Summary: Long antegrade cephalomedullary nailing is the standard of surgical care of atypical subtrochanteric fractures of the femur. Long nailing of such fractures is a technically demanding procedure. Our case report discusses the management of sequential bilateral atypical subtrochanteric fractures in an elderly female patient and the technical issues pertaining to nailing of such fractures. During the nailing procedure of the second fracture, an intraoperative distal peri-implant fracture occurred, and it was addressed with the application of a distal femoral locking plate. At 2-year postoperative follow-up, the patient was ambulating independently and had sufficient range of motion in both hips and knees.

Key Words: NOF, Nailing, Bisphosphonates, Atypical Fracture

INTRODUCTION
Atypical femoral fractures constitute a rare entity.\(^1\)\(^,\)\(^2\) Although the subtrochanteric region of the femur is particularly susceptible to the development of these fractures, they can occur anywhere along the femur from just distal to the lesser trochanter to just proximal to the supracondylar flare.\(^3\)\(^,\)\(^4\) The prolonged use of bisphosphonates has been correlated to the increased likelihood of developing such fractures, especially in the female elderly population.\(^3\)\(^,\)\(^4\) The incidence of bilateral sequential fractures is high, especially when bisphosphonate treatment is not discontinued after the index atypical fracture.\(^1\)\(^,\)\(^2\)

The overall medical and surgical management of atypical subtrochanteric fractures remains a challenge. Currently, there is paucity of high quality evidence in regard to their surgical treatment, but they are commonly addressed with long cephalomedullary intramedullary nailing.\(^5\) Long nailing of pertrochanteric fractures has been correlated with increased incidence of intraoperative periprosthetic fractures from anterior impingement of the nail at the distal femur, mostly due to suboptimal nailing technique, posterior nail entry point, increased femoral bowing, and nonanatomic nail designs.\(^6\)

CASE REPORT
A 78-year-old woman sustained a left subtrochanteric fracture after a standing height simple mechanical fall inside her house. She was transferred to the hospital by the ambulance service, and after the primary and secondary surveys in the Accident and Emergency Department, the left femoral fracture was confirmed to be her only injury. On physical examination, a shortened externally rotated...
left lower extremity with crepitus on attempted motion with no peripheral neurovascular deficit was evident. The radiographs of the pelvis and femur revealed a subtrochanteric fracture with features consistent with an atypical fracture pattern (Figs. 1A, B).

The patient had a significant medical history consisting of the left-sided heart failure, hypertension, osteopenia, irritable bowel syndrome, and kyphosis of the thoracic spine. At presentation, her medication included furosemide 40 mg twice daily, calcium carbonate 1250 mg with vitamin D3 500 IU once daily, alendronic acid 70 mg once weekly, loperamide 2 mg once daily, and mebeverine hydrochloride 200 mg once daily.

The patient was taken to theater the same day for surgical fixation of her left subtrochanteric fracture. This was undertaken under general anesthesia on a fracture table with foot traction applied to the ipsilateral leg and lithotripsy position of the contralateral lower extremity. The fracture was reduced by closed means, and a long trochanteric nail was inserted using standard techniques. During the nailing procedure, a suboptimal entry point (too lateral and too posterior) with a subsequent eccentric (too anterior) nail tip placement was noted, and a subsequent nail impingement to the anterior lateral cortex was evident. Nevertheless, the operating surgeon accepted the above, as well as the fracture reduction in a mild varus position, and the patient was allowed to immediate postoperative weight bear as pain allowed with a walking frame. The alendronic acid therapy was discontinued (after 6 years of continuous administration), after consultation of the bone metabolic disorder clinicians, and the fracture went to healing uneventfully in 9 months (Figs. 2A–D).

During the follow-up period, a lateral cortical beak of the contralateral (right) proximal femur was noted on the plain pelvic radiographs (Fig. 3). No action was taken at that point in time because the patient was completely asymptomatic. Unfortunately, 3 years after the left femoral nailing, the patient had another mechanical low-energy fall and suffered a right subtrochanteric fracture (Fig. 4). The medical comorbidities were the same as 4 years earlier with the addition of the right-sided heart dysfunction. The patient was on the same medication with the exception of alendronic acid. No anabolic (teriparatide) or other type of agent had been added to her antiosteoporotic medication since the diagnosis and management of the first atypical fracture.

The patient underwent again an antegrade intramedullary procedure with a cephalomedullary nail for the fixation of the right subtrochanteric fracture. Standard preparation and positioning was implemented with ipsilateral foot traction and contralateral

FIGURE 1. A, Anteroposterior radiograph of the left proximal femur demonstrating a subtrochanteric fracture with the characteristic features of an atypical fracture including short obliquity, no comminution, periosteal lateral cortical thickening, and a medial spike. B, Anteroposterior radiograph of the pelvis showing no evidence of a contralateral incomplete fracture or cortical beaking from a stress reaction.

FIGURE 2. A–D, Postoperative radiographs at 9 months showing healing of the fracture despite the varus malalignment and the anterior cortical impingement of the distal nail tip.
lithotripsy lower extremity position. An unsuccessful closed reduction was then attempted, followed by open reduction and nail insertion. Once again, the reduction and the nail entry point were suboptimal, resulting in eccentric placement of nail tip with encroachment at the anterior distal cortex—intraoperative cortical breach (Figs. 5A–C). A senior surgeon was then called to address this intraoperative complication. A distal femoral locking plate was inserted in a minimal invasive manner bypassing level of the cortical breach (Figs. 6A–D).

Postoperatively, the patient was instructed to partial weight bearing for the first 6 weeks followed by gradual progression to full weight bearing within the next 6 weeks. Full weight bearing was not instructed from the first postoperative mostly to protect the iatrogenic distal femoral defect and its extramedullary fixation. No further change to her antiosteoporotic medication was recommended from the bone metabolic disorder unit. The patient went to a complete union of the peri-implant fractures in 6 months and of the atypical subtrochanteric fracture in 14 months (Figs. 7A–C). At 3 years postoperative follow-up after the second nailing procedure, the patient was still ambulating independently and had sufficient range of motion in both hips and knees.

**DISCUSSION**

Prolonged, that is more than 5 years, use of bisphosphonates has been associated with atypical femoral fractures.\(^5\) When an atypical femoral fracture is diagnosed, discontinuation of bisphosphonates is usually indicated along with supplementation of an anabolic agent—teriparatide subcutaneous injections—to accelerate bone healing and increase bone turnover. Supplements of calcium and vitamin D are also continued.\(^2,5\) The patient presented in these series had been using alendronic acid for 6 years. When the first atypical fracture was diagnosed, the bisphosphonates were stopped but no teriparatide was given besides the referral to the bone metabolic department. This could be a potential contributing factor to the development of her second atypical fracture 3 years later. Of note is the fact that the pelvic radiograph at the time of the initial admission was not indicative of any stress reaction on the contralateral side and the patient was not complaining of pain on that hip/femur (Fig. 1B).

The specifics of both of this patient’s fractures demonstrated the unique radiographic features of atypical fractures including their short obliquity, the absence of comminution, the standard periosteal lateral cortical thickening, and a medial spike. Of note is also the fact that the right femur demonstrated abnormal radiographic appearances even before the subsequent low-energy fracture. There is still controversy related to prophylactic fixation of pending bisphosphonate-related atypical fractures, especially in the absence of clinical symptoms or stress reaction in an Magnetic Resonance Imaging.
Imaging scan.\textsuperscript{7,8} In the presented case, no prophylactic nailing was performed, a decision mainly guided by the absence of pain and of any radiologic signs of a stress reaction or of an impending fracture.

According to the contemporary understanding,\textsuperscript{2,5} when an atypical femoral fracture is diagnosed, a radiograph of the contralateral femur is indicated because it has been shown that stress reactions in the form of localized ellipsoid thickening of the lateral cortex or beaking of the proximal femur in plain x-rays or of increased uptake in bone scintigraphy were demonstrated in up to approximately 40\% of the cases.\textsuperscript{9} Nonoperative management is indicated when the patient is completely asymptomatic and no cortical beaking is evident on plain radiographs, whereas prophylactic nailing is recommended in contrary evidence.

In the absence of any findings in plain radiographic control and if the patient is symptomatic, then an MRI is indicated. If then a stress reaction is found, usually nonoperative management is recommended with protected weight bearing, discontinuation of bisphosphonates, and administration of an anabolic antosteoporotic agent, that is, teriparatide along with vitamin D and calcium. A repeat MRI is recommended after 3 months. Pain after 3 months of nonoperative management and/or MRI features suggestive of nonresolving edema are then indications for prophylactic nailing\textsuperscript{2,5} (as in suggested algorithm of Fig. 8).

When atypical femoral fractures occur, their management is surgical with long cephalomedullary intramedullary nailing being the most commonly used method of fixation. Antegrade long nailing is the contemporary preferred method of subtrochanteric fracture fixation because of its biomechanical superiority compared with extramedullary fixation and the protection of the entire femoral length especially in pathologic and osteoporotic bone.\textsuperscript{10} Nevertheless, the use of plates can be justified in cases of extreme cortical thickening, when nailing is considered too difficult, or as a reduction or an adjunct tool during the nailing procedure.\textsuperscript{5}

Nailing of a subtrochanteric fracture in the presence of preinjury abnormal femoral anatomy is a technically demanding procedure that requires careful planning and extreme vigilance during the actual surgical procedure. Knowledge of the specific properties of the implant used, implementation of various reduction techniques, correct entry point, and maintenance of reduction during the procedure (reaming, insertion of implant, and proximal/distal interlocking) is of paramount importance to avoid 2 of the most commonly encountered complications: that is varus malalignment and anterior encroachment of the nail at the supracondylar region. At the end of the first nailing procedure, both of the above issues were encountered, but the fracture went to uneventful healing. During the second nailing procedure and because of the suboptimal entry point and the malreduction of the fracture before initiation of reaming, the distal anterior cortex was breached. The intraoperative solution that was offered was the minimally invasive application of a distal locking femoral plate bypassing the tip of the nail and the cortical defect. Proximal plate anchorage was achieved using monocortical locking screws, whereas distal fixation was

\textbf{FIGURE 6.} A–D, Intraoperative fluoroscopic views showing the distal femoral locking plate and the reductions achieved for the management of the intraoperative fracture.

\textbf{FIGURE 7.} A–C, Postoperative follow-up radiographs at 2 years showing complete fracture healing of the atypical subtrochanteric fractures and the intraoperative peri-implant defect.
performed using standard techniques. The above is the standard method of bailing out in intraoperative and postoperative fractures occurring at the distal femur during or after nailing procedures for the management of pertrochanteric fractures. Both the distal and proximal femoral fractures progressed to union, with the atypical subtrochanteric having a protracted healing period, which is not uncommon in bisphosphonate-related fractures.

CONCLUSIONS

The case discussed in this report highlights some of the most important issues pertaining to the management of atypical subtrochanteric fractures and the difficulties/complications of long intramedullary femoral nailing. The reported case could serve as a model for further consideration with regard to the medical management of atypical fractures (discontinuation of bisphosphonates, administration of anabolic agents), management of pending atypical fractures (diagnostic imaging and the need for prophylactic nailing), technicalities pertaining to nailing of these fractures, and finally management of intraoperative distal femoral cortical encroachment/fractures.

REFERENCES