 13 months postoperatively. A radiographic examination revealed the fractured IMN (main nail breakage) (Fig. 2c). The patient provided informed consent in writing to disclosure of surgery-related technical and patient information.

We planned a revision surgery for post-operative non-union of the atypical proximal femoral fracture. A two-dimensional

template was used to simulate the IMN (Fig. 3). Zimmer Natural Nail Antegrade Femur (ZNN IMN, diameter, 11 mm; length, 380 mm, Zimmer, Winterthur, Switzerland) was chosen as an IMN for revision surgery. Due to the advanced femoral lateral bowing deformity, a mismatch with the nail was noted when the unaffected femur was used to construct the template (Fig. 3a). When the opposite side nail (opposite side ZNN IMN system) was used as a template, the nail was aligned with the medullary canal, and the tip of the nail coincided with the center of the medullary canal; hence, the opposite side nail was chosen (Fig. 3b). Based on a report from Park et al. in 2016, an opposite side IMN fitting, the medullary canal was used to perform surgery [7]. The operation was performed with the patient in the lateral position on a radiolucent fracture table under fluoroscopy. A 7 cm horizontal skin incision was made at the fracture site (Fig. 4a). The existing IMN was removed, and the medullary canal was reamed to 13 mm. After the refreshment of the false joint, the lateral cortex was cut into a wedge shape using a chisel (Fig. 4b). The proximal bone fragment was reduced to a

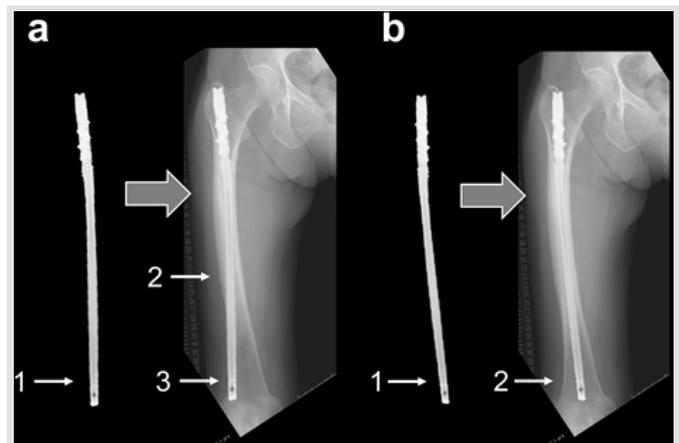


Figure 3: Outcomes of the simulation analysis using two-dimensional template. Radiographs of the simulated model are shown in a and b. a-1: Fit for the ZNN Antegrade Femur (ZNN IMN) system with the right femur. a-2: Jamming point of the lateral cortical bone of the femur. a-3: The intramedullary nail (IMN) tip is not located at the center of the medullary canal the femur. b-1: Fit for opposite side ZNN IMN system. b-2: The IMN tip is located properly at the center of the medullary canal the femur.



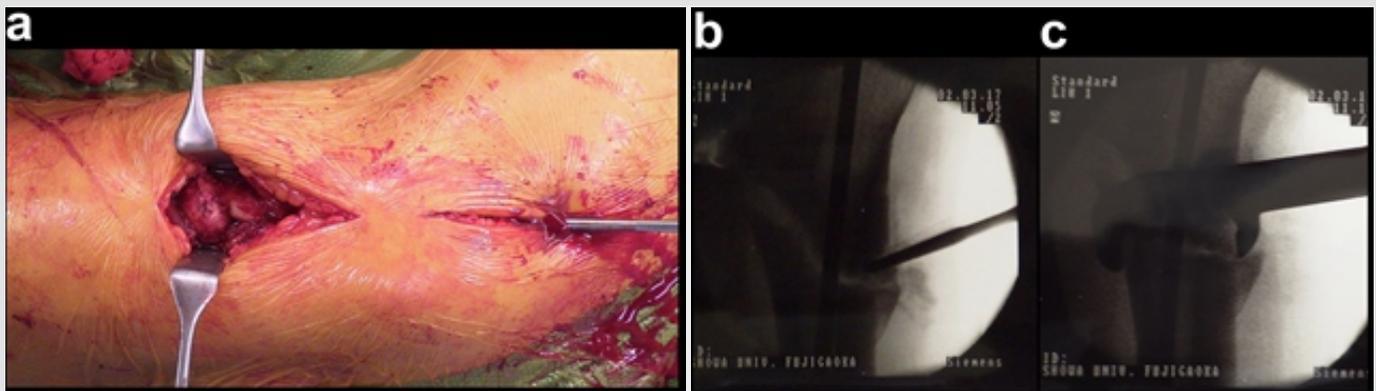


Figure 4: (a) Photographs during open reduction and internal fixation. (b) The lateral cortex was cut into a wedge shape using a chisel. (c) The proximal bone fragment was reduced to a valgus position using a clamp.

valgus position using a clamp (Fig. 4c). The false joint was fixed using a cable (Cable-Ready System, Zimmer, Warsaw, IN) to maintain the reduction position. Then, the opposite side ZNN IMN was inserted (Fig. 5a). The IMN was inserted to the distal end. The nail was inserted in such a manner that the nail end overlapped with the femoral component of the prosthetic knee (Fig. 5b). The skin was sutured layer by layer before concluding the operation. For follow-up, the patient underwent radiographic examinations of the right femur 1 month, 2 months, 3 months, 5 months, 1 year, and 2 years postoperatively. Radiographical assessments of healing of the fracture confirmed callus formation and complete bone union 3 months and 1 year after the operation, respectively. As of 2 years postoperatively, she has returned to the normal level of activity and can walk without pain (Fig. 5c).

Discussion

BPs are widely used for the treatment of osteoporosis. BPs inhibit the bone remodeling process and improve bone mineral density and mechanical properties [8]. Schilcher et al. have reported that atypical femoral fractures account for 0.5% of

femoral shaft fractures [1]. Prasarn et al. compared the outcomes of IMN treatment for atypical femoral fractures between a group of patients with a history of treatment with oral BPs and a group of patients without such a history. They have reported that intraoperative fractures, non-union, and implant breakage were found more frequently in the group with BP treatment history than in the group without BP treatment history [6]. Sasaki et al. have reported that delayed or incomplete union was found in 50% of BP-induced femoral fractures accompanied by severe lateral bowing [9]. Rocos et al. have reported that delayed or incomplete union occurred in 50% of BP-induced atypical femoral fractures after treatment with IMNs [5]. Meanwhile, in women with osteoporosis, teriparatide accelerates union of atypical femoral fractures [10]. In the present case, oral BP administration was discontinued and switched to teriparatide, yet non-union occurred.

Femoral lateral bowing

Marcano et al. have reported that Asians are at a higher risk for atypical femoral fracture [11]. The femoral anterior radius of curvature in Americans was larger than that in elderly Japanese

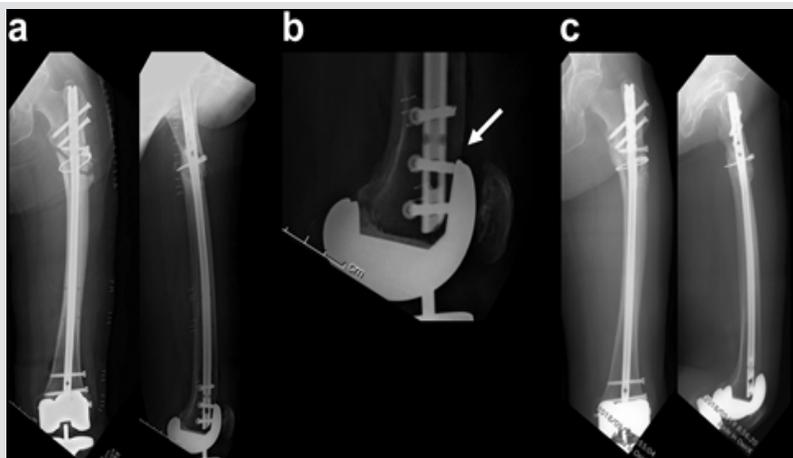


Figure 5: (a) To adjust for the native bowing of the femurs, the atypical femoral fracture in the left femur was managed using a right ZNN IMN system. (b) Nail end was overlapped with femoral component of total knee. (c) Post-operative radiographs, 24 months after surgery, showing bone union.

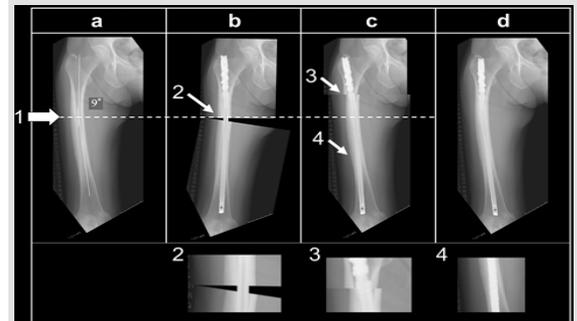


Figure 6: Outcomes of the simulation analysis using the two-dimensional template. (a) The alignment measures for the right femur were 9 of lateral bowing. (b) Fit for the Zimmer Natural Nail intramedullary nail (ZNN IMN) system with osteotomy at the center of angulation. (c) Fit for the ZNN IMN system with osteotomy at the subtrochanteric area. (d) Fit for opposite side ZNN IMN system. 1. Center of angulation (white dotted line). 2. Osteotomy at the center of angulation: The distal fragment angulate to 9° valgus. 3. Osteotomy at the subtrochanteric area: The proximal fragment translate to lateral. 4. Jamming point of the lateral cortical bone of the femur.



women; the femoral anterior radius of curvature was 1040 mm in the latter population, whereas it was 1200–1300 mm in the former population [12–14]. Thus, the shape of the femur may be a risk factor. Oh et al. have reported that femoral bowing deformity was associated with an increased risk for atypical fracture [15]. Fixation with full-length reconstruction nails is a standard procedure for the treatment of atypical femoral fractures, but the nail shape often does not fit the medullary canal morphology [3] due to femoral lateral bowing. Some surgical methods have been reported to address this problem.

Revision surgery

A reported method of revision surgery for delayed and incomplete union of atypical proximal femoral fractures is the combined use of an IMN and a lateral tension band plate with reduction to a valgus position after wedge excision of the lateral cortex [5]. The ASBMR has also recommended that the medullary canal should be over-reamed to a diameter at least 2.5 mm larger than the IMN diameter to compensate for the narrow medullary diameter before an IMN is inserted [3]. In the present case, an opposite side IMN fitted the medullary canal and was useful for revision surgery due to severe femoral lateral bowing. Park et al. has also reported that the opposite side IMN fitted the medullary canal of atypical femoral fractures with severe lateral bowing [7]. In the present case, the femur was bowed 9° (Fig. 6; lateral bowed femur with 9°). Due to the bowed femur, only a short nail was inserted in the initial operation. Figure 6c illustrates that a long nail cannot be

inserted. It also shows that the IMN cannot slide within the medullary canal beyond a certain point where the distal end of the IMN comes into contact with the cortex due to lateral bowing of the femoral shaft (Fig. 6c: 4). In atypical proximal femoral fractures, involving fractures at proximal sites, the nail pushes the proximal bone fragment and makes it shift outward (Fig. 6c: 3). In such a case, the cable or plate is required to be reinforced. Alternatively, 9° correction is required when the ZNN IMN system is to be used after osteotomy at the center of femoral bowing (Fig. 6b). The main limitation of our study is related to the small sample size and study design.

Conclusion

A proposed treatment strategy for revision of post-operative non-union of atypical femoral fractures : A full-length reconstruction nail is used for fixation. If the nail cannot be inserted due to femoral bowing deformity, an opposite side IMN (opposite side of ZNN) can be combined with valgus osteotomy to use the full-length reconstruction nail for fixation. Particularly for atypical proximal femoral fractures, involving fractures at proximal sites, additional cables, or plates can be used to increase the fixation force. Exchange nailing and the use of opposite side IMN were useful for the revision of post-operative non-union of atypical femoral fractures.

Clinical Message

Exchange nailing as revision surgery for post-operative non-union of atypical femoral fractures combined with an IMN on the opposite side was useful.

References

- Schilcher J, Michaëlsson K, Aspenberg P. Bisphosphonate use and atypical fractures of the femoral shaft. *N Engl J Med* 2011;364:1728-37.
- Reid IR. Short-term and long-term effects of osteoporosis therapies. *Nat Rev Endocrinol* 2015;11:418-28.
- Shane E, Burr D, Ebeling PR, Abrahamsen B, Adler RA, Brown TD, et al. Atypical subtrochanteric and diaphyseal femoral fractures: Report of a task force of the American society for bone and mineral research. *J Bone Miner Res* 2010;25:2267-94.
- Aspenberg P, Schilcher J. Atypical femoral fractures, bisphosphonates, and mechanical stress. *Curr Osteoporos Rep* 2014;12:189-93.
- Rocos B, Fleming T, Harding K, Acharya M, Riddick A, Kelly M. A case series and discussion on surgical treatment strategy for atypical proximal femoral fractures associated with bisphosphonate use. *Cureus* 2018;10:e3670.
- Prasarn ML, Prasarn ML, Ahn J, Helfet DL, Lane JM, Lorich DG. Bisphosphonate-associated femur fractures have high complication rates with operative fixation. *Clin Orthop Relat Res* 2012;470:2295-301.
- Park JH, Lee Y, Shon OJ, Shon HC, Kim JW. Surgical tips of intramedullary nailing in severely bowed femurs in atypical femur fractures: Simulation with 3D printed model. *Injury* 2016;47:1318-24.
- Odvina CV, Zerwekh JE, Rao DS, Maalouf N, Gottschalk FA, Pak CY. Severely suppressed bone turnover: A potential complication of alendronate therapy. *J Clin Endocrinol Metab* 2005;90:1294-301.
- Sasaki S, Miyakoshi N, Hongo M, Kasukawa Y, Shimada Y. Low-energy diaphyseal femoral fractures associated with bisphosphonate use and severe curved femur: A case series. *J Bone Miner Metab* 2012;30:561-7.
- Lou S, Lv H, Wang G, Zhang L, Li M, Li Z, et al. The effect of teriparatide on fracture healing of osteoporotic patients: A meta-analysis of randomized controlled trials. *Biomed Res*



- Int 2016;2016:6040379.
11. Marcano A, Taormina D, Egol KA, Peck V, Tejwani NC. Are race and sex associated with the occurrence of atypical femoral fractures? Clin Orthop Relat Res 2014;472:1020-7.
 12. Egol KA, Chang EY, Cvitkovic J, Kummer FJ, Koval KJ. Mismatch of current intramedullary nails with the anterior bow of the femur. J Orthop Trauma 2004;18:410-5.
 13. Ehmke LW, Polzin BM, Madey SM, Bottlang M. Femoral nailing through the trochanter: The reamer pathway indicates a helical nail shape. J Orthop Trauma 2006;20:668-74.
 14. Maehara T, Shinohara K, Yamashita K, et al. The morphology of the femur in elderly Japanese females: Analysis using 3D-CT. J Jpn Soc Fract Repair 2012;34:451-5.
 15. Oh Y, Fujita K, Wakabayashi Y, Kurosa Y, Okawa A. Location of atypical femoral fracture can be determined by tensile stress distribution influenced by femoral bowing and neck-shaft angle: A CT-based nonlinear finite element analysis model for the assessment of femoral shaft loading stress. Injury 2017;48:2736-43.

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