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Revision surgery in a middle-aged patient with pertrochanteric fracture nonunion due to wedge effect caused by cephalomedullary nail: A case report

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SUMMARY

Trochanteric femur fractures have traditionally been treated surgically with compression hip screws or cephalomedullary nails. With the increasing use of cephalomedullary nails, potential complications from this technique have surfaced. One of them is the potential for varus malreduction of trochanteric femur fractures, known as the "wedge effect", which is the distraction of fracture fragments generated during reamer and nail passage resulting in varus malalignment at the neck-shaft angle. Although trochanteric nonunion in the non-elderly is exceedingly rare, we experienced one such case after nailing due to the wedge effect that was subsequently successfully treated with a compression hip screw without bone grafting. Therefore, in the case of stable pertrochanteric fractures (AO/OTA 31A1) in younger patients, compression hip screw surgery may be the better choice of initial surgery to avoid later nonunion.

Trochanteric femur fractures are traditionally treated surgically with compression hip screws (CHSs) or cephalomedullary nails (CMNs). A survey of orthopedic surgeons regarding preferred fixation method revealed a recent trend toward the use of CMNs [1]. With the increasing use of CMNs, potential complications from this technique have surfaced, such as varus malreduction of trochanteric femur fractures [2]. O'Malley et al. further investigated this complication, coining the term "wedge effect" to describe the distraction of fracture fragments generated during reamer and nail passage resulting in varus malalignment at the neck-shaft angle [3].

Although a nonunion incidence of 1–2 % has been reported for trochanteric fractures [4], trochanteric nonunion in the non-elderly is exceedingly rare [5]. In general, nonunion of this lesion in older patients is usually salvaged with some form of hip replacement; however, in younger patients, a repeat open reduction and internal fixation (ORIF) is usually performed [5]. Here, we describe one case of pertrochanteric nonunion in a middle-aged patient after nailing due to the wedge effect and explain its subsequent treatment with a CHS.

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Case

A 49-year-old man presented with severe left hip pain after a motorcycle accident. He had no pre-existing comorbidities. Radiographs revealed a left pertrochanteric fracture classified as stable (AO/OTA 31A1.2) (Fig. 1). On the same day, an ORIF was performed on a fracture table using the TFN-ADVANCED Proximal Femoral Nailing System (TFNA, Depuy Synthes, Oberdorf, Switzerland). A 125-degree angle nail with a femoral neck blade was chosen. Post-operative X-rays showed acceptable reduction of the intertrochanteric femur (Fig. 2). Passive and active ranges of motion of the hip joint were allowed immediately, and full weight bearing was permitted after 4 weeks due to the nondisplaced acetabular posterior wall fracture (Fig. 1). Postoperatively, telescoping did not work properly. Low-intensity pulsed ultrasound was started 4 months postoperatively; however, bone union was not achieved, and the patient continued to complain of left hip pain. A subsequent X-ray at 10 months showed hypertrophic nonunion (Fig. 3), and revision surgery was deemed necessary. There was no evidence of infection.

Eleven months after initial surgery, revision surgery was performed using a CHS (LCP DHS 135 degrees, Depuy Synthes, Oberdorf, Switzerland) without bone grafting. A 135-degree angle plate with femoral neck screw was chosen (Fig. 3). Full weight bearing was permitted just after revision surgery. At 1 year after revision surgery, bone union was radiologically observed at 3/4 cortices, meeting the criteria of the United States Food and Drug Administration (Fig. 4). The patient was able to return to pre-injury activity levels, and his range of motion of the affected hip was the same as that of the healthy side. At 2 years, complete bone union was observed at 4/4 cortices (Fig. 4).

Discussion

We presented a case of pertrochanteric nonunion in a middle-aged patient that was successfully treated with a CHS. Failed treatment of trochanteric fractures leads to marked disability and pain, and revision surgery is frequently accompanied by higher complication and reoperation rates than primary surgery [6]. We performed re-internal fixation using a CHS without bone grafting because our case was hypertrophic nonunion, which preserves bone activity. Based on "the diamond concept" of fracture healing [7], the mechanical environment was considered key to solve this nonunion. More specifically, the absence of dynamic compression at fracture site was the main cause of nonunion. Therefore, the priority of the revision surgery was removing the CMN and achieving dynamic compression with a CHS at the fracture site. To obtain better dynamic compression, a lag screw matching the femoral neck-shaft angle of the patients was inserted vertically at the fracture line. In addition, the nonunion site was not touched, and autologous bone grafting was not performed; thus, the invasiveness of the surgery was minimized. The nonunion had healed uneventfully by 1 year after the revision surgery without bone grafting, but because the gap caused by the wedge effect was relatively large, bone grafting could have resulted in earlier bone union.

During the initial surgery, the position of the nail guidewire was slightly lateral (Fig. 2A). Moreover, reaming the superolateral aspect of the femoral neck was not enough (Fig. 2B). As a result, the fracture site was dissected by the insertion of the nail (Fig. 2C). It has already been reported that nail surgery causes dissection of the fracture site, and this has been described as the "wedge effect" [3]. This effect can be attributed primarily to the inadequate removal of the bone at the medial aspect of the nail insertion point [8]. O'Malley et al. define the wedge effect as a deformity accompanied by varus deformity [3]; however, in our case varus deformity was not significant. Therefore, we did not consider it necessary to adjust the angle. In all of O'Malley's cases (average age: 77 years) bone union was observed [3], while our case displayed bone nonunion. This may partly be because our patient was younger and had better

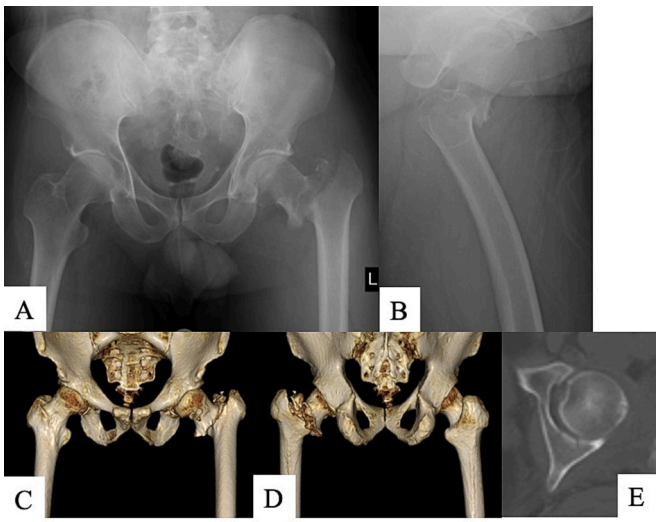

Fig. 1. Initial posttraumatic radiographs (A and B) and computed tomography scan (C and D) of the hip. Multi-planar reconstruction showed nondisplaced acetabular posterior wall fracture (E).

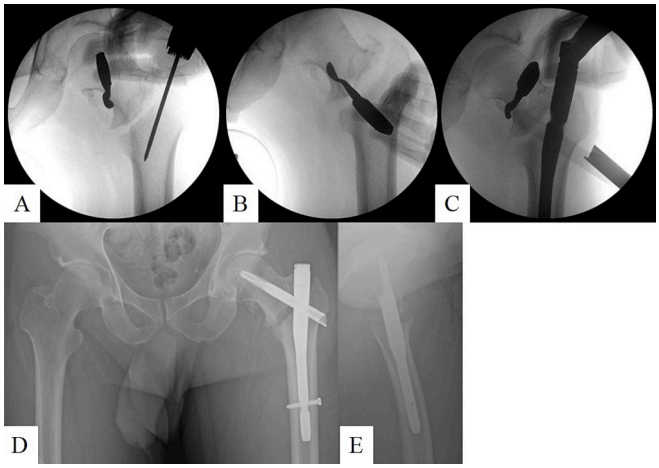

Fig. 2. Image intensifier during initial operation (A, B, and C). Initial radiographs postoperatively (D and E).

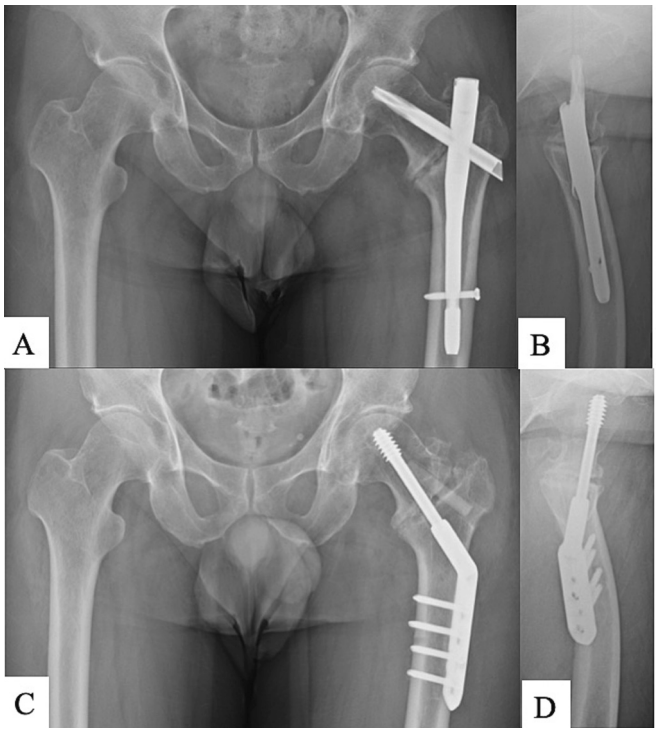

Fig. 3. Radiograph showing nonunion at 10 months after initial surgery (A and B). Radiograph immediately post revision surgery (C and D).

bone quality. Therefore, the proximal lateral bone fragments did not break postoperatively and continued jamming the nail, leading to an inability to achieve dynamic compression between the fracture blocks, ultimately causing nonunion.

Additionally, there was also a mismatch in the angle of the lag screw, which was lower than the cervical body angle of the patient and not perpendicular to the fracture, creating a situation where compression was difficult to achieve at the fracture site. The angle tends to be higher in younger patients than that in older patients [9], and it is necessary to select a nail that matches the cervical body angle as much as possible.

It is important to emphasize that in pertrochanteric fractures like ours, due to the proximity of the fracture line to the appropriate nail entry, the entry reamer insertion inevitably results in the reamer being easily retracted into the fracture line, leading to a fracture gap after nail insertion. To prevent this, it may be advisable to keep compression at fracture site with a pointed bone clamp forceps during reaming of entry point [8], and to gradually increase the reamer size of entry. Some CMNs are equipped with devices that can apply limited interfragmentary compression to the fracture site, which is sometimes effective. However, if the nail entry location is

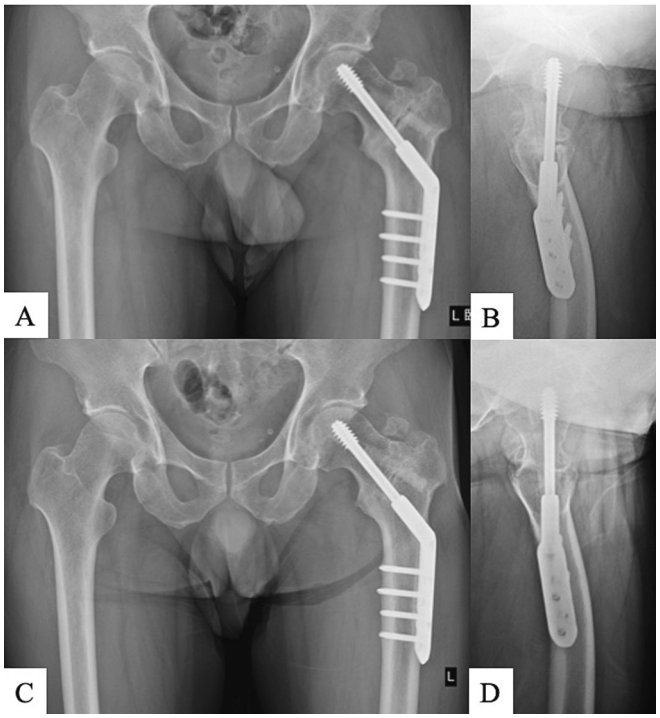

Fig. 4. Radiographs at 1 year (A and B) and 2 years (C and D) after revision surgery.

incorrect, the compression device does not perform as expected. In particular, if the patient is young and has good bone quality, as in our case, the bone does not break at the fracture site and the nail itself is left in contact with the proximal part of the fracture, thus retaining the fracture gap. In fact, the compression device provided with the TFNA was used in our case but failed to produce compression. The easiest solution would have been to use a CHS rather than a CMN as the primary surgery method in the simple fracture pattern like our case.

Other possible methods of revision surgery for our case could be re-fixation with nails, locking plates, and angle blade plates (ABPs) [10]. *Re*-nailing is challenging, and nailing itself was the cause of nonunion here. With locking plates, dynamic compression cannot be achieved [8]. Additionally, the surgery would have been more invasive due to the need for a larger surgical field to accommodate the longer plates; further, as plates are mechanically weaker than nails, a period of non-weight bearing would have been required post-operatively. ABPs are useful for revision surgery because they can refine varus deformity and target bone in the inferior portion of the femoral head, which typically has not been violated by prior fixation devices [5], but they do not provide dynamic compression at fracture site either. Here, there was no varus deformity to refine and the femoral head was also preserved. Taken together, we chose to use a CHS with 135-degree neck-shaft angle, creating dynamic compression, and allowing the lag screw to be placed perpendicular to the fracture line.

Conclusion

We report a case of pertrochanteric nonunion in a middle-aged patient successfully treated with a CHS without bone grafting. In non-elderly patients with a stable pertrochanteric fracture, initial CHS surgery may be recommended to avoid later nonunion.

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Informed consent statement

Express written consent was obtained from the patient for the publication of this case, as well as its media materials. This case report was approved by the Institutional Review Board.

CRediT authorship contribution statement

T. Waki: Study conception and design, acquisition of data, analysis and interpretation of data, drafting and revision of article.

T. Matsumura: Study conception and design, analysis and interpretation of data, drafting and revision of article.
G. Fukumoto: Analysis and interpretation of data, drafting and revision of article.
T. Takami: Analysis and interpretation of data, drafting and revision of article.
T. Yano: Acquisition of data, drafting and revision of article.
K. Ito: Acquisition of data, drafting and revision of article.
S. Matsushima: Acquisition of data, drafting and revision of article.
T. Matsumoto: Analysis and interpretation of data, drafting and revision of article.
R. Kuroda: Analysis and interpretation of data, drafting and revision of article.

Declaration of competing interest

None.

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