3 Indication and Contraindication of Femoral Nailing

3.1 Indication

Femoral Shaft Fracture with Various Degrees of Comminution

Closed femoral nailing is a treatment of choice in femoral shaft fractures with various degrees of comminution (Fig. 3.1). The static interlocking method enables us to fix them without risk of collapse at the comminuted segment. It also offers stable fixation for immediate weight-bearing after IM nailing. IM nailing is possible in open fracture after careful, meticulous debridement of the open wound, usually in Gustilo-Anderson classification I and II, sometimes in IIIa (Fig. 3.2) [1–8].

Segmental Fracture of the Femur

Segmental fracture of the femur is another best indication of IM nailing, although it requires high surgical skills (Fig. 3.3). Again, step by step procedure is necessary to overcome the problems encountered [9].

Delayed Union or Nonunion of Femoral Shaft Fracture

Nail conversion after failed plate fixation (Fig. 3.4) and exchange nailing is a popular method to overcome the compromised healing of femoral shaft fracture. For details, see Chap. 9–11 [10–16].

Pathologic Fracture

Certain metabolic bone diseases and tumorous conditions (osteomalacia, osteogenesis imperfect (Fig. 3.5), Paget's disease (Fig. 3.6), hypophosphatemic rickets, fibrous dysplasia, etc.) weaken the femur and cause bowing and even fracture [18–21]. Therefore, prophylactic or therapeutic IM nailing is necessary to let the patients walk on weight-bearing. Deformity of the femur and medullary canal is a contraindication of IM nailing. However, it may be the final solution for a patient who suffers from repeated limb fractures due to osteogenesis imperfect. A metastatic bone tumor is another condition that IM nailing is required for the same purpose (Fig. 3.7).

Reconstruction of Segmental Defect

The IM nail and external fixator combination enables us to correct the leg length discrepancy in a severely injured patient. After correction of the femoral length, a defect can be filled with a simple autogenous bone graft (Fig. 3.8) [23–26] or *Masquelet* technique [27]. For details, see Chap. 7.

K. H. Yang, *The Art of Intramedullary Nailing for Femoral Fracture*,
https://doi.org/10.1007/978-981-19-3730-9_3

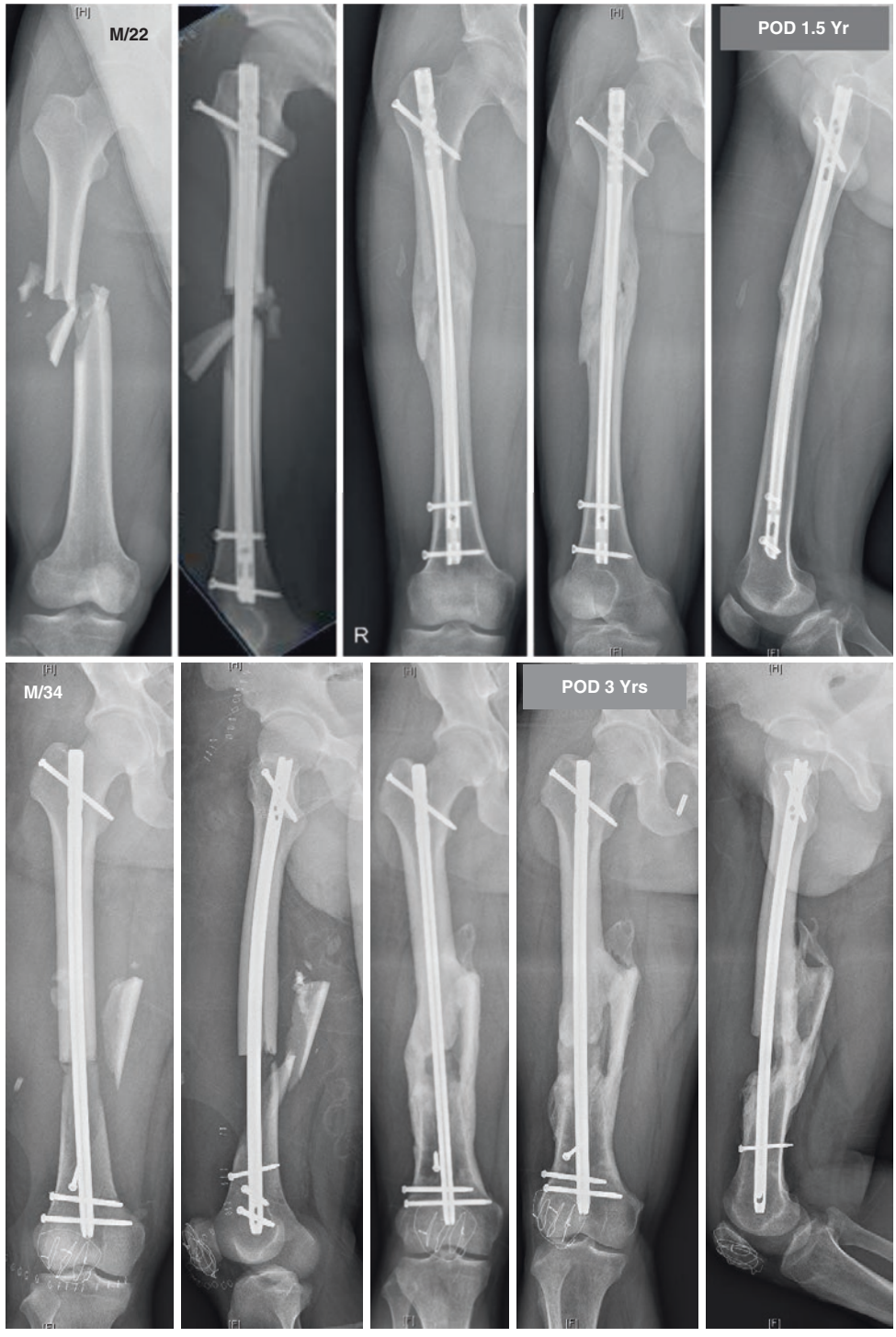

Fig. 3.1 Two cases of severely comminuted femoral shaft fracture. The positions and the situations of the butterfly fragment are different. Although the bone union was obtained in both cases, a large butterfly fragment that was displaced to the other side of the femur should have been reduced by the open technique in the second lower. Bone graft was necessary to fill up the defect before the nail removal in this case

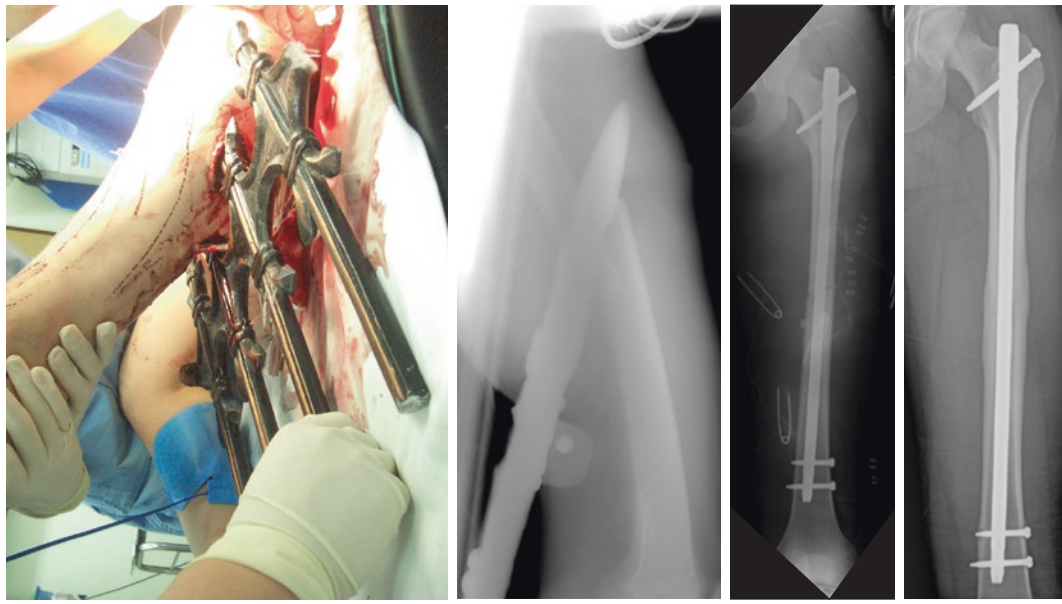

Fig. 3.2 A 20-year-old female patient fell from the second floor through the window. The spear-shaped fence hit her thigh and fractured the femur (left). Sequential radiograms of this patient at the emergency room, operating room (immediate postoperative), and outpatient clinic (final follow-up, right)

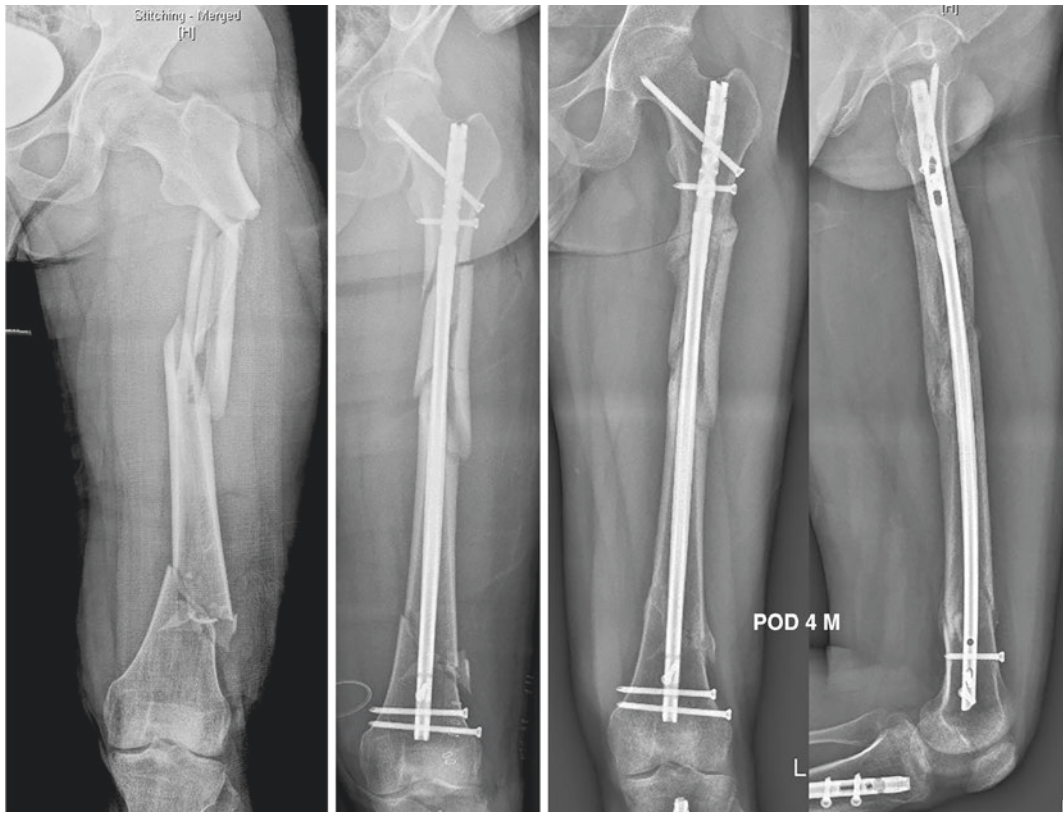

Fig. 3.3 IM nailing is the treatment of choice for segmental femoral shaft fracture if the surgeons have good experiences and techniques to overcome the problems during the IM nailing procedures. Early callus formation is evident after this minimally invasive technique

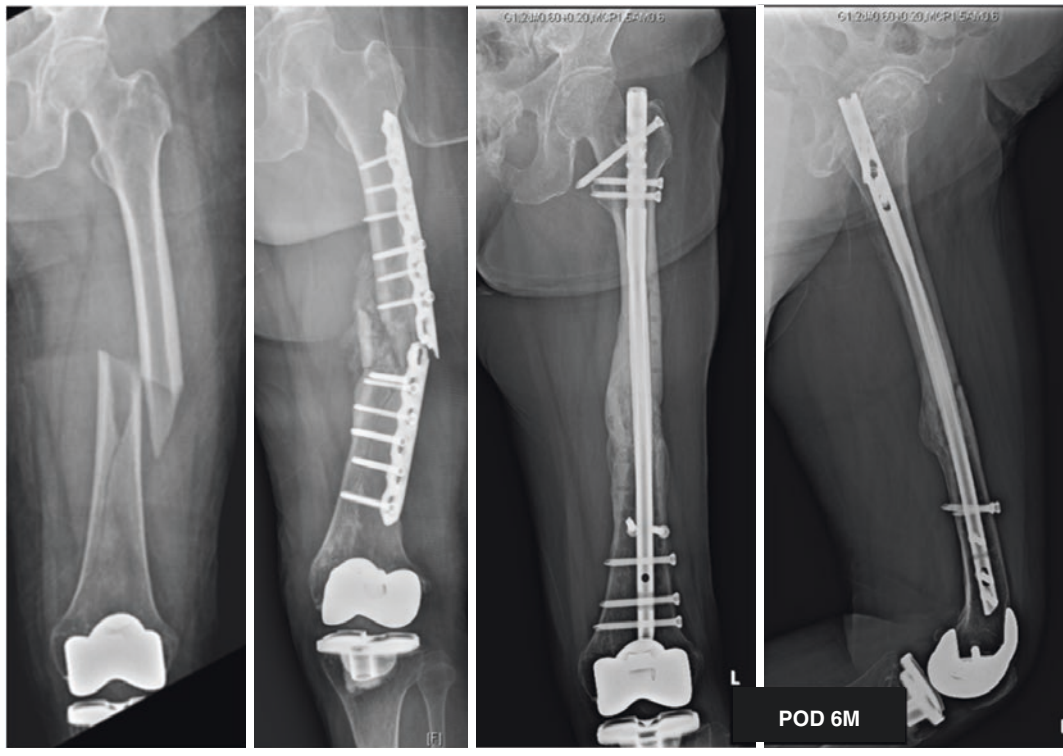

Fig. 3.4 A 77-year-old lady fell from the standing height and sustained a spiral-type femoral shaft fracture. She underwent open reduction and internal fixation with a locking plate at the local hospital. The plate broke 4 months after surgery, and she was transferred to me. A broken plate was removed, and a femoral nail was inserted. Due to weakness of bone after several months of immobilization, three interlocking screws and two Poller screws were used to stabilize the distal fragment. The fracture was united 6 months after nail conversion [17]

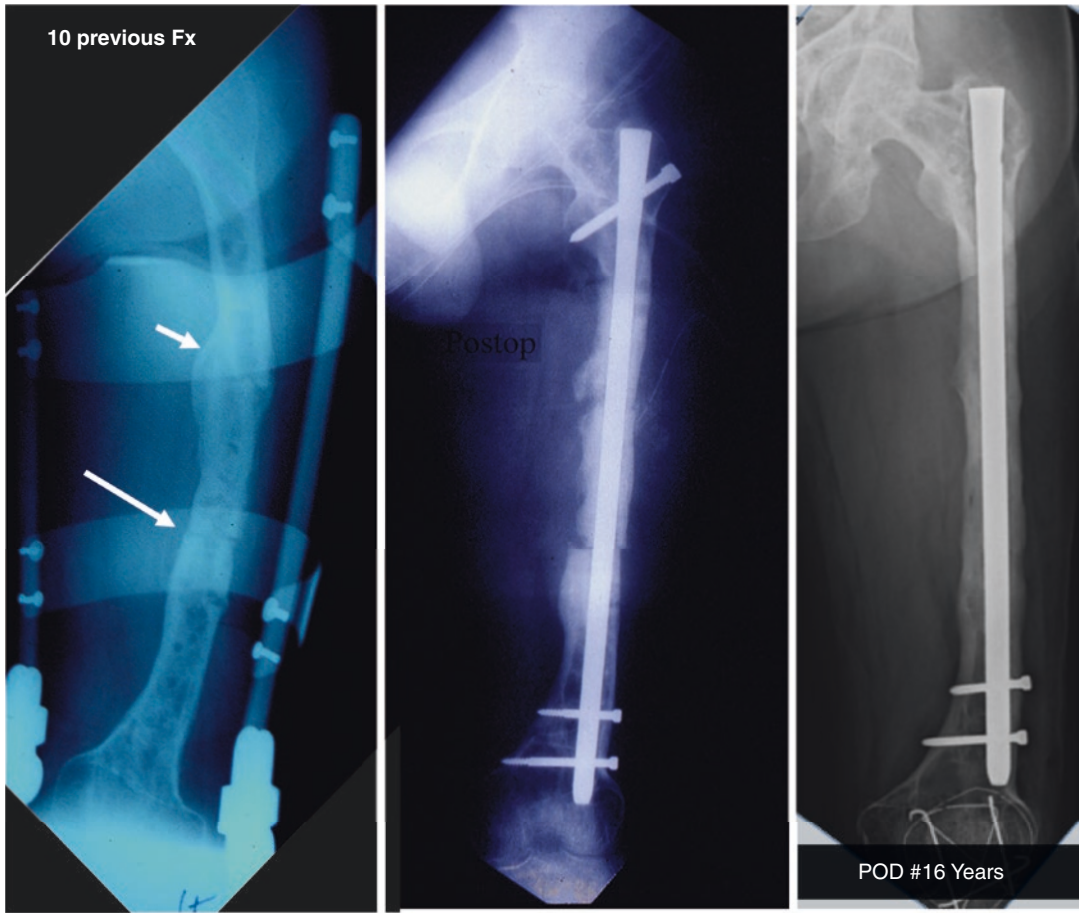

Fig. 3.5 This 30-year-old male patient suffered from 10 previous femur fractures and walked with the support of a long leg brace. He experienced another new fracture at the mid-shaft of the bowed femur after a fall (long white arrow). One of the previous fractures resulted in malunion (short white arrow). Deformity of the femur and associated obstruction of the medullary canal is a contraindication of the IM nailing. However, it could be the only solution in the treatment of osteogenesis imperfect. The Sofield technique is frequently applied to children, but rarely to adults. After osteotomy at the malunion site, IM nailing was performed to straighten the femur. The fracture healed uneventfully, but a proximal interlocking screw was removed due to pain 2 years postoperatively. The femur has been protected from the pathologic fracture for 16 years after the corrective osteotomy and IM nailing

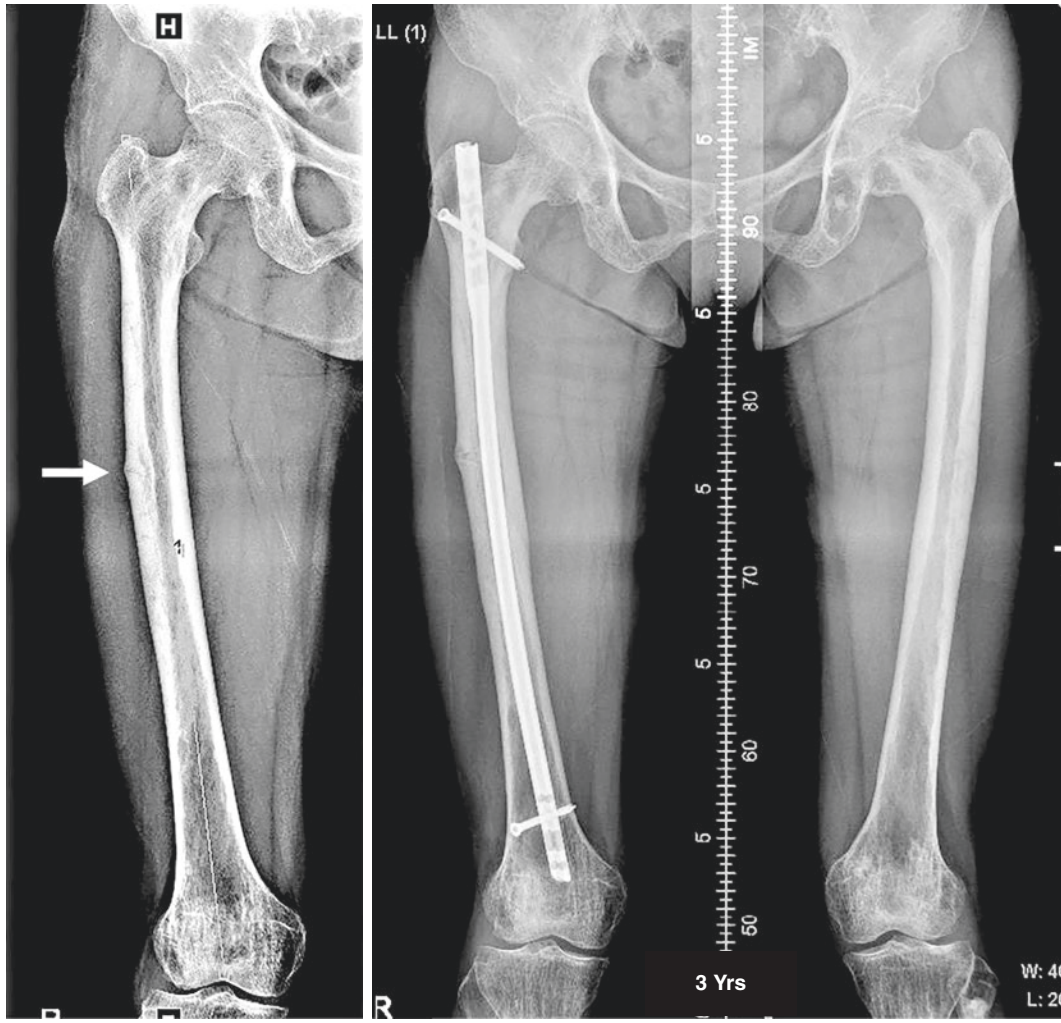

Fig. 3.6 A 66-year-old female patient suffered from Paget's disease on both femora and maxilla. Prophylactic femoral nailing was performed due to progressive bowing, pain, and impending fracture (white arrow). A femoral nail was inserted in external rotation to accommodate excessive anterolateral femoral bowing. Despite the slow healing process of the crack on the femoral bowing apex, the pain subsided 3 years after IM nailing [18, 22]

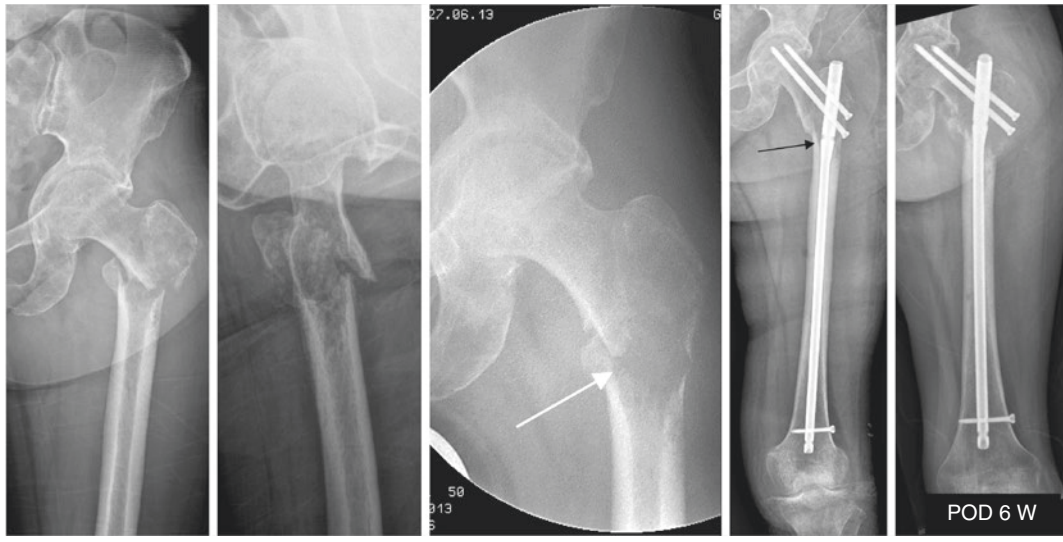

Fig. 3.7 A 60-year-old lady sustained a pathologic subtrochanteric fracture that was caused by a metastatic bone tumor from lung cancer. Intraoperative fluoroscopic image showed a significant void in the subtrochanteric area (white arrow). Because the IM canal was small, it could only accommodate an 8.3 mm diameter femoral nail. In addition, jamming of the transitional part of the nail (black arrow) interfered with proper insertion of the proximal interlocking screws into the femoral head. Further destruction of the trochanter was noted 6 weeks after IM nailing

Lengthening of Femur

Shortening of the femur after the injury is a serious complication that results in limping and back pain due to scoliosis. Specially designed nails with rachets inside can increase the length of the nail and interlock the femur to correct leg length discrepancy (Fig. 3.9). The outcomes of motorized intramedullary lengthening nail are good with acceptable complication rates [28, 29]. For details, see Chap. 12.

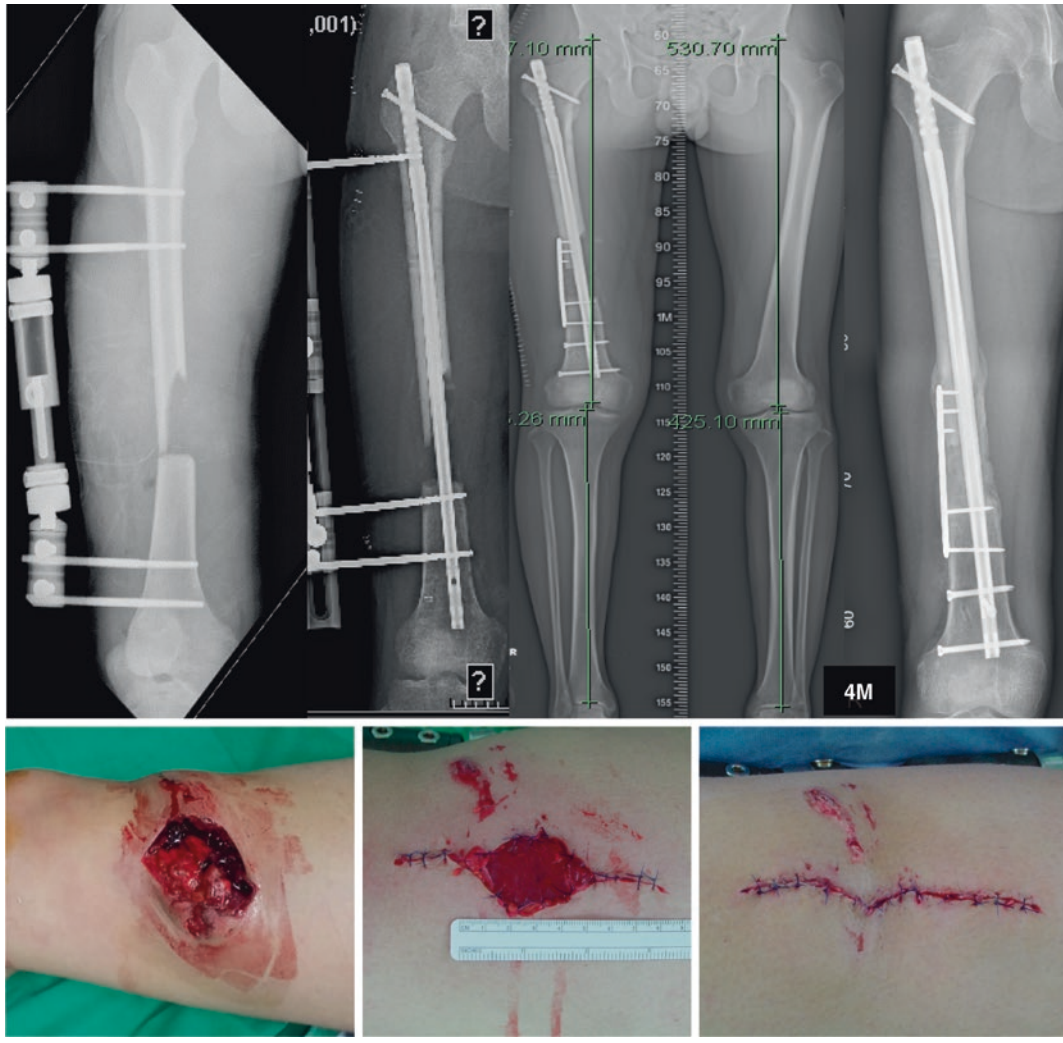

Fig. 3.8 A 19-year-old boy sustained an open femur shaft fracture after a motorcycle accident. Segments of bone were missing through the open wound. An external fixator was applied after debridement at first. Due to the shortening of the femur, primary closure of the open wound was possible after debridement (lower column). Two weeks after injury, the femur was fixed with IM nail and augmented with a Monorail type of Orthofix external fixator. The gradual lengthening of the femur was performed until the length of the injured femur matched with an intact side. Then, distal interlocking of the femoral nail and autoiliac bone graft was performed. Augmentative lateral plate fixation was an operating surgeon's discretion. Bone union is evident at postoperative 4 months

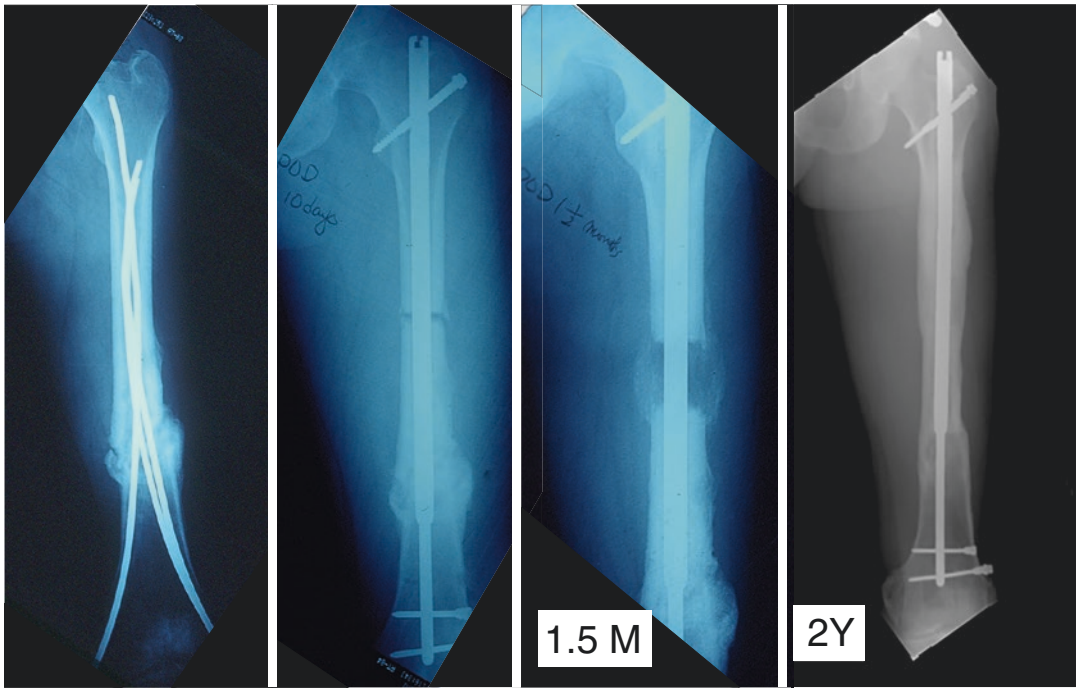

Fig. 3.9 Fixation of femoral shaft fracture with the Ender nail resulted in bony union with shortening of 6 cm. The shortened femur was osteotomized using the IM saw and fixed with an Albizzia nail. Gradual lengthening was performed after 2 weeks, and early callus formation was evident at postoperative 1.5 months. The lengthened part was completely remodeled at postoperative 2 years

3.2 Contraindication

1. Active infection: Active infection is a contraindication of osteosynthesis with an internal implant, such as nail and plate.
2. Narrow medullary canal; Obliteration or excessive narrowing of the medullary canal is a contraindication of IM nailing (Figs. 3.10 and 3.11).
3. Deformity of the medullary canal due to previous injury.

   Severe deformity of the long bone precludes IM nailing unless correctional osteotomy is performed before the nailing (Fig. 3.12). For IM nailing in deformed femur, see Chap. 11 [33].
4. Severe lung injury in a multiple injured patient [34–38].

   The reamer head acts as a piston within a syringe. So, the rapid advancement of the reamer head causes high IM pressure and pulmonary embolism of the medullary contents, which is critical in severe lung injury (Fig. 3.13).

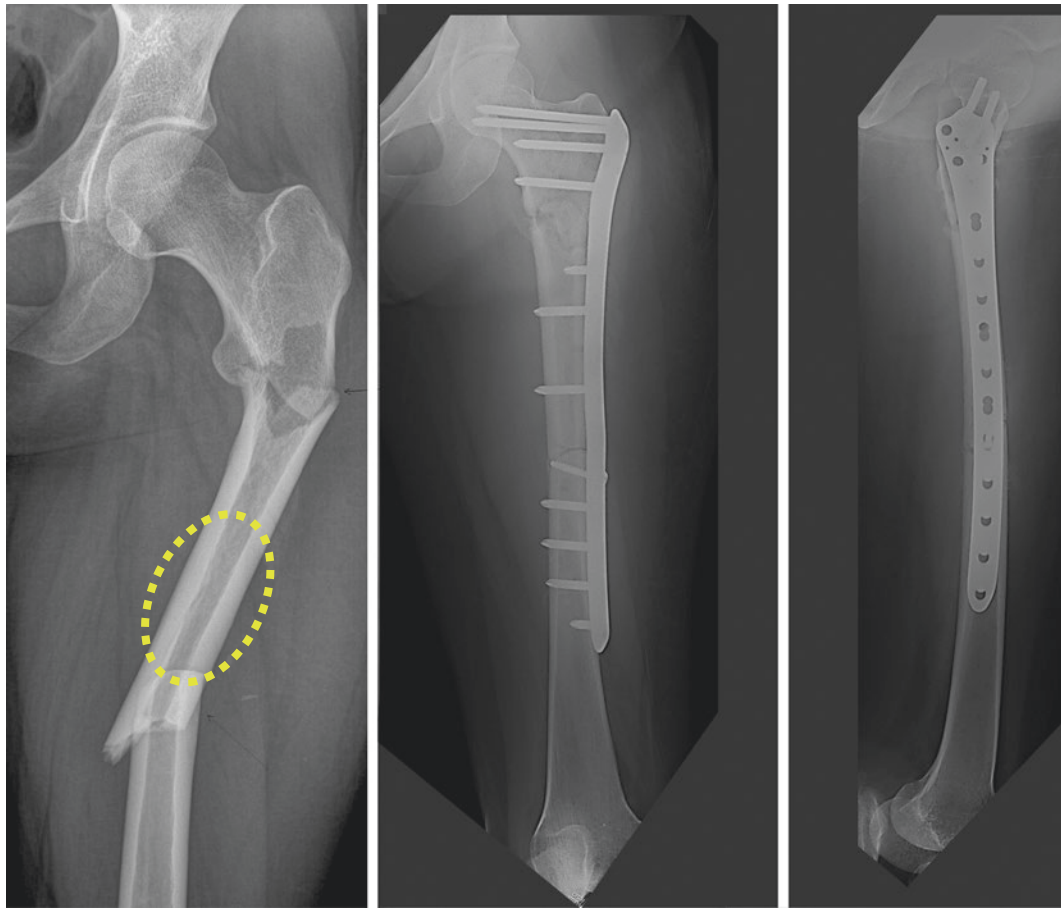

Fig. 3.10 An extremely narrow medullary canal in the middle segment of the segmental femoral shaft fracture precluded IM nailing because of the fear of spinning the middle segment, heat necrosis, and fat embolism during IM reaming. Therefore, osteosynthesis was performed using MIPO technique instead

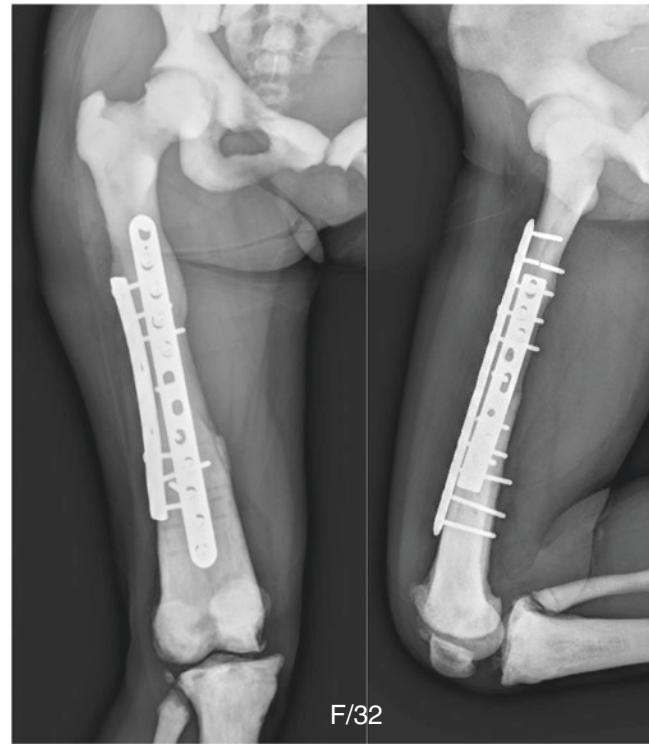

Fig. 3.11 A case of osteopetrosis with an extremely narrow medullary canal. It is wise to avoid IM nailing if the medullary canal is not traceable [30–32]

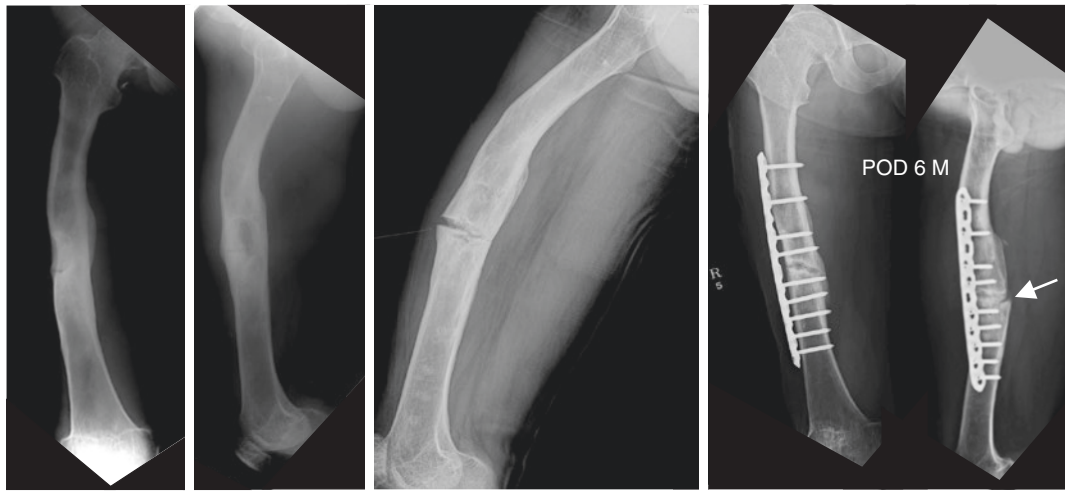

Fig. 3.12 The locking plate for the complex deformity in the femoral shaft. The patient had complex deformity at the femoral shaft and sustained an insufficiency fracture at the distal zone of the deformity. We aligned the straight portions of both proximal and distal fragments and attached the locking plate and screws from the lateral aspect of the femoral shaft. It mimicked as if we performed a correctional opening osteotomy. The fracture site and posterior opening gap (white arrow) were healed 6 months after plate osteosynthesis. A locking plate is a useful tool in fixing the irregular surfaces of the femoral shaft. Otherwise, tightening of the conventional screw pulls the cortex to the undersurface of the plate, interfering with open osteotomy effect

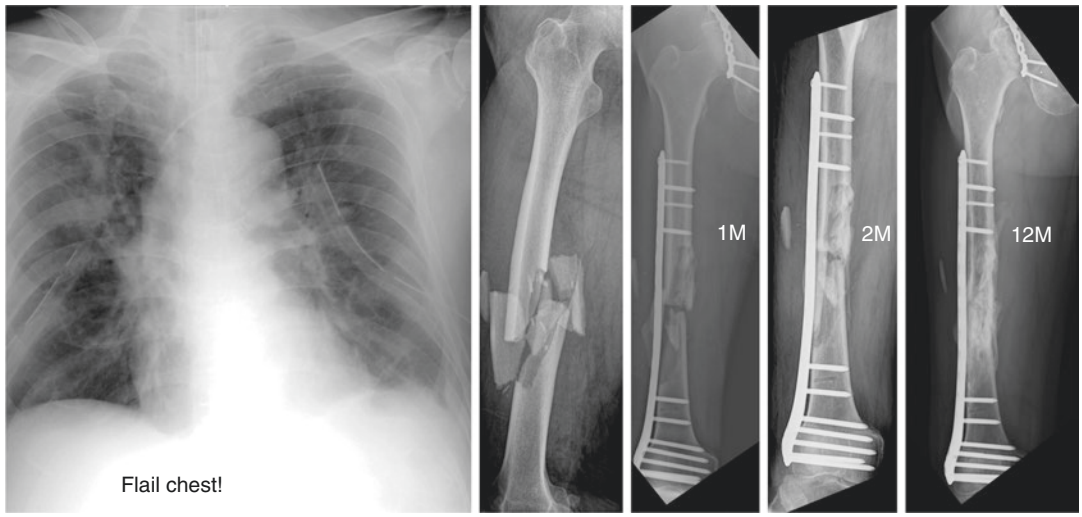

Fig. 3.13 IM nailing in a multiply injured patient with severe lung injury may aggravate the lung function due to embolization of the marrow contents. The chest tubes were inserted in both sides of the pleural cavities to treat the flail chest. MIPO technique was used to treat the severely comminuted femoral shaft fracture. Union was obtained 12 months after the operation

References

1. Brumback RJ, Reilly JP, Poka A, Lakatos RP, Bathon GH, Burgess AR. Intramedullary nailing of femoral shaft fractures. Part I: Decision-making errors with interlocking fixation. J Bone Joint Surg Am. 1988;70(10):1441–52.
2. Brumback RJ, Uwagie-Ero S, Lakatos RP, Poka A, Bathon GH, Burgess AR. Intramedullary nailing of femoral shaft fractures. Part II: Fracture-healing with static interlocking fixation. J Bone Joint Surg Am. 1988;70(10):1453–62.
3. Court-Brown CM, Browner BD. Locked nailing of femoral fractures. In: Browner BD, editor. The science and practice of intramedullary nailing. 2nd ed. William & Wilkins; 1996. p. 161–82.
4. Kim PH, Leopold SS. Gustilo-Anderson classification. Clin Orthop Relat Res. 2012;470:3270–4.
5. Nork SE. Femoral shaft fracture. In: Court-Brown CM, et al., editors. Rockwood and Green's fractures in adult. 8th ed. Philadelphia: Wolters Kluwer; 2015. p. 2149–228.
6. Saleeb H, Tosounidis T, Papakostidis C, Giannoudis PV. Incidence of deep infection, union and malunion for open diaphyseal femoral shaft fractures treated with IM nailing: a systematic review. Surgeon. 2019;17(5):257–69.
7. Patch DA, Levitt EB, Nicholas AA, Heatherly AR, Bonner HV, Halstrom JR, Watson JB, Spitler CA. Civilian ballistic femoral shaft fractures compared with blunt femur shaft fractures. J Orthop Trauma. 2021; https://doi.org/10.1097/BOT.0000000000002317.
8. Winquist RA, Hansen ST Jr, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. J Bone Joint Surg Am. 1984;66(4):529–39.
9. Wiss DA, Brien WW, Stetson WB. Interlocked nailing for treatment of segmental fractures of the femur. J Bone Joint Surg Am. 1990;72(5):724–8.
10. Brinker MR, O'Connor DP. Exchange nailing of ununited fractures. J Bone Joint Surg Am. 2007;89:177–88.
11. Furlong AJ, Giannoudis PV, DeBoer P, Matthews SJ, MacDonald DA, Smith RM. Exchange nailing for femoral shaft aseptic non-union. Injury. 1999;30(4):245–9.
12. Hak DJ, Lee SS, Goulet JA. Success of exchange reamed intramedullary nailing for femoral shaft nonunion or delayed union. J Orthop Trauma. 2000;14(3):178–82.
13. Pihlajamäki HK, Salminen ST, Böstman OM. The treatment of nonunions following intramedullary nailing of femoral shaft fractures. J Orthop Trauma. 2002;16(6):394–402.
14. Swanson EA, Garrard EC, Bernstein DT, O'Connor DP, Brinker MR. Results of a systematic approach to exchange nailing for the treatment of aseptic femoral nonunions. J Orthop Trauma. 2015;29(1):21–7.
15. Tsang ST, Mills LA, Baren J, Frantzias J, Keating JF, Simpson AH. Exchange nailing for femoral diaphyseal fracture non-unions: risk factors for failure. Injury. 2015;46(12):2404–9.

16. Wu CC, Chen WJ. Exchange nailing for aseptic nonunion of the femoral shaft. Int Orthop. 2002;26(2):80–4.
17. Krettek C, Stephan C, Schandelmaier P, Richter M, Pape HC, Miclau T. The use of Poller scrrews as blocking screws in stabilizing tibial fracture treated with small diameter intramedullary nails. J Bone Joint Surg Br. 1988;81:963–8.
18. Kang H, Park YC, Yang KH. Paget's disease: skeletal manifestations and effect of bisphosphonates. J Bone Metab. 2017;24:97–103.
19. Rauch F, Glorieux FH. Osteogenesis imperfecta. Lancet. 2004;363(9418):1377–85.
20. Abulsaad M, Abdelrahman A. Modified Sofield-Millar operation: less invasive surgery of lower limbs in osteogenesis imperfecta. Int Orthop. 2009;33(2):527–32.
21. Li YH, Chow W, Leong JC. The Sofield-Millar operation in osteogenesis imperfecta. A modified technique. J Bone Joint Surg Br. 2000;82(1):11–6.
22. Park YC, Song HK, Zheng XL, Yang KH. Intramedullary nailing for atypical femoral fracture with excessive anterolateral femoral bowing. J Bone Joint Surg Am. 2017;99:726–35.
23. Davda K, Heidari N, Calder P, Goodier D. 'Rail and nail' bifocal management of atrophic femoral nonunion. Bone Joint J. 2018;100-B:634–9.
24. Park J, Yang KH. Indications and outcomes of augmentation plating with decortication and autogenous bone grafting for femoral shaft nonunions. Injury. 2013;44:1820–5.
25. Yang KH, Won YK, Kim SB, Oh BH, Park YC, Jeong SJ. Plate augmentation and autologous bone grafting after intramedullary nailing for challenging femoral bone defects: a technical note. Arch Orthop Trauma Surg. 2016;136(10):1381–5.
26. Farsetti P, Maio FD, Potenza V, Efremov K, Marsiolo M, Caterini A, Ippolit E. Lower limb lengthening over an intramedullary nail: a long-term follow-up study of 28 cases. J Orthop Traumatol. 2019;20:30.
27. Alford AI, Nicolaou D, Hake M, McBride-Gagyi S. Masquelet's induced membrane technique: review of current concepts and future directions. J Orthop Res. 2021;39(4):707–718. https://doi.org/10.1002/jor.24978. Epub 2021 Jan 13.
28. Fragomen AT. Motorized intramedullary lengthening nails: outcomes and complications. Tech Orthop. 2020;35:225–32.
29. Guichet JM, Deromedis B, Donnan LT, Peretti G, Lascombes P, Bado J. Gradual femoral lengthening with the Albizzia intramedullary nail. J Bone Joint Surg Am. 2003;85(5):838–48.
30. Amit S, Shehkar A, Vivek M, Shekhar S, Biren N. Fixation of sub trochanteric fractures in two patients with osteopetrosis using a distal femoral locking compression plate of the contralateral side. Eur J Trauma Emerg Surg. 2010;36:263–9.
31. Chhabra A, Westerlund LE, Kline AJ, McLaughlin R. Management of proximal femoral shaft fractures in osteopetrosis: a case series using internal fixation. Orthopedics. 2005;28:587–92.
32. Kim JY, Park YC, Moon HS, Do WS, Yang KH. Intramedullary nailing for sub trochanteric fracture in autosomal dominant type II osteopetrosis case report of 2 patients. Medicine. 2020;99(32):e21648.
33. Russell GV, Graves ML, Archdeacon MT, Barei DP, Brien GA Jr, Porter SE. The clamshell osteotomy: a new technique to correct complex diaphyseal malunions. J Bone Joint Surg Am. 2009;91:314–24.
34. Bixcut IM. Reamer system. Stryker Trauma GmbH. 2009:1–8.
35. Clatworthy MG, Clark DI, Gray DH, Hardy AE. Reamed versus unreamed femoral nails a randomised prospective trial. J Bone Joint Surg Br. 1998;80:485–9.
36. Högel F, Gerlach UV, Südkamp NP, Müller CA. Pulmonary fat embolism after reamed and unreamed nailing of femoral fractures. Injury. 2010;41:1317–22.
37. Li AB, Zhang WJ, Guo WJ, Wang XH, Jin HM, Zhao YM. Reamed versus unreamed intramedullary nailing for the treatment of femoral fractures a meta-analysis of prospective randomized controlled trials. Medicine. 2016;95(29):e4248.
38. Pape HC, Regel G, Dwenger A, Krumm K, Schweitzer G, Krettek C, Sturm JA, Tscherne H. Influences of different methods of intramedullary femoral nailing on lung function in patients with multiple trauma. J Trauma. 1993;35:709–16.