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Case report

Deep-Seated Post-Traumatic Osteomyelitis Following Open Femur and Tibia Fractures: Case Report and Literature Review

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ABSTRACT

Osteomyelitis, a difficult to treat inflammation of bone and marrow, poses substantial challenges due to biofilm formation, relative avascularity, hardware involvement, and high recurrence risk. *Staphylococcus aureus* remains the most common causative pathogen, though a wide range of bacteria, mycobacteria and fungi may be implicated. Diagnosis integrates clinical features, laboratory markers, imaging, and bone biopsy, the latter remaining the gold standard for pathogen identification. Management strategies typically combine prolonged antimicrobial therapy with surgical debridement and, when necessary, reconstructive techniques or amputation. Adjunctive measures such as local antibiotic delivery and hyperbaric oxygen therapy may support outcomes in refractory cases. We present a complex case of post-traumatic osteomyelitis in a 65 year old man with high-energy open fractures of the femur and tibia sustained in a motor vehicle accident. His prolonged course required multiple surgical interventions, vascular repair, hardware removal, antibiotic spacers and hyperbaric oxygen therapy, complicated by persistent infection, chronic pain, and neurocognitive deficits. This case underscores the multifactorial challenges of osteomyelitis management and highlights the need for coordinated multidisciplinary care to optimize outcomes.

Keywords: Osteomyelitis; Physical Medicine; Rehabilitation; Infection; Amputation

INTRODUCTION

Osteomyelitis, an inflammation of bone and marrow that is usually bacterial in origin, is notoriously difficult to manage [1,2]. It is associated with prolonged treatment, recurrent disease, and substantial cost [2,3]. Critical complicating factors include the bone's relative avascularity, the propensity for biofilm formation, and the involvement of hardware, each of which contribute to treatment resistance and functional decline [4,5].

Here, we review the epidemiology, pathophysiology, diagnosis and management of osteomyelitis. We then present a case study of a 65-year-old man who sustained high-energy open fractures of the femur and tibia after being pinned under a vehicle, ultimately developing a deep-seated bone infection requiring multiple surgical interventions and prolonged antimicrobial therapy.

Osteomyelitis may be caused by different pathogens and show distinct clinical presentations

The predominant pathogen in osteomyelitis, accounting for 40 to 60 percent of cases, is *Staphylococcus aureus* [1,2]. Other relevant pathogens include coagulase-negative *Staphylococcus* (especially in prosthetic infections), *Streptococcus*, Gram-negative bacilli such as *Pseudomonas aeruginosa*, anaerobes in diabetic foot infections, mycobacterial species, and, less commonly, fungi [2,6].

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Osteomyelitis pathogenesis involves bacterial colonization of bone, microbial invasion of osteocytes and activation of host inflammatory responses leading to vascular compromise and necrosis [2,4]. Biofilm formation enables persistent infection and resistance to treatment, while sequestra (necrotic bone fragments) act as bacterial sanctuaries, necessitating surgical removal for resolution [4].

There are multiple frameworks for classifying osteomyelitis. Waldvogel classification stratifies osteomyelitis by duration (acute *versus* chronic) and mechanism (hematogenous *versus* contiguous, with or without vascular compromise), whereas the Cierny-Mader system further accounts for anatomical involvement and host physiology [7]. Modern considerations also factor in temporal onset (acute <2 weeks; chronic >6 weeks), anatomical location, host vascular and immunologic status, and presence of implants [2,8].

When osteomyelitis is acute, it is characterized by systemic signs such as fever and malaise, local symptoms, such as pain and swelling, and lab markers such as elevated levels of inflammatory markers like C-reactive protein and erythrocyte sedimentation rate [8]. Chronic cases, on the other hand, often present indolently, with draining sinuses and persistent pain [2,8]. Chronic osteomyelitis occasionally presents with pathological fractures and often without systemic symptoms, especially in compromised hosts or when hardware is present [2,8].

Diagnosis relies on the integration of clinical, laboratory, imaging, and microbiological evidence

Bone biopsy remains the gold standard for pathogen identification in osteomyelitis [2,8]. Notably, in chronic osteomyelitis with sinus tracts, two consecutive deep sinus tract cultures (with bone contact) have a high predictive value for identifying the causative pathogen, showing 96 percent concordance with bone biopsy in monomicrobial cases [2,9].

In addition to bone biopsy, imaging can contribute to osteomyelitis diagnosis. For instance, Magnetic Resonance Imaging (MRI) excels at early detection due to its high sensitivity and specificity in soft tissue [10-12]. Nuclear medical approaches, such as leukocyte scans, Positron Emission Tomography (PET), and Computed Tomography (CT) provide additional specificity in complex cases, especially when infections arise from prosthetics [13,14].

There are certain special populations, who, upon diagnosis, may require certain considerations to optimize management. For example, pediatric patients with hematogenous spread and prevalent metaphyseal involvement should raise concerns regarding potential growth disturbances [2,8]. In addition, in diabetic foot, which is characterized by polymicrobial, contiguous spread in the presence of vascular disease and neuropathy, the "probe-to-bone" test remains highly predictive, and amputation is required in 15 to 25 percent of cases [2,15,16].

There are multiple treatment strategies, often involving antimicrobial therapy and surgical management

Antimicrobial therapy in osteomyelitis typically involves a long course of 6 to 12 weeks, adjusted based on culture data [17-19]. Antibiotic combinations chosen before the exact causative organism is known should cover likely pathogens, such as *Staphylococcus,* Methicillin Resistant *Staphylococcus Aureus* (MRSA), gram-negatives, and anaerobes [18,19]. MRSA-targeted options include vanomycin, with linezolid or daptomycin as alternatives. Gram-negative coverage may utilize fluoroquinolones because of their ability to penetrate bone [18,19].

Surgical management is indicated when sequestrum abscesses, hardware-associated infections, or spinal instability are present, when medical therapy has failed, and when there is involvement deemed limb-threatening [2,8,20]. Key surgical approaches include thorough debridement with removal of necrotic tissue and reconstruction strategies [20,21].

Debridement may require repetition [20]. The Masquelet or induced membrane technique, is an especially effective two-stage reconstructive approach for large bone defects, with success rates exceeding 75 percent in complex long-bone reconstructions. In deep-seated infections, repeated washouts are often required [21].

Adjunctive measures may provide value in intervention in osteomyelitis. Local antibiotic delivery systems with Polymethylmethacrylate (PMMA) cement spacers or beads impregnated with gentamicin or other agents can achieve high local concentrations, whereas hyperbaric oxygen therapy may augment healing in refractory cases with poor vascularity [19,21]. Imaging can also support intervention. Plain radiographs can be used to monitor progression but lack sensitivity in early disease. Due to its superior bony detail, CT is also useful for surgical planning or guiding biopsy [11,12].

In severe cases where infection cannot be controlled, particularly with extensive bone and soft-tissue loss, poor vascular supply, or multiple failed salvage attempts, amputation may become necessary [22-25]. Functional outcomes after amputation depend heavily on rehabilitation, prosthetic fitting, and patient comorbidities [22,26]. Delaying amputation in the setting of non-salvageable limbs can prolong morbidity, increase infection risk, and reduce quality of life [25].

CASE PRESENTATION

An illustrative case underscores the complexity of managing post-traumatic osteomyelitis

Patient information: A 65-year-old, Caucasian, right-hand dominant male was seated on a metal bench in front of a restaurant shopping mall area when a car lost control and struck him, pinning him under the vehicle. He was unconscious at the scene, bleeding from his extremities and suffered multiple abrasions, lacerations and fractures. EMS found significant injuries to both upper and lower extremities, with left leg deformity and swelling. He was transported to a Level One trauma center.

Initial findings included: Open wounds and significant swelling in the left lower extremity. Loss of tissue, especially around the left knee and foot. Hypotension requiring transfusion of packed red blood cells. Extensive imaging revealing multi-system trauma.

Initial diagnostic findings: Neuroimaging revealed a nasal bone fracture and a small right-sided frontal subdural hemorrhage not requiring neurosurgical intervention. Orthopedic imaging showed multiple pelvic fractures involving the superior and inferior pubic rami with acetabular extension and sacral fracture, retained metallic fragments in the pelvis and leg and complex fractures of the left femur, tibia, fibula and ankle joint. Vascular studies identified injury to the distal superficial femoral artery with pseudoaneurysm formation.

Initial surgical management

The patient underwent emergent irrigation and debridement of multiple Grade 3 open fractures. External fixation devices were applied to stabilize the femur and ankle. Vascular repair was performed for a peripheral artery injury in the lower extremity. Photos from the last surgeries are provided in the Supplemental Material (Figures 1-13).

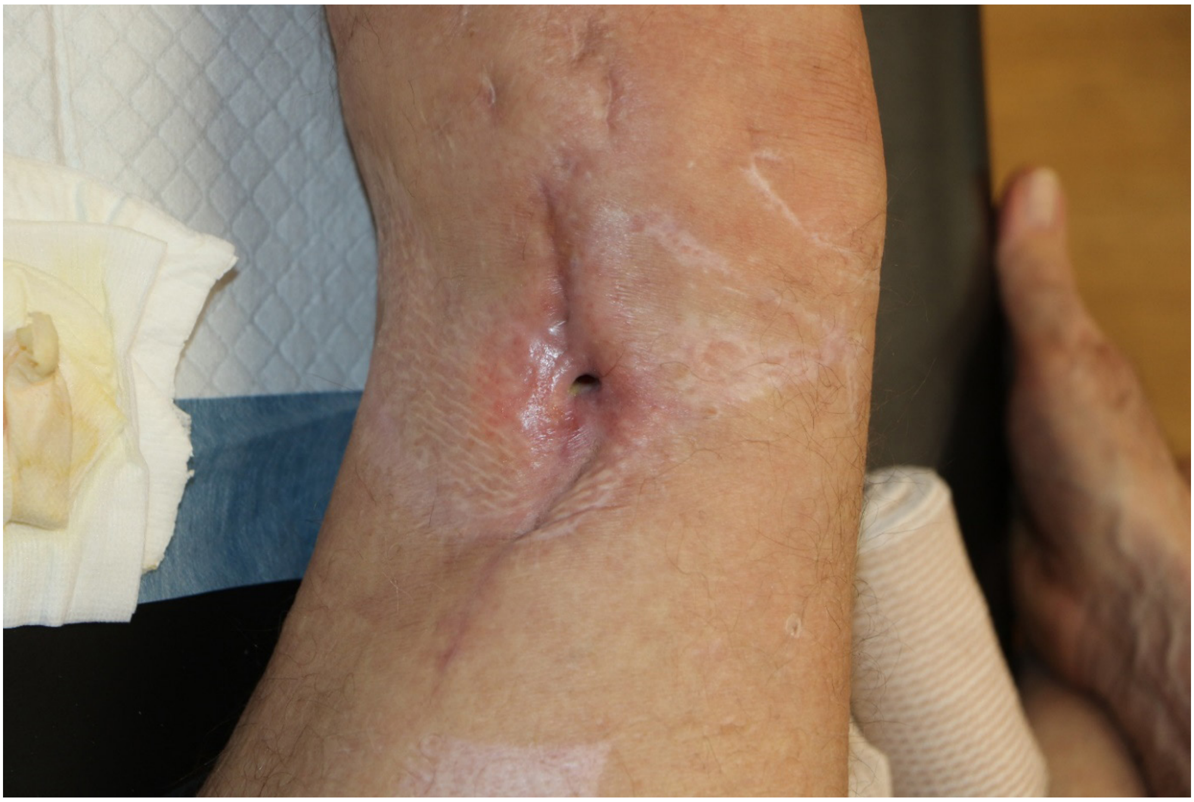

Figure 1: Sinus tract on skin that adhered to bone.

Figure 2: Necrotic infected bone that was removed.

Figure 3: Infected bone.

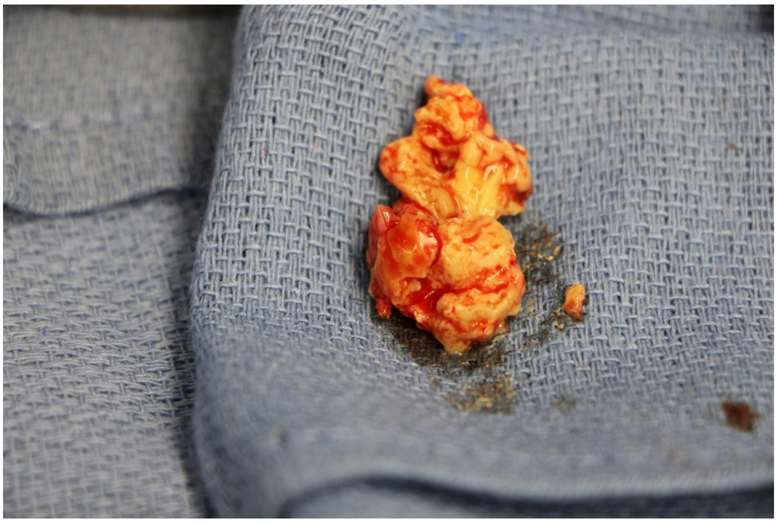

Figure 4: Infected bone marrow.

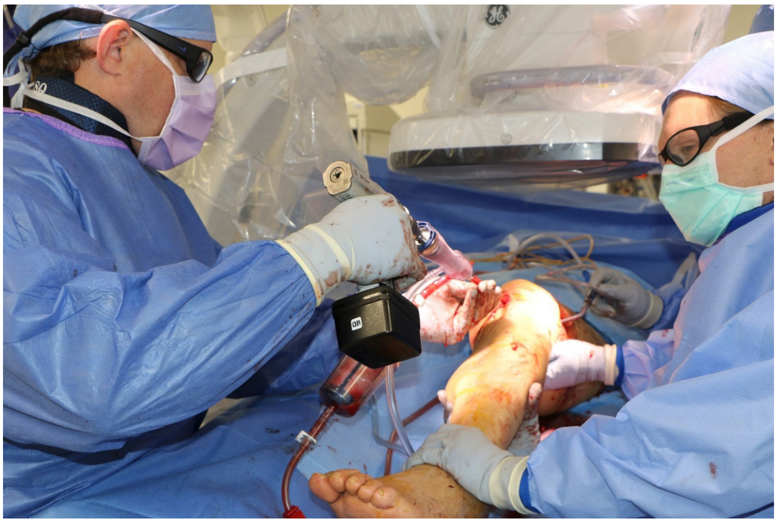

Figure 5: Debridement of intermedullary canal with Remur Irrigator Aspirator (RIA).

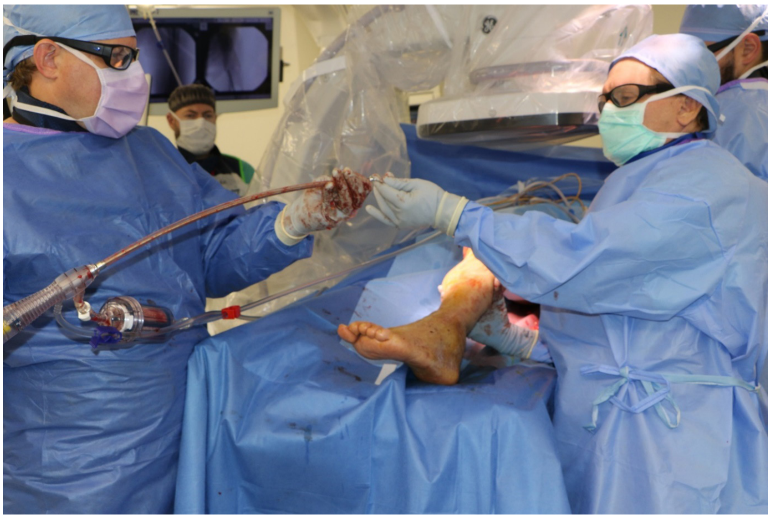

Figure 6: Remur irrigator aspirator being placed.

Figure 7: Copious irrigation of the infected bone.

Figure 8: Irrigation with antimicrobial fluid.

Figure 9: Replacement of new retrograde nail.

Figure 10: Placement of distal locking screws.

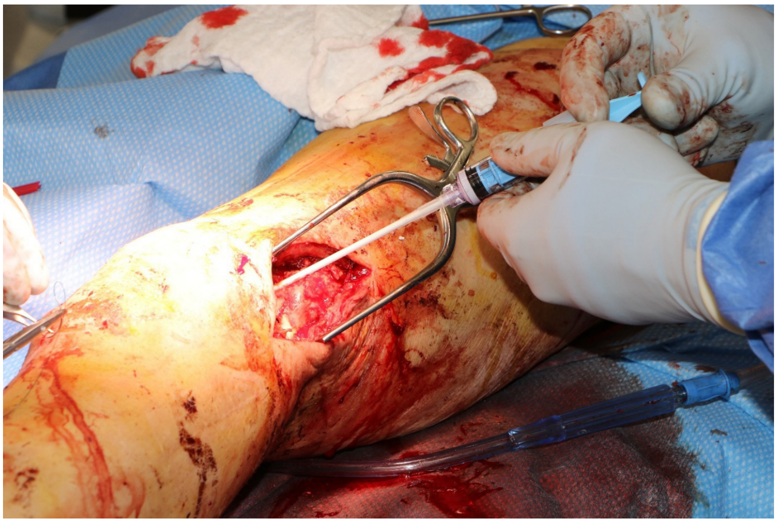

Figure 11: Application of Cerament G (composite of calcium sulfate, calcium hydroxyapatite, and gentamicin).

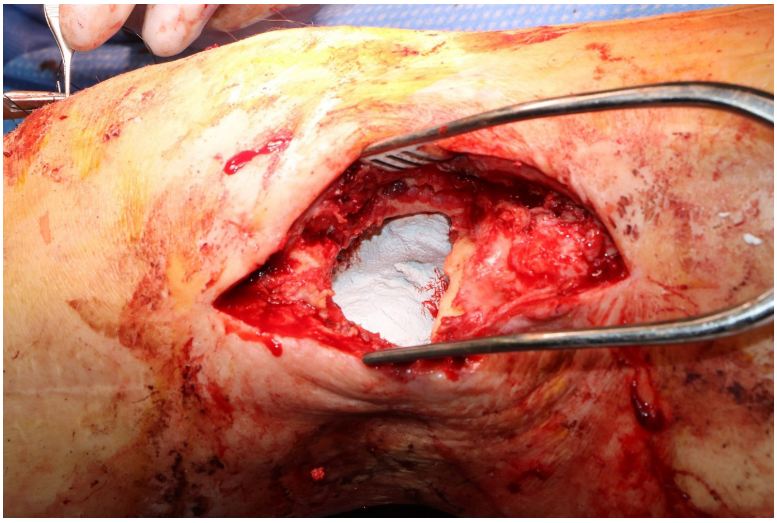

Figure 12: Fully crystallized Cerament G.

Figure 13: Soft tissue coverage complete with thigh advancement and gastrocnemius flap.

Subsequent surgeries and procedures

Over the following weeks, he required repeated debridements and wound washouts, as well as additional orthopedic procedures, including retrograde intramedullary nailing of the femoral shaft and open reduction internal fixation of a lateral condyle fracture.

Persistent infection complicated recovery, with cultures positive for methicillin-sensitive *staphylococcus aureus* and *Pseudomonas*. This necessitated prolonged intravenous antibiotics, eventual removal of orthopedic hardware, placement of antibiotic cement spacers and bone graft substitutes. Hyperbaric oxygen therapy was initiated to support wound healing, but recurrent wound breakdown at the left knee required multiple further surgical interventions.

Rehabilitation and recovery

Rehabilitation began with an acute inpatient rehabilitation program addressing impaired gait, balance and activities of daily living. He transitioned to an outpatient physical medicine program under close medical supervision by a physiatrist. Due to functional limitations, he required home health aide services eight hours per day, seven days a week for mobility assistance (including fall prevention), wound care and daily living needs.

Ongoing complications

The patient experienced chronic pain in his left knee, ankle and foot, which he frequently rated at 8 to 10 on a 10 point pain scale, along with numbness, tingling and weakness in his left lower extremity. MRI with diffusion tensor imaging confirmed a moderate traumatic brain injury and he reported persistent memory and concentration difficulties. Due to the severity of his injuries and recurrent infections, he remained at risk for an above-knee amputation.

Current status and prognosis

At the most recent follow-up, the patient remained under the care of a multidisciplinary care team, including orthopedic surgery, plastic surgery, vascular surgery, infectious disease, neurology and physiatry. He continued to require daily assistance, had limited weight-bearing ability and required ongoing wound monitoring. His prognosis remained guarded due to the persistent infection risk, chronic pain, neurocognitive symptoms and functional limitations

CONCLUSION

This case highlights the challenges of treating deep-seated post-traumatic osteomyelitis involving multiple long bones and polymicrobial infection, including Gram-negative organisms. Repeated surgical debridement, targeted antimicrobial therapy and local antibiotic delivery were all critical in achieving infection control. Management was complicated by the biology of chronic bone infection. Poor local vascularity, biofilm formation and sequestra that acted as bacterial reservoirs. Removal of hardware, while destabilizing in the short term was essential to eradication.

The case also underscores the importance of early aggressive surgical management in severe open fractures to prevent chronic infection. In situations where salvage is unlikely to result in a functional limb, early amputation should be discussed as part of shared decision making to reduce prolonged morbidity.

Optimal management requires early intervention, multidisciplinary coordination and individualized treatment planning. Deep-seated post-traumatic osteomyelitis represents one of the most challenging conditions in musculoskeletal infection management, combining the inherent difficulties of chronic bone infection with the added complexity of high-energy trauma, vascular compromise and potential hardware involvement. Across the literature the consensus emphasizes early and thorough surgical debridement, culture-directed prolonged antimicrobial therapy and adjunctive measures such as local antibiotic delivery and hyperbaric oxygen therapy when appropriate. Equally important is timely recognition of when salvage is no longer viable, with early consideration of amputation in non-functional or high-morbidity limbs. Multidisciplinary coordination and individualized treatment planning remain essential to achieving infection control, preserving function, and optimizing patient outcomes.

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