International Journal of Research in Orthopaedics
Ermakov AM et al. Int J Res Orthop. 2026 Jul;12(4):1107-1112
https://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20262048

Case Report

One-stage management of bilateral polymicrobial tibial fracture-related infection using Ilizarov fixation and staged reconstruction

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Received: 04 December 2025
Revised: 16 January 2026
Accepted: 26 May 2026

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ABSTRACT

Fracture-related infection (FRI) is a serious complication of high-energy open tibial fractures, particularly Gustilo–Anderson type IIIb injuries. Simultaneous bilateral tibial FRI caused by multidrug-resistant (MDR) gram-negative organisms is exceptionally rare and poses major reconstructive challenges. We report a 34-year-old obese male smoker who developed acute bilateral tibial FRI following bilateral Gustilo IIIb tibial fractures and a displaced left femoral-neck fracture that had been initially stabilized elsewhere using temporary monolateral external fixation. During a single hospital admission at our tertiary center, management included radical bilateral debridement with multiple deep-tissue cultures, high-volume irrigation, and application of bilateral Ilizarov circular external fixation, followed by early split-thickness skin grafting, culture-directed intravenous antibiotics with subsequent oral therapy, and delayed cementless total hip arthroplasty (THA). Deep cultures from both tibiae grew MDR Klebsiella pneumoniae and Acinetobacter baumannii, both sulbactam-susceptible, fulfilling the confirmatory criteria of the FRI Consensus Group. The patient received five weeks of intravenous cefepime–sulbactam followed by seven weeks of oral levofloxacin (total 12 weeks). The Ilizarov frames provided stable fixation and supported mobilization, and THA at week eight restored limb length and hip function. The frames were removed at six months, and radiographs confirmed complete bilateral union at one year. At two years, the patient remained infection-free, had returned to full work duties, and demonstrated excellent functional outcomes (Harris Hip Score 93; AOFAS Ankle–Hindfoot 88 and 90), with only minor pin-site infections managed conservatively. This case adds evidence that coordinated single-admission staged reconstruction can achieve durable infection eradication, fracture union, and high functional recovery even in bilateral MDR tibial FRI.

Keywords: Fracture-related infection, Ilizarov fixation, Tibia, Multidrug-resistant organisms, Soft-tissue reconstruction, Total hip arthroplasty

INTRODUCTION

Fracture-related infection (FRI) is one of the most challenging complications in orthopedic trauma, particularly in high-energy open tibial fractures where soft-tissue damage, contamination and compromised vascularity significantly increase infection risk. Reported infection rates in Gustilo–Anderson type IIIb open tibial fractures are as high as 27%, making them among the most infection-prone injuries in limb trauma.[1-3] Host factors such as obesity and smoking further impair perfusion and wound healing, and are recognized risk factors for deep infection and delayed union.[4-6] The FRI Consensus Group has provided standardized diagnostic criteria and management principles, emphasizing multiple deep-tissue samples, clear confirmatory signs and integration of

surgical and antimicrobial strategies.[6-8] Management becomes particularly complex when the causative organisms are multidrug-resistant (MDR) gram-negative bacilli such as Acinetobacter baumannii and Klebsiella pneumoniae, which are well known for biofilm formation, environmental persistence and limited antimicrobial options.[9-12] Although unilateral tibial FRI has been extensively described, simultaneous bilateral tibial FRI due to MDR polymicrobial infection is exceptionally rare. This report describes the successful one-stage (single admission) management of bilateral MDR polymicrobial tibial FRI in a young adult using radical debridement, Ilizarov circular external fixation, early split-thickness skin grafting, targeted antibiotics and delayed cementless total hip arthroplasty (THA) for an associated displaced femoral-neck fracture. The case highlights key diagnostic, surgical and organizational principles in the management of complex FRI. This is a single-patient case report from a tertiary referral trauma center. Clinical data were collected retrospectively from the patient's medical records, operative notes, imaging and follow-up assessments. On arrival to our unit, all patients with suspected FRI are evaluated using a standardized protocol based on FRI Consensus recommendations.[6-8] In this case, the protocol included full clinical examination, laboratory work-up with inflammatory markers, plain radiography and early aggressive surgical debridement of both lower limbs with systematic sampling. Five separate deep-tissue specimens from each tibia were obtained prior to antibiotic administration and sent for gram stain, culture and susceptibility testing. Antibiotic treatment was initially empirical and subsequently targeted according to microbiology results and infectious-disease specialist advice. Surgical methods followed established principles of FRI management: radical excision of all nonviable soft tissue and bone until punctate cortical bleeding was seen, high-volume irrigation with normal saline, removal of temporary external fixators, and definitive stabilization using circular Ilizarov external fixation applied outside the zone of injury. Frame construction was individualized for each limb to achieve mechanical stability and allow early mobilization. Soft-tissue reconstruction was planned together with plastic surgery. Following initial debridement, the wounds were reassessed at a planned second-look procedure to confirm the presence of healthy granulation tissue and the absence of exposed vital structures. Based on these findings, bilateral split-thickness skin grafting was performed. Antibiotic duration and choice were guided by organism susceptibility, clinical response and normalization of inflammatory markers.

After infection control was established and soft-tissue cover was stable, cementless THA was performed for the displaced femoral-neck fracture to restore hip function and correct leg length discrepancy. Rehabilitation followed standard local protocols, with early range-of-motion exercises, progressive weight-bearing in the frames as tolerated, and a structured physiotherapy programme after frame removal and THA. A focused PubMed search (2015-2024) using relevant keywords found no comparable published case. Formal statistical analysis was not applicable given the single-patient design.

CASE REPORT

A 34-year-old obese male construction worker (BMI 32 kg/m²), active smoker, sustained bilateral open comminuted tibial fractures and a displaced left femoral-neck fracture following a high-energy road traffic accident.

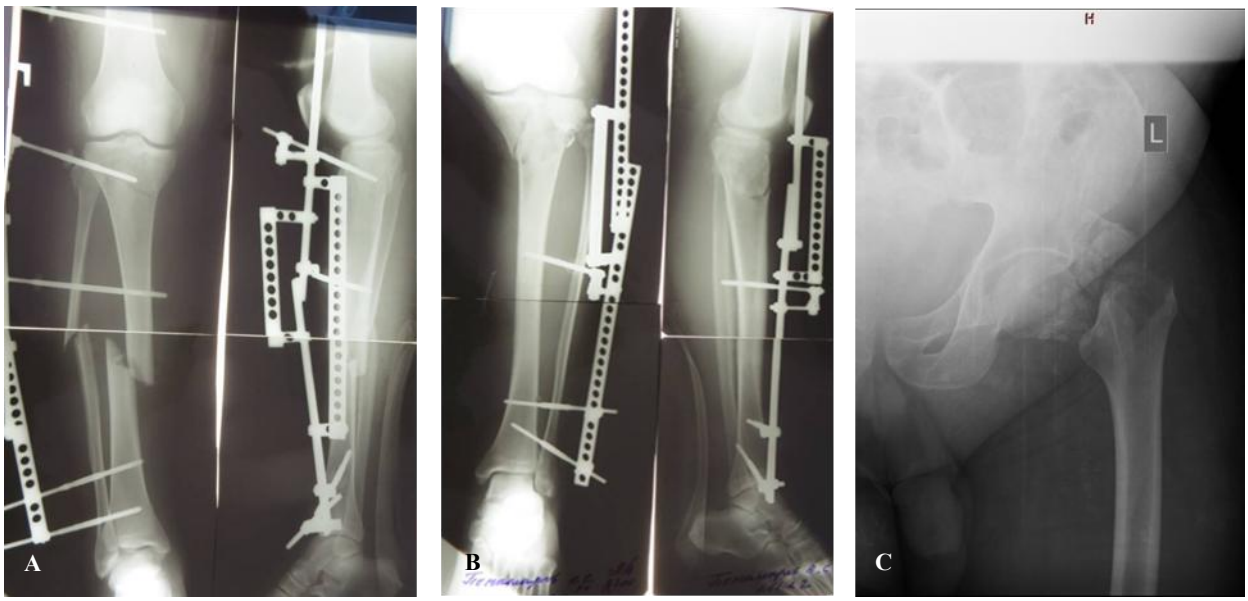

Figure 1 (A-C): Initial radiographs on arrival from the regional hospital showing bilateral comminuted open tibial fractures with temporary monolateral external fixation, and a displaced left femoral-neck fracture (anteroposterior and lateral views).

At a regional hospital, both tibiae were stabilized with monolateral external fixators, and the hip injury was initially not definitively addressed. Over the following days he developed increasing pain, purulent discharge and recurrent fever, and was referred to our tertiary center on day 4 post-injury.

On admission he was febrile (38.1°C), heart rate 104 beats/min, blood pressure 132/78 mm Hg, respiratory rate 20 breaths/min and oxygen saturation 98% on room air. Both legs showed contaminated wounds with soft-tissue loss, exposed tibial cortex and purulent drainage around the fixator pins. The left lower limb was visibly shortened by approximately 3 cm, with pain at the hip. distal pulses and neurological examination were normal.

Plain radiographs revealed bilateral comminuted tibial fractures, with metaphyseal and intra-articular extension on the left, and a displaced left femoral-neck fracture without evidence of head collapse (Figure 1). Baseline laboratory investigations showed white blood cell count 13×10^9/l, C-reactive protein (CRP) 120 mg/l and erythrocyte sedimentation rate (ESR) 60 mm/h.

Operative management and microbiology

On day 5 post-injury, both temporary monolateral external fixators were removed and extensive excisional debridement was performed for each tibia. All nonviable skin, subcutaneous tissue, fascia and devitalized bone were excised until punctate cortical bleeding was observed. High-volume irrigation with 9 l of normal saline per limb was used. After debridement there was no significant residual dead space and satisfactory cortical contact could be achieved, so bone graft and antibiotic beads were not used.

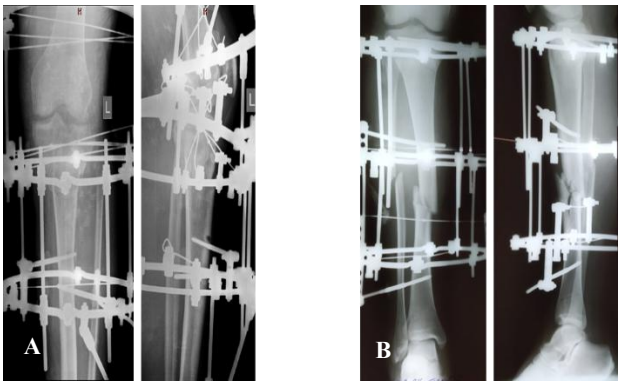

Figure 2 (A and B): Immediate post-operative radiographs after radical debridement and application of bilateral Ilizarov circular external fixators demonstrating restored alignment and stable fixation of both tibiae (anteroposterior and lateral views).

Five separate deep-tissue samples from each tibia were obtained before starting antibiotics. Gram stain suggested gram-negative bacilli. Final cultures grew MDR Klebsiella pneumoniae and Acinetobacter baumannii from both sides, with identical susceptibility profiles. Both organisms remained susceptible to sulbactam (MIC ≤4µg/ml) and to fluoroquinolones.

Empirical therapy with vancomycin and cefoperazone–sulbactam was started immediately after sampling and later narrowed to cefepime–sulbactam 2/1 g every 8-12 hours intravenously for five weeks, based on susceptibility testing and infectious-disease guidance.

After debridement, Ilizarov circular external fixation was applied bilaterally (Figure 2). The right tibia was stabilized with a three-ring frame; the left tibia with a two-ring construct and an additional distal half-ring to maintain metaphyseal alignment and joint congruity. Multiple tensioned wires and half-pins in safe corridors provided multiplanar stability and permitted early mobilization and weight-bearing as tolerated.

Two weeks later, planned second-look surgery showed healthy granulation tissue covering the tibiae, with no exposed major vessels, nerves or tendons. Together with the plastic surgery team, bilateral split-thickness skin grafting was performed over the anteromedial tibial defects. Graft take was satisfactory in both limbs (Figure 3).

Figure 3 (A and B): Local status of both legs following second-look surgery and bilateral split-thickness skin grafting, showing healthy granulation tissue and well-integrated grafts over the anteromedial tibial surfaces.

Once clinical and laboratory signs indicated good infection control and the soft tissues were stable, a cementless THA was performed eight weeks after admission for the displaced left femoral-neck fracture (Figure 4).

Intraoperative samples from the hip were sterile. Component positioning and leg length restoration were confirmed radiographically and clinically, with final leg length discrepancy less than 5 mm. Following five weeks

of intravenous cefepime–sulbactam, the antibiotic regimen was switched to oral levofloxacin 750 mg once daily for an additional seven weeks, giving a total antibiotic duration of 12 weeks. Liver and renal function tests remained within normal limits throughout therapy.

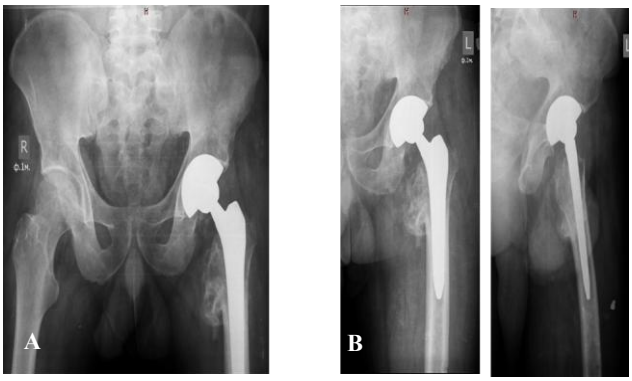

Figure 4 (A and B): Post-operative pelvis and hip radiographs after cementless total hip arthroplasty for the displaced left femoral-neck fracture, demonstrating appropriate component positioning and leg length restoration.

Rehabilitation and follow-up

Early ankle and knee range-of-motion exercises were started within the first postoperative week. Partial weight-bearing with a walker was initiated as pain allowed, and progressed to weight-bearing as tolerated within the frames. After THA, routine hip precautions were observed but mobilization was encouraged from the first postoperative days to prevent deconditioning.

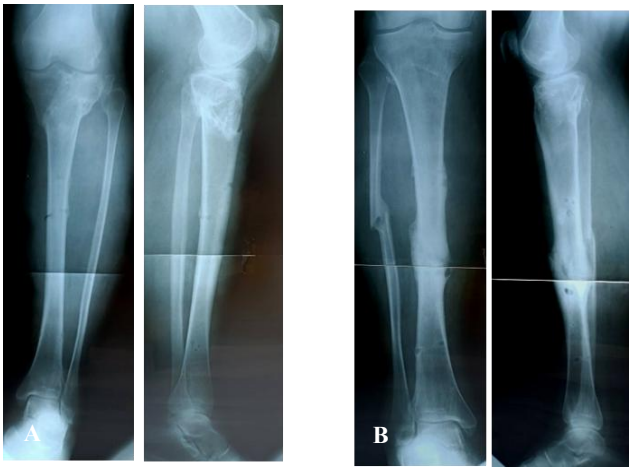

Figure 5 (A and B): One-year follow-up radiographs showing complete union of both tibiae with maintained alignment and no residual bone defect (anteroposterior and lateral views).

The Ilizarov frames were removed at six months. The patient then entered a structured outpatient physiotherapy programme focusing on gait retraining, hip abductor strengthening and proprioceptive training. He returned to full manual work at 18 months. At one year, radiographs confirmed complete union of both tibiae with satisfactory alignment and no residual defect (Figure 5). At two years, clinical review showed stable soft tissues, intact grafted areas and no recurrence of infection (Figure 6).

Figure 6 (A-C): Two-year follow-up clinical photograph demonstrating well-healed grafted skin, symmetrical leg length, and independent ambulation without walking aids.

Functional outcomes at final follow-up were excellent: Harris Hip Score 93, AOFAS Ankle–Hindfoot score 88 on the right and 90 on the left. The patient walked independently without assistive devices, reported no pain in daily activities and had resumed his original occupation.

Two minor superficial pin-site infections (Checketts–Otterburn grade 1-2) occurred during frame treatment and resolved with local pin care and short courses of oral antibiotics. No frame revision, re-debridement or additional procedures were required. There were no episodes of deep infection, non-union, implant loosening or dislocation during the follow-up period.

DISCUSSION

This case highlights several important aspects of contemporary FRI management applied to an extremely rare and complex scenario of bilateral MDR tibial involvement.

First, the diagnosis and initial management strictly followed FRI Consensus recommendations, which emphasize clinical signs such as purulent drainage and exposed bone in combination with multiple deep-tissue cultures.[6-8,20] Collecting five tissue samples from each tibia before antibiotic administration allowed secure microbiological diagnosis and targeted therapy. The isolation of MDR Acinetobacter baumannii and Klebsiella pneumoniae is clinically significant, as these organisms are frequently implicated in hospital-acquired infections

and are associated with biofilm formation and limited antibiotic options.[9-12] Their susceptibility to sulbactam and fluoroquinolones enabled a rational, stewardship-compliant regimen with five weeks of intravenous cefepime–sulbactam followed by seven weeks of oral levofloxacin.[11,12]

Second, the use of Ilizarov circular external fixation was central to achieving infection control and union. External circular frames avoid placing implants into infected bone, allow repeated debridement if required and offer excellent versatility for alignment control and early loading. High union rates have been reported in infected tibial non-unions and defects treated with the Ilizarov method.[13-15] In our patient, bilateral union without deformity was achieved despite extensive soft-tissue compromise and MDR infection, supporting the effectiveness of this strategy when combined with meticulous debridement and close follow-up.

Third, soft-tissue reconstruction was tailored to the post-debridement defect. Gustilo IIIb fractures often require flap coverage, particularly where there is extensive exposure of bone or vital structures.[16,17] In this case, staged debridement produced a well-vascularized granulation bed over relatively narrow anteromedial tibial surfaces, with no exposed major neurovascular structures or tendon. The plastic surgery team therefore judged that split-thickness skin grafting would be sufficient. The durability of the grafts over two years without breakdown supports the appropriateness of this decision in the specific defect pattern. Fourth, management of the associated displaced femoral-neck fracture with cementless THA was important both for pain relief and for restoring leg length and function. Contemporary evidence supports arthroplasty for displaced femoral-neck fractures in active adults, particularly when early mobilization is a priority.[18,19] In this case, THA performed after control of tibial infection allowed correction of a 3 cm leg length discrepancy to within 5 mm, which is crucial for gait symmetry and long-term function.

Finally, the entire pathway was completed within a single prolonged hospital admission. While many complex FRI cases are managed across multiple admissions and prolonged outpatient care, continuous inpatient treatment allowed close interdisciplinary coordination, strict monitoring of infection parameters and early, supervised rehabilitation. This “one-stage” admission model may reduce treatment interruptions and improve adherence, particularly in patients with bilateral involvement and limited social support.

Limitations

This report describes a single case and its findings cannot be generalized to all bilateral FRI scenarios. Advanced imaging such as CT or MRI was not performed after debridement; decisions were based on clinical assessment, intraoperative findings and microbiology. Host factors such as obesity and smoking may have influenced both infection risk and healing, but these are common in real-world trauma populations and therefore enhance external relevance. Nevertheless, larger series would be needed to confirm the reproducibility of this approach.

CONCLUSION

This case shows that simultaneous bilateral polymicrobial MDR tibial FRI can be eradicated and reconstructed through a structured, principles-based approach. Radical excisional debridement with confirmatory deep-tissue cultures, Ilizarov circular fixation, timely definitive soft-tissue coverage, and prolonged culture-directed antimicrobial therapy achieved sustained infection control and union. Staged cementless THA restored limb length and enabled rehabilitation without reinfection, supporting coordinated multidisciplinary single-admission staged management in rare bilateral FRI.

ACKNOWLEDGEMENTS

The authors would like to thank the plastic surgery, infectious disease, physiotherapy and nursing teams involved in the multidisciplinary care of this patient.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Ermakov AM, Sudnitsyn AS, Gnutikova OV, Haddad S, Kashoob AM, Al-Barwani AM. One-stage management of bilateral polymicrobial tibial fracture-related infection using Ilizarov fixation and staged reconstruction. Int J Res Orthop 2026;12:1107-12.