Acta Biomed 2025; Vol. 96, N. 5: 17239 DOI: 10.23750/abm.v96i5.17239

Case report

Gustilo-Anderson 3C femoral diaphyseal fracture with bone loss and ipsilateral Garden 3 neck fracture treated with intramedullary nailing and bone allograft

Mauro Spina[1], *Enrico Salvatore D'Agostino*[2], *Fabio Zoccatelli*[2], *Ilaria Giorgio*[2]

[1]Orthopaedics and Spine Surgery Department, University and Hospital Trust, Verona, Italy; [2]Orthopaedics and Traumatology Department, University and Hospital Trust, Verona, Italy

Abstract. Segmental femoral fractures with extensive bone loss represent a rare and complex challenge in orthopedic trauma. We report a case of a 32-year-old male who sustained an open diaphyseal femoral fracture (Gustilo-Anderson type III C; AO/OTA 32C3) with concomitant femoral artery injury, a 10 cm segmental bone defect, and an ipsilateral displaced femoral neck fracture (Garden III; Pauwels III; AO/OTA 31A2). Initial management consisted of thorough surgical debridement and temporary external fixation to parzial restore femoral length, combined with vascular repair and thigh fasciotomy performed by the vascular surgery team. After five weeks of intravenous antibiotic therapy addressing postoperative infection, definitive fixation was achieved with intramedullary nailing and anti-rotational cannulated screws for the femoral neck. Nine months post-trauma, a homologous cylindrical bone graft was performed alongside lateral locked plating to support the segmental defect. At nine years follow-up, radiographs demonstrated hypertrophic callus formation and complete femoral neck consolidation without evidence of avascular necrosis. The patient exhibited full, painless hip range of motion with no limb length discrepancy and an excellent functional outcome (Harris Hip Score: 100). This case highlights the importance of a multidisciplinary approach, precise surgical timing, and patient compliance in achieving favorable outcomes in complex femoral fractures with bone loss. (www.actabiomedica.it)

Key words: segmental femoral fractures, bone loss, intramedullary nail, bone allograft

Introduction

Segmental femoral fractures are usually the result of high-energy trauma and can be defined as fractures of the femur with at least two main fracture lines at different levels, leaving an intact segment of the femur between them (1). Fractures involving the ipsilateral femoral neck and femoral shaft represent approximately 1% to 9% of all femur fractures (2). From an epidemiologic review of open fractures in adults, the open femoral shaft constitutes 1.8% of all open fractures (3). Moreover, bone loss can be found in 11.4% of all open fractures and most of these are Gustilo IIIB injuries, while a smaller number could be classified as Gustilo IIIC (4). "Critical size" post-traumatic bone defects are defined as fracture gaps that do not heal spontaneously after only surgical stabilization and require additional surgery (4). Large segmental bone defects are defined as segmental defects over 6 cm and can be managed using several methods (5-6). We present a case of open femoral diaphyseal fracture with large bone loss associated with a displaced neck fracture, treated with a single implant associated with bone allograft.

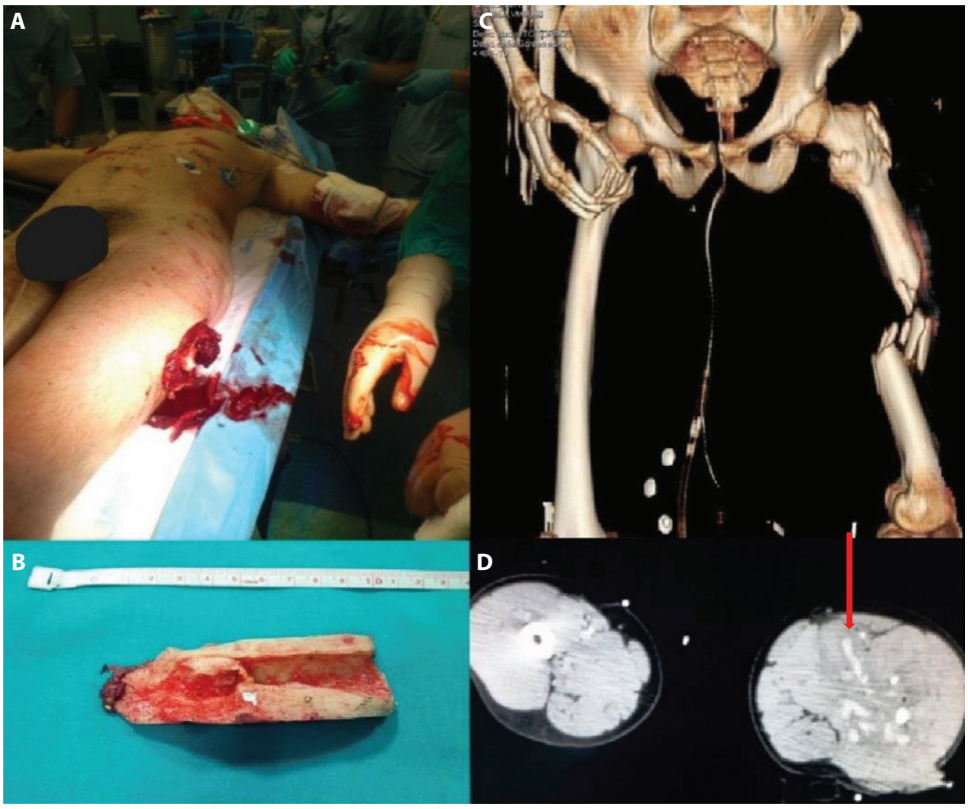

Figure 1. Clinical image showing open femoral fracture with femoral artery lesion (A). 10 cm avulsed femoral bone fragment on the street (B). 3D reconstruction of a total body CT scan showing a complex femoral fracture (C). Axial image of a contrast-enhanced CT scan showing femoral artery lesion of the left thigh (red arrow) (D).

Case report

A 32-year-old man was involved in a motor vehicle crash and was carried at our Level One Trauma Centre. The ER staff has subjected the patient to the diagnostic protocol for major trauma which includes X-ray and contrast-enhanced total body CT scan. The imaging exams showed a comminuted open diaphyseal femoral fracture, which also was complicated by the femoral artery lesion (classified Gustilo-Anderson 3C; AO/OTA 32C3). The same fracture was associated to a 10 cm bone loss (fragment avulsed on the street) and an ipsilateral displaced femoral neck fracture (classified Garden 3; Pauwels 3; AO/OTA 31A2) (Figure 1). No lesions were found in any different body district. In clinical history, the patient reports a previous proximal fracture of the ipsilateral femur at the age of 20 years, treated with a plate and screws synthesis, lately removed. The complex diaphyseal femoral fracture was debrided and stabilized with a Temporary External Fixator in emergency, partial restoring the length of the femur (Figure 2). The injured femoral artery was sutured, and a medial and lateral fasciotomy of the thigh was performed by Vascular Surgery Team (first surgical phase). The patient's precarious general condition required a ten-day hospitalization in Intensive Care, after which he was transferred to the Orthopedics and Traumatology Unit. Emergency surgery was followed by a 37-day period of intravenous antibiotic therapy. Initially was administered Ampicillin /Sulbactam 3gr every 8 hours and Gentamicin 240 mg per day, then Piperacillin sodium/Tazobactam sodium 4.5gr every 6 hours. Vancomycin 500 mg every 6 hours and Imipenem Cilastatin 500 mg every

Figure 2. An antero-posterior (AP) radiographic views showing a complex femoral fracture stabilized with a temporary external fixator, partially restoring femoral length.

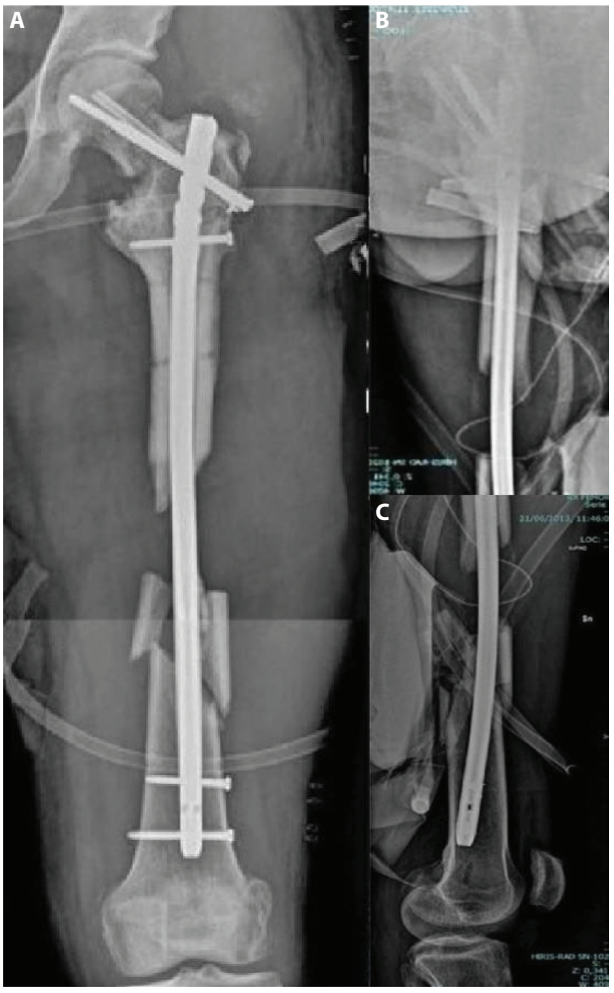

Figure 3. Antero-posterior (A) and latero-lateral (B and C) radiographic views showing a complex femoral fracture fixed with an intramedullary nail and an anti-rotation cannulated screw in the femoral neck.

6 hours were administered for surgical wound infection with isolated Enterococcus Faecium. After five weeks, in the absence of fever, negative PCR and normal white blood cells, the external fixator was removed and both fractures were fixed through an intramedullary nail (Recon Synthes) and an anti-rotation cannulated screw in the femoral neck (second surgical phase) (Figure 3). The length of the intramedullary nail was obtained by the length of the contralateral femur using a preoperative panoramic X-Ray of the lower limbs. Staphylococcus Epidermidis and Enterococcus Faecium were isolated from intraoperative samples and intravenous antibiotic therapy was continued for a further 23 days with Meropenem 1 gr every 8 hours, Clindamycin 600 mg per day and Daptomycin 8 mg/Kg per day, then Cubicin 500 mg per day and Merrem 1 gr every 8 hours, replaced by Tygacil 100 mg per day. In stable condition, the patient was discharged from the hospital with the recommendation of not bearing weight on the affected limb. After 9 months, in the absence of clinical and laboratory signs of infection, the final surgical procedure was performed using a 10 cm homologous cylindrical bone graft on the

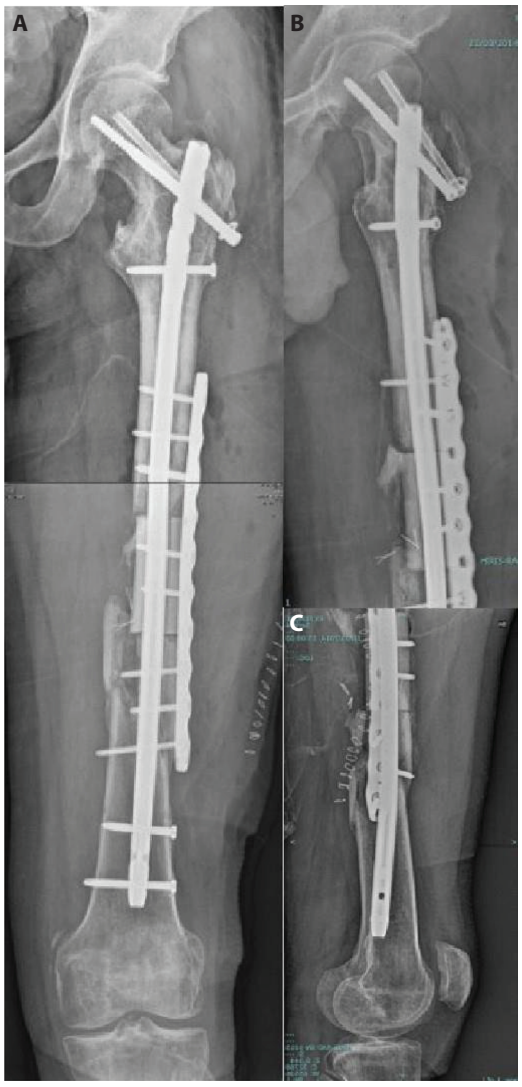

Figure 4. Antero-posterior (A) and latero-lateral (B and C) radiographic views showing a 10 cm homologous cylindrical bone graft surrounding the intramedullary nail, stabilized by a lateral plate bridging the graft.

intramedullary nail, stabilized by a lateral plate (NCB Zimmer) bridging the graft (third surgical phase) (Figure 4). In stable conditions, the patient was discharged from the hospital on the eighth post-operative day with partial weight bearing on the affected limb. Periodic clinical and radiographic follow-up was established. Five months after the last surgery, the X-ray image showed a stable implant, consolidation of the femoral neck and the first signs of diaphyseal callus, which led to progressive full weight bearing on the affected limb. Ten months after the last surgery, the X-ray image showed a good integration of the bone graft and complete consolidation of the femoral neck without any signs of head necrosis (Figure 5). After this clinical radiographic follow up, the patient resumed his heavy work activities. Nine years after the trauma, the radiographic examination showed a complete healing of the femoral bone with a hypertrophic diaphyseal callus without any pathological sequelae (Figure 6). The clinical examination revealed a full and painless range of motion in both the hip and knee joints, with no limb length discrepancy between the lower limbs (Harris Hip Score of 100) (Figure 6).

Discussion

Ipsilateral and simultaneous diaphyseal femoral open fracture with large bone loss and displaced femoral neck fracture in young patients remain among the rarest and most difficult to treat orthopedic trauma. In a multicenter and multinational analysis of 74 patients with ipsilateral femoral neck and diaphyseal fractures, only 16 patients (21.6%) had an open diaphyseal fracture (7). A search of PubMed and Google Scholar reveals several reports that propose different surgical strategies for femoral bone loss and ipsilateral femoral neck and shaft fractures. Surgical treatment of large bone loss in long bones involves different surgical strategies with specific indications. Treatment with intramedullary nails for post-traumatic “critical size” femoral bone defects provides excellent stability and restoration of length and alignment; proper soft tissue management and appropriate use of local and systemic antibiotics remain mandatory (8). The bone transport procedure for a post-traumatic aseptic or infected bone defect using the Ilizarov method is a minimally invasive technique that spares soft tissue, promoting bone lengthening and reconstruction. It is a system that allows compression or distraction (or the combination of both forces) by moving bone fragments via transosseous wires with external ring fixator adjustments for bone union (9). Circular frames are now more popular than monoaxial devices because they provide better stability. Vascularized fibula autograft is recommended for patients with large bone defects up to 20 cm,

Figure 5. Antero-posterior (A) and latero-lateral (B and C) radiographic views (B and C) showing good integration of the bone graft, complete consolidation of the femoral neck, and no radiographic signs of femoral head necrosis.

especially unicortical or joint-adjacent bone defects, soft tissue defects, and for those patients who can tolerate microsurgery. However, it is necessary to stabilize the fractured bone segments with an external fixator bridged on the vascularized fibular autograft to prevent the risk of fracture (10). The Masquelet technique is an innovative two-stage therapeutic approach for bone reconstruction in which the placement of a spacer in the bone defect induces a neo-formation of a tissue called "induced membrane" (11). The first stage includes debridement of bone and soft tissue, insertion of a polymethylmethacrylate cement spacer, skeletal stabilization and soft tissue reconstruction as appropriate. The second stage includes removal of the cement spacer, preservation of the membrane, repeated debridement of the bone edge, insertion of autologous bone graft and closure of the membrane containing the graft without tension. Final synthesis with an external fixator, plate, or intramedullary nail is required. Surgical treatment of ipsilateral femoral neck fractures and shaft fractures is highly debated, regarding synthesis with a single or double implant. Single fixation is a

Figure 6. Clinical examination (A) and antero-posterior radiographic view (B), showing complete healing of the femoral bone with a hypertrophic diaphyseal callus and no limb length discrepancy between the lower limbs

reconstruction nail to fix both the femoral neck and shaft fracture simultaneously. Double fixation using two devices, i.e. the femoral shaft fracture is fixed with retrograde or anterograde intramedullary nail or plate, and the femoral neck fracture is fixed with cancellous screws or dynamic/sliding hip screws (2). Whatever the surgical strategy, anatomical fixation of the femoral neck is of paramount importance, followed by restoration of the length, alignment and rotation of the femoral shaft (12). In the current literature, there is a lack of surgical strategies in the simultaneous presence of both orthopaedic types of traumas. In this case report, the Algorithm for management of bone loss described by Keating et al. (4) was followed: femoral defects up to 15 cm may heal spontaneously after intramedullary nailing, and patients with bone loss up to this magnitude can be observed up to 20 weeks before further intervention is indicated. According to this algorithm, a locked intramedullary nail is the best choice of fixation for most of these types of fractures. The first surgical phase, performed as an emergency with a temporary external fixator, was aimed at restoring the length of the femur and facilitating repair of the femoral artery by the Vascular Surgery Team. Once the acute infectious condition was resolved, the aim of the second surgical phase of synthesis with intramedullary nailing and anti-rotational cephalic screw was to reduce the femoral neck fracture, to obtain a stable synthesis of both fractures and to re-establish the correct length and rotation of the femur. Upon consolidation of the femoral neck, the third surgical phase (homologous cylindrical bone grafting around the nail to fill the 10 cm bone gap and bridge plate between the two fracture stumps) had the objective of obtaining a stable implant to facilitate rapid and progressive weight bearing. This surgical strategy was possible thanks to strong collaboration with the Infectious Disease Specialist who set up a long and targeted antibiotic therapy.

Conclusion

This case report is extremely interesting given the rarity of these complex injuries and the absence of consolidated treatment strategies in literature for ipsilateral diaphyseal femoral open fracture with large bone loss and displaced femoral neck fracture. The surgical strategy used in this case through intramedullary nail and bone allograft was certainly risky and highly questionable, but it was successful. This positive outcome was possible thanks to correct surgical timing, a strong and fruitful collaboration among orthopaedic surgeon, vascular surgeon, infectious disease specialist and the patient compliance to a long treatment course.

Ethic Approval: this article was performed in line with the principles of the Declaration of Helsinki. This is a case report. The Ethics Committee "CESC VR-RO" of Azienda Ospedaliera Universitaria Integrata di Verona (Italy) has confirmed that no ethical approval is required.

Conflict of Onterest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by E.S.D. and F.Z. The manuscript was written by M.S and I.G. The patients were operated by M.S. All authors have read and agreed to the published version of the manuscript

Declaration on the Use of AI: None.

References

1. Aufranc OE, Jones WN, Stewart WG. Segmental fracture of the femur. JAMA 1965;194(4):354–6. doi:10.1001/jama.1965.03090170032011
2. Zhao Y, Li J, Liu Y, Cui G, Li Z. Comparison of reconstruction nails versus dual implants in the treatment of ipsilateral femoral neck and shaft fractures in adults: a meta-analysis and systematic review. BMC Musculoskelet Disord 2023;24(1):800. doi: 10.1186/s12891-023-06933-6
3. Court-Brown CM, Bugler KE, Clement ND, Duckworth AD, McQueen MM. The epidemiology of open fractures in adults.A15-yearreview.Injury2012;43(6):891-7.doi:10.1016/j.injury.2011.12.007
4. Keating JF, Simpson AH, Robinson CM. The management of fractures with bone loss. J Bone Joint Surg Br 2005;87(2):142–50. doi: 10.1302/0301-620x.87b2.15874
5. Gugala Z, Lindsey RW, Gogolewski S. New approaches in the treatment of critical-size segmental defects in long bones. Macromolecular Symposia 2007;253:147-61. doi.org/10.1002/masy.200750722
6. Polyzois VD, Stathopoulos IP, Lampropoulou-Adamidou K, Vasiliadis ES, Vlamis J, Pneumaticos SG. Strategies for managing bone defects of the lower extremity. Clin Podiatr Med Surg 2014;31(4):577–84. doi: 10.1016/j.cpm.2014.06.008
7. Chang-Wug Oh, Joon-Woo Kim, Ki Chul Park, et al. Clinical outcomes and affecting factors of ipsilateral femoral neck and shaft fractures - Multination, multicenter analysis. J Orthop Sci 2023;28(3):614-20. doi:10.1016/j.jos.2021.12.021
8. Hofmann A, Dietz SO, Pairon P, Rommens PM. The role of intramedullary nailing in treatment of open fractures. Eur J Trauma Emerg Surg 2015;41(1):39–47. doi: 10.1007/s00068-014-0485-5
9. Gubin AV, Borzunov DY, Marchenkova LO, Malkova TA, Smirnova IL. Contribution of G.A. Ilizarov to bone reconstruction: historical achievements and state of the art. Strateg Trauma Limb Reconstr 2016;11(3):145–52. doi:10.1007/s11751-016-0261-7
10. Ren GH, Li R, Hu Y, Chen Y, Chen C, Yu B. Treatment options for infected bone defects in the lower extremities: free vascularized fibular graft or Ilizarov bone transport?. J Orthop Surg Res 2020;15(1): 439. doi: 10.1186/s13018-020-01907-z
11. Masquelet AC, Fitoussi F, Begue T, Muller GP. Reconstruction of the long bones by the induced membrane and spongy autograft. Ann Chir Plast Esthet 2000;45(3):346–353
12. Gupta A, Jain A, Mittal S, Chowdhury B, Trikha V. Ipsilateral femoral neck and shaft fractures: case series from a single Level-I trauma centre and review of literature. Eur J Orthop Surg Traumatol 2023;33(4):803-9. doi: 10.1007/s00590-021-03199-3

Correspondence:
Received: 20 May 2025
Accepted: 20 June 2025
Mauro Spina, MD
Orthopaedics and Spine Surgery Department, University and Hospital Trust of Verona, Italy
Piazzale Aristide Stefani, 1 - 37126 Verona
E-mail: spina.mauro@gmail.com,
ORCID: 0000-0003-0079-021X