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A High-Energy Military Femoral Fracture With Multidrug-Resistant Infection: A Case Report

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Patient: Male, 37-year-old
Final Diagnosis: Femoral fracture
Symptoms: Pain, deformity, inability to bear weight on the affected leg, reduced range of motion in the joint, and discharge from the wounds
Clinical Procedure: —
Specialty: Orthopedics and Traumatology

Objective: Unusual clinical course

Background: The Masquelet induced membrane technique is a 2-stage surgical procedure used to reconstruct large bone defects and uses a temporary cement spacer to generate a biologically active, vascularized membrane that promotes bone healing when filled with an autograft. This report describes the case of a 37-year-old military man with a high-energy femoral fracture, multiple debridement procedures, and a bone defect managed with the Masquelet induced membrane technique.

Case Report: In the patient's home country, life-saving surgery was performed, followed by repeated excision of damaged tissue and long-term treatment, including the use of an external fixation device. After 6 months, the patient was transferred to Latvia for rehabilitation. In March 2023, he was admitted from a rehabilitation center to Riga East Clinical University Hospital in an acute setting, presenting with severe pain and purulent discharge from the left thigh.

During treatment, he underwent multiple debridement procedures, insertion of a cement-coated nail, and defect reconstruction using the Masquelet induced membrane technique. Due to shortening of the affected limb, post-traumatic osteoarthritis, and poor bone quality, further osteosynthesis and stable implant fixation in the proximal femur were not feasible. Consequently, cementless left hip arthroplasty using a revision femoral stem was performed.

Conclusions: This case demonstrates that staged orthopedic management combining the Masquelet induced membrane technique, cementless revision hip arthroplasty, and individualized antimicrobial therapy guided by infectious disease consultation can achieve a favorable functional outcome at 2-year follow-up in a patient with high-energy femoral trauma complicated by multidrug-resistant infection.

Keywords: Arthroplasty, Replacement, Hip • Case Reports • Drug Resistance, Multiple, Bacterial • Femoral Fractures • Military Personnel • Orthopedics • Soft Tissue Injuries

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Introduction

Military injuries include a variety of gunshot wounds, burns, and complex war-related injuries. This high-energy trauma is usually associated with extensive and severe soft tissue defects that require multiple wound debridement procedures and osteosynthesis, carrying a high risk of complications [1,2]. Military circumstances often cannot provide the necessary resources, including equipment and environment, for proper and fully sterile wound debridement, especially because these wounds are frequently contaminated or infected [1].

Given these conditions, antibacterial medications are not administered based on targeted pathogens but rather empirically for suspected bacteria. This indirect use of antibiotics often leads to microbial resistance, which is a common cause of soldier mortality and severe complications such as osteomyelitis, delayed wound healing, amputations, sepsis, and septic shock [1-10].

The Masquelet induced membrane technique is a 2-stage procedure for reconstructing large segmental bone defects in which a temporary cement spacer is first placed to induce a vascularized, biologically active membrane, which at a second stage is removed and replaced with autograft to promote consolidation [11,12]. It tolerates a previously contaminated or infected bed and allows microbiological clearance to be confirmed between stages [12]. The technique has been used to reconstruct large femoral defects after fracture-related infection [13] and high-energy trauma, including septic nonunion [14] and a large (12-cm) infected defect [15], open femoral fractures with extensive bone loss [16], and ballistic or combat injuries [17]. These reports are compared with our case in the Discussion section below.

The aim of this case report is to describe the staged orthopedic and antimicrobial management of a 37-year-old man with a high-energy left femoral fracture complicated by recurrent multidrug-resistant infection, and to discuss the rationale behind key therapeutic decisions—including the Masquelet induced membrane technique for bone reconstruction, cementless revision hip arthroplasty for proximal femoral failure, and discontinuation of long-term antibacterial therapy—that resulted in a favorable functional outcome at 2-year follow-up.

Case Report

We report the case of a 37-year-old man admitted to Riga East Clinical University Hospital "Gaiļezers" on March 9, 2023, with excruciating pain in the thigh above the knee and purulent secretions from a postoperative wound of the left hip.

The initial injury occurred in June 2022. Following the injury, several life-saving surgeries were performed, including insertion of a profunda femoris artery prosthesis, which ultimately failed functionally. The patient was treated with external fixation for approximately 3 months. After multiple infection sanitation procedures, osteosynthesis with a gamma nail was performed. Persistent pain in the hip and above-knee region remained and was accompanied by purulent discharge from the postoperative wound and edema.

Upon admission, wound swabs, blood cultures, and additional laboratory tests were obtained. Microbiological analysis revealed growth of *Klebsiella pneumoniae* in the wound, along with an elevated C-reactive protein level (59.4 mg/L; reference range 0.0-5.0 mg/L). The detected strain produced *K. pneumoniae* carbapenemase. Diagnostic imaging, including radiography and computed tomography angiography, demonstrated a condition following high-energy trauma of the proximal one-third of the femoral diaphysis, previously treated with a long gamma nail and 2 intraosseous screws at the distal femoral metadiaphysis. A fragmentary lesion of the proximal one-third of the left femoral diaphysis with multiplanar displacement was observed, including full-width dorsal displacement of bone fragments, minimal callus formation, and multiple metallic fragments within the surrounding soft tissues, consistent with an injury caused by an explosion (**Figure 1A-1C**).

On hospital day 7, he underwent surgery during which the gamma nail was removed, followed by wound lavage and debridement. A rod coated with antibiotic-impregnated cement containing gentamicin and vancomycin was placed in the femoral canal, and additional smears were collected (**Figure 2A**). Microbiological examination revealed growth of *Enterococcus faecium* (1000 CFU/mL), resistant to most commonly used antibiotics and sensitive only to standard doses of tigecycline and colistin.

On day 32, a second debridement was performed with replacement of the rod and flushing of the bone canal using chlorhexidine solution, including insertion of a drainage system (**Figure 2B**). Microbiological smears from this procedure showed growth of *Staphylococcus epidermidis* and *K. pneumoniae*, both resistant to commonly used antibiotics. The patient continued antibacterial therapy with colistin (3 million international units 3 times daily intravenously) and tigecycline (100 mg once daily intravenously).

The patient underwent multiple additional debridements and rod replacements until wound cultures were negative for microbial growth. Following this, a decision was made to proceed to the second stage of treatment. Based on consultation with an infectious disease specialist, the recommended antibacterial therapy was completed. At follow-up, the wounds appeared clean and dry, with no signs of infection or elevated body temperature.

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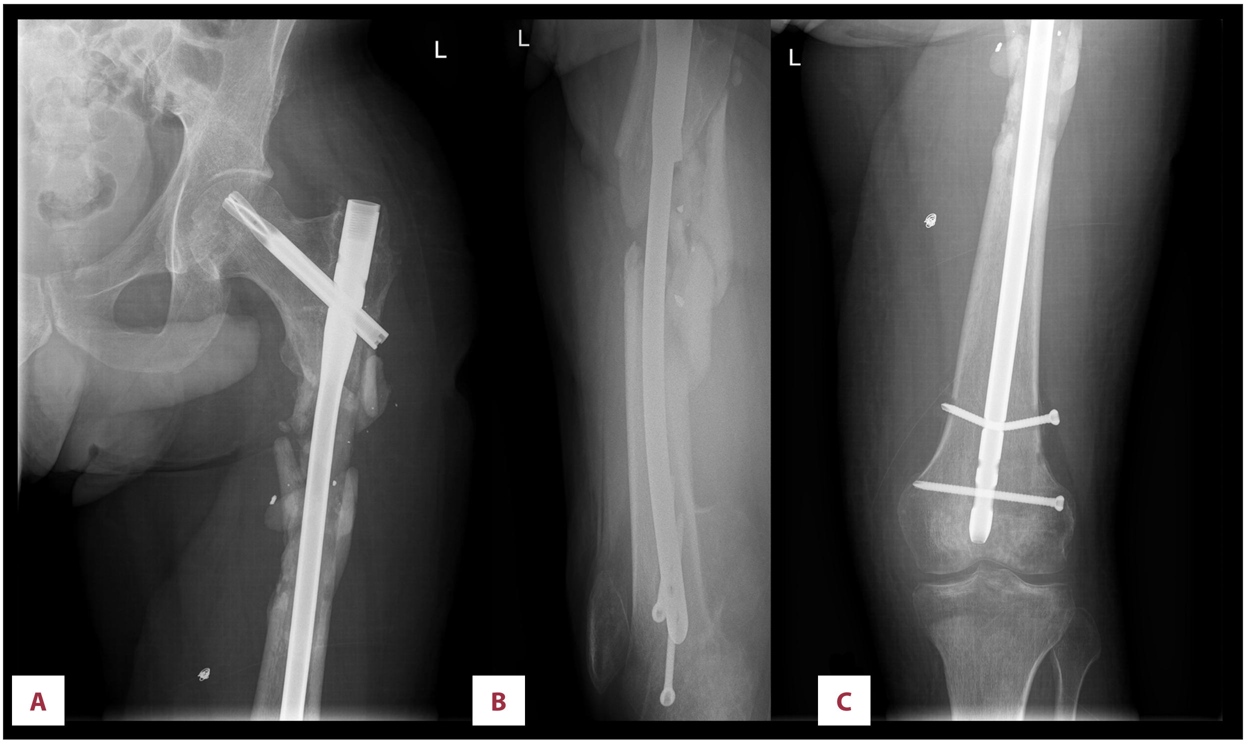

Figure 1. Radiographic findings on admission. X-rays (anteroposterior [**A**], lateral [**B**], anteroposterior [**C**]) showing the damaged limb after osteosynthesis with a long gamma nail and 2 intraosseous screws, fracture of the proximal screw, and minimal callus formation at the fracture site.

Figure 2. First-stage infection control with an antibiotic-loaded cement spacer. X-ray (anteroposterior [**A**]) showing a rod coated with antibiotic-impregnated cement containing gentamicin and vancomycin, placed in the femoral canal. X-ray (anteroposterior [**B**]) showing the condition of the bone after repeated debridement procedures.

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Figure 3. Reconstruction of the femoral defect using the Masquelet induced membrane technique. X-ray (anteroposterior [**A, B**]) showing the condition after a femoral defect caused by an explosion.

On day 105, the temporary osteosynthesis rod was removed, followed by repeated debridement. The previous rod was replaced with a new cement-coated rod. The bone defect was reconstructed using the Masquelet induced membrane technique with autologous bone harvested from the ipsilateral iliac crest (**Figure 3A, 3B**).

One month after surgery, the patient developed fever (38.1 °C) and elevated inflammatory markers (C-reactive protein, 130 mg/L; leukocytes, 11.1×10^9/L). Central venous catheter–associated bacteremia was suspected, and antibacterial therapy was initiated with colistin (9 million IU intravenously on the first day, followed by 3 million IU 3 times daily) and tigecycline (100 mg once daily, later reduced to 50 mg 3 times daily).

The patient's condition improved, his inflammatory markers normalized, and the postoperative wound showed no signs of infection. After discontinuation of antibacterial therapy, no negative clinical dynamics were observed.

On day 154, another surgical intervention was performed. Because of massive bone loss, shortening of the affected leg by 6.5 cm, and poor bone quality of the femoral head with multiple cysts, a decision was made to perform cementless left hip arthroplasty. This included placement of an acetabular component (52 mm), a cementless revision femoral long stem (size +19, length 380 mm) with distal locking screw, and a ceramic head (32 mm) (**Figure 4A, 4B**).

Three weeks postoperatively, a purulent mass developed on the patient's left leg. Microbiological examination revealed growth of *Providencia stuartii* (NDM-producing strain), resistant to all antibiotics except aztreonam and cefepime at high concentrations. Following consultation with an infectious disease specialist, antibacterial therapy was initiated with trimethoprim–sulfamethoxazole (960 mg 3 times daily) and trimethoprim (480 mg).

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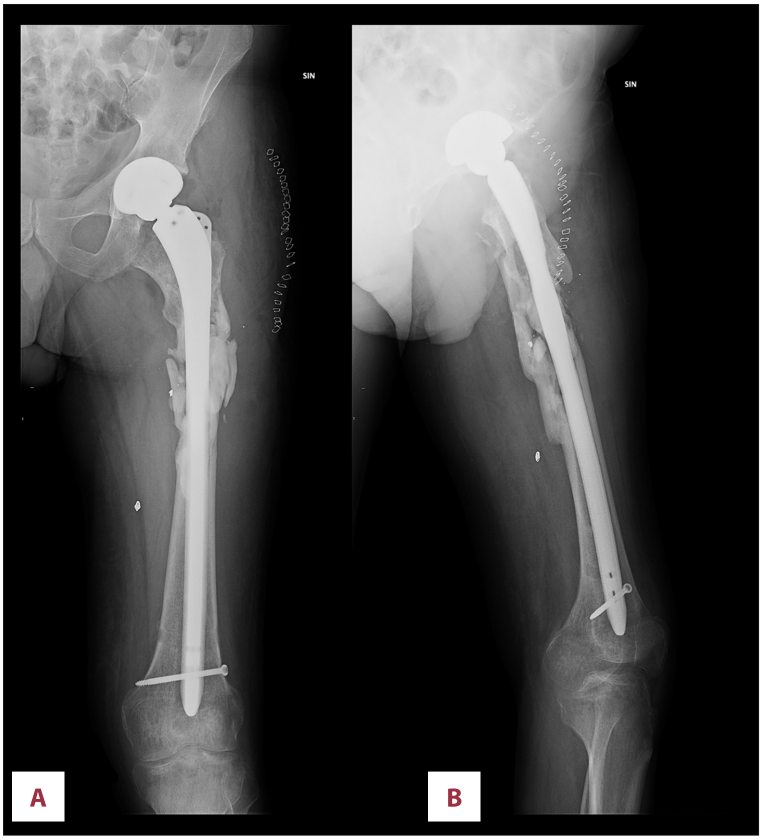

Figure 4. Cementless revision hip arthroplasty. X-rays (anteroposterior [**A**], lateral [**B**]) demonstrating hip arthroplasty with placement of an acetabular component (52 mm), a cementless revision femoral long stem (size +19, length 380 mm) with distal locking screw, and a 32-mm ceramic head.

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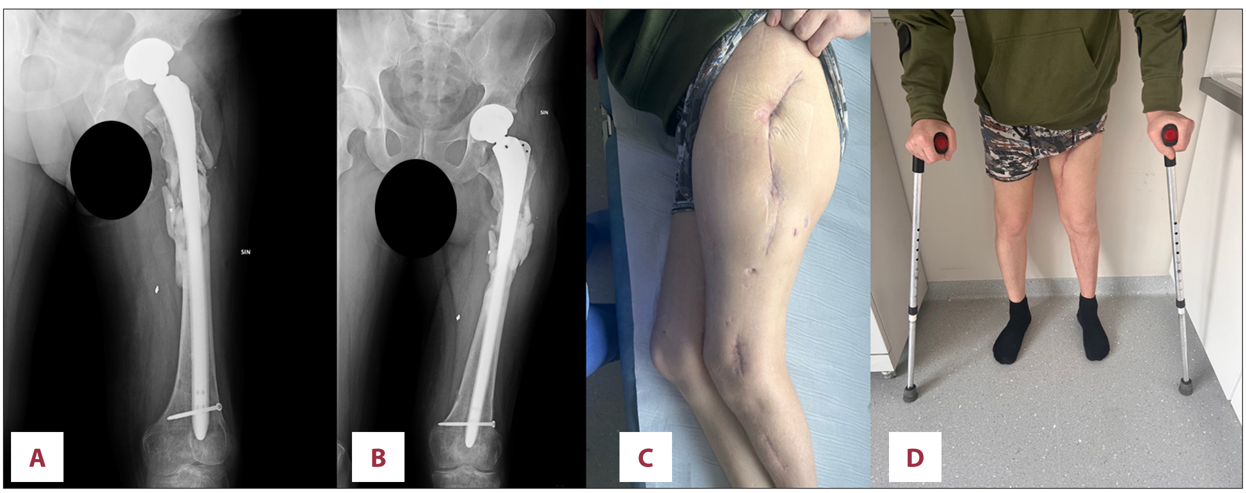

Figure 5. Clinical and radiographic outcome. X-rays (anteroposterior [**A**], lateral [**B**]) demonstrating the results of hip arthroplasty without signs of implant loosening. [**C**] Clinical photograph showing postoperative wounds. [**D**] Clinical photograph presenting final results with the patient partial weight-bearing with 2.2-cm leg shortening.

The patient underwent hyperbaric oxygen therapy and vacuum-assisted closure therapy for 5 weeks. Based on the decision of the medical council, antibiotic therapy was discontinued. The wounds healed spontaneously over the following weeks, and the patient continued rehabilitation at a rehabilitation center (**Figure 5C**).

At the 1-month follow-up, the patient reported no concerns and was able to walk pain-free, with a residual leg length discrepancy of 2.2 cm (**Figure 5A, 5B, 5D**). Rehabilitation focused on progressive weight-bearing, hip and knee range-of-motion exercises, and quadriceps strengthening, supplemented by gait retraining with a shoe lift to compensate for the residual shortening.

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At the 2-year follow-up, conducted online from the patient's home country, no signs of infection were noted. The patient denied pain in the affected leg and reported no episodes of fever. He walked independently without crutches, reported only mild fatigue after prolonged exertion, had returned to most activities of daily living, and continued participation in outpatient physiotherapy.

Discussion

This case shows that a large, infected segmental femoral defect complicated by successive multidrug-resistant organisms can be reconstructed with the Masquelet induced membrane technique and salvaged with cementless revision hip arthroplasty when stable proximal osteosynthesis is not feasible, achieving a favorable functional outcome at 2-year follow-up. In this case report, we present different treatment solutions for a patient with recurrent soft tissue infection during the management of high-energy trauma. Multiserial infections in trauma patients are typically treated with repeated debridement procedures and antibiotic therapy; however, in some cases these measures are insufficient for complete eradication of pathogens [18,19].

The Masquelet induced membrane technique was selected for the bone defect because it tolerates a contaminated bed better than vascularized bone transfer, allows confirmation of microbiological clearance between stages, and has been reported to achieve consolidation rates of 70% to 90% in segmental femoral defects of comparable size [11]. The temporary antibiotic-impregnated cement spacer additionally provided local high-dose delivery of vancomycin and gentamicin while a viable induced membrane was forming, which was important given the documented carbapenemase-producing *K. pneumoniae* and vancomycin-resistant *E. faecium* isolates. Cementless revision hip arthroplasty with a long distally locked stem was indicated rather than further osteosynthesis because of post-traumatic osteoarthritis, multiple cysts in the femoral head, poor proximal bone stock, and 6.5 cm of shortening, which together precluded stable implant fixation in the proximal femur, a scenario in which conversion to arthroplasty has been advocated when reconstructive options have been exhausted [20].

Our findings are consistent with previous reports of induced-membrane reconstruction of large femoral defects. A septic femoral nonunion [14] and a 12-cm infected femoral defect [15] have been reconstructed successfully with the induced-membrane technique, and union has been achieved after high-energy open [16] and ballistic [17] femoral injuries at rates comparable to conventional trauma. Our case extends these reports to an explosion-induced femoral defect complicated by carbapenemase- and NDM-producing organisms, a combination not previously described to the best of our knowledge.

Given the global problem of antibacterial resistance, many researchers have focused on alternative strategies to limit further antibiotic use in patients with polymicrobial infections. Some studies suggest that not only do commensal gut bacteria influence the spread of gastrointestinal infections [21], but that microorganisms forming the normal skin flora can also help counteract soft tissue infections caused by pathogenic bacteria. For example, the common skin commensal *Cutibacterium acnes* has been shown to limit the spread of *Pseudomonas aeruginosa*, a frequent cause of such infections [22]. Chronically infected wounds usually contain multiple bacterial strains that form biofilms, making them particularly difficult to eradicate using antibiotics alone. Even proper debridement procedures, currently considered the most effective approach when combined with antibacterial therapy, are not always successful [18,19].

Medications, including antibiotics, are associated with a wide range of adverse effects, especially when used for prolonged periods in the chronic treatment of infections. These adverse effects include not only organ damage, such as hepatotoxicity and nephrotoxicity [23], but also effects on the patient's immune system, further complicating the management of chronic infections.

Conclusions

This case illustrates that a staged, multidisciplinary approach combining repeated debridement, the Masquelet induced membrane technique, cementless revision hip arthroplasty, and individualized antimicrobial therapy guided by infectious disease consultation can result in a favorable functional outcome at 2-year follow-up in a patient with high-energy femoral trauma complicated by recurrent multidrug-resistant infection. In the present case, antibacterial therapy was discontinued because progressive resistance profiles and emerging signs of drug toxicity rendered further treatment unlikely to be effective and potentially harmful; subsequent wound healing without recurrence of infection was observed during follow-up. As these observations derive from a single patient, no causal inference can be drawn regarding the role of restored cutaneous microbiota or immune recovery, and broader therapeutic implications cannot be generalized from this report. Further studies are warranted to evaluate when antimicrobial discontinuation can be safely considered in similar clinical scenarios.

Institution Where Work Was Done

Riga East Clinical University Hospital, Riga, Latvia.

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Informed Consent

Written informed consent was obtained from the patient for the use of clinical data and publication of this case report.

AI Declaration

During the preparation of this manuscript, the authors used a large language model–based tool (Claude; Anthropic, PBC) to improve the grammar, language, and readability of author-written text. The tool was not used to generate scientific content, data, interpretations, or references, and all content was reviewed and verified by the authors, who take full responsibility for the manuscript.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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