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# Comprehensive management of grade 3A open femoral shaft fracture with infected non-union using fibular graft: A case report

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**Abstract**
Grade 3A open femoral shaft fractures present significant management challenges, particularly when complicated by infected non-union. This case report describes the comprehensive treatment of a 28-year-old male with a post-traumatic, infected non-union of the femoral shaft following a Grade 3A open fracture sustained in a road traffic accident. Initial external fixation and debridement were followed by multiple surgical interventions, including antibiotic therapy, sequestrectomy, and eventually reconstruction using a non-vascularized autologous fibular graft and locking compression plate. The patient was closely monitored for signs of infection and union, with progressive weight-bearing introduced based on radiologic and clinical assessments. Union was achieved at 10 months post-operatively, with restoration of limb function and no recurrence of infection. This case highlights the efficacy of fibular grafting in managing complex infected non-unions, emphasizing the importance of infection control, mechanical stability, and biological augmentation in achieving successful outcomes.

**Keywords:** Femoral shaft fracture, infected non-union, fibular graft, open fracture, bone reconstruction, orthopedic trauma, autologous graft

## Introduction

Open fractures of the femoral shaft represent one of the most severe injuries in orthopedic trauma, often resulting from high-energy mechanisms such as motor vehicle accidents or falls from height. Among these, Grade 3A open fractures, as classified by the Gustilo-Anderson system, involve extensive soft tissue damage with adequate periosteal coverage, posing a significant challenge in terms of both initial management and long-term outcomes. The risk of infection, non-union, and functional impairment is considerably higher compared to closed fractures, especially when there is delay in definitive fixation or complications in the soft tissue envelope. In the presence of infected non-union, treatment becomes considerably more complex, requiring a multidisciplinary approach focused on infection control, mechanical stability, and biological enhancement for bone healing.

Non-union of the femoral shaft, particularly when associated with infection, represents a pathological state where the bone fails to heal within the expected time frame despite appropriate surgical stabilization. This condition is often exacerbated by initial contamination, multiple previous surgeries, poor vascular supply, or inadequate debridement. Infected non-unions of long bones not only prolong the treatment course but also carry significant morbidity, increasing the likelihood of long-term disability, psychosocial burden, and economic costs for both patients and healthcare systems. The femur, being the strongest and one of the most vascularized bones in the body, has a high potential for healing; however, in the presence of persistent infection and instability, this potential is significantly diminished. Therefore, achieving union in such cases requires a comprehensive strategy that addresses both biological and mechanical deficiencies.

Standard treatment protocols for femoral shaft fractures typically include intramedullary nailing as the gold standard due to its minimally invasive nature and ability to preserve the surrounding soft tissue. However, in open fractures, especially with extensive contamination and soft tissue compromise, external fixation is often employed as a temporizing measure. When complications such as infected non-union arise, multiple interventions may be required, including aggressive debridement, removal of infected hardware, systemic and local antibiotic therapy, and bone grafting. In these scenarios, bone grafts serve a dual purpose: filling bone defects and stimulating osteogenesis. While autologous iliac crest bone grafts are considered the gold standard for non-vascularized grafting, the fibula is increasingly recognized for its mechanical strength and structural properties, especially in bridging large segmental defects.

The use of fibular grafts, particularly non-vascularized ones, has been well documented in the treatment of long bone non-unions and defects, offering mechanical stability, osteoconductivity, and integration potential. Non-vascularized fibular autografts are relatively simple to harvest, do not require microvascular anastomosis, and have shown favorable outcomes in both upper and lower extremity reconstructions. In femoral applications, they provide a cortical structure capable of bridging large gaps and supporting weight-bearing, especially when combined with rigid internal fixation. Moreover, the fibula's relatively redundant biomechanical role in load-bearing allows its harvest with minimal donor site morbidity in most cases. However, the success of fibular grafting is highly dependent on meticulous surgical technique, adequate debridement of necrotic tissue, and achieving stable fixation to ensure graft incorporation and eventual union.

In addition to the mechanical and surgical considerations, infection control remains paramount in managing infected non-unions. The principles of treating osteomyelitis must be rigorously applied: radical debridement of infected and devitalized tissue, removal of all foreign material, appropriate culture-directed antibiotics, and ensuring a vascularized bed for the graft. Often, these cases require staged surgeries, starting with infection control, followed by definitive reconstruction. Local antibiotic carriers such as calcium sulfate beads or polymethylmethacrylate (PMMA) spacers impregnated with antibiotics are frequently employed in the initial stages to maintain dead space management and deliver high local antibiotic concentrations. Systemic antibiotics, guided by culture and sensitivity, are typically administered for an extended duration and monitored through clinical, radiological, and serological markers such as ESR and CRP.

In cases with substantial bone loss or segmental defects, reconstruction becomes particularly challenging. Options include the Ilizarov technique for distraction osteogenesis, Masquelet-induced membrane technique, vascularized bone transfer, and non-vascularized autografting. Each of these modalities has its own set of indications, limitations, and resource requirements. The Ilizarov technique, while effective, demands prolonged external fixation, patient compliance, and can be associated with pin-site infections. The Masquelet technique, though biologically promising, requires two stages and carries a risk of membrane failure or graft resorption. Vascularized fibular grafts, though offering superior biological viability, necessitate microsurgical expertise and longer operative times. In contrast, non-vascularized fibular grafts provide a balance between structural integrity and procedural simplicity, particularly in centers without access to advanced reconstructive services.

This case report presents the management of a young adult male who sustained a Grade 3A open femoral shaft fracture complicated by infected non-union. Initial treatment involved external fixation and multiple debridements, but persistent infection and segmental bone loss necessitated a more definitive reconstructive approach. A non-vascularized autologous fibular graft, in conjunction with locking compression plating, was employed to restore femoral continuity and achieve union. This case underscores the importance of individualized treatment planning in complex orthopedic trauma, where infection control, stable fixation, and biological reconstruction must be harmonized to restore function. It also highlights the practical utility of fibular grafts in the setting of infected long bone non-unions, particularly when vascularized options are not feasible or indicated.

Through this report, we aim to contribute to the growing body of literature supporting the use of autologous fibular grafts in challenging reconstructive scenarios. Given the limited number of comprehensive case reports detailing the integration of infection management with structural bone reconstruction in femoral non-unions, especially from low- to middle-income healthcare settings, this report seeks to offer practical insights into the surgical decision-making, technical considerations, and postoperative management strategies essential for achieving successful outcomes in such complex cases.

## Methods

### Patient Presentation and Initial Assessment

A 28-year-old male presented to the emergency department following a high-velocity road traffic accident. On arrival, he was hemodynamically stable, but sustained a visibly deformed and bleeding right thigh wound consistent with an open fracture. On clinical examination, the patient had a Grade 3A open femoral shaft fracture of the right leg according to the Gustilo-Anderson classification, characterized by a large laceration (>10 cm) with adequate soft tissue coverage but extensive periosteal stripping.

Neurovascular examination revealed intact distal pulses and preserved motor and sensory function in the affected limb. No other associated systemic or orthopedic injuries were identified. The patient had no significant past medical history and was not on any chronic medications.

Initial management followed Advanced Trauma Life Support (ATLS) protocols, including intravenous fluid resuscitation, tetanus prophylaxis, analgesia, and empirical broad-spectrum intravenous antibiotics (cefazolin and gentamicin). The wound was covered with a sterile saline dressing pending surgical debridement. Radiographic imaging of the right femur (anteroposterior and lateral views) confirmed a comminuted midshaft fracture (AO/OTA classification: 32-C3) with no intra-articular extension.

### Stage 1: Emergency Management and Initial Stabilization

The patient was taken to the operating room within 6 hours for emergency wound debridement and external fixation. Under general anesthesia, thorough irrigation with 9 liters of normal saline and surgical debridement were performed to remove gross contamination, devitalized tissue, and foreign material. The femoral shaft fracture was stabilized using a unilateral external fixator, allowing access to the soft tissue wound for dressing changes and facilitating early mobilization.

Wound cultures were taken intraoperatively for microbiological analysis. Postoperatively, the patient was transferred to the surgical ward and monitored for signs of systemic or local infection. Empiric antibiotics were continued until culture results became available, at which point they were adjusted based on microbial sensitivity.

Over the following weeks, the patient underwent two additional debridements due to persistent purulent discharge and elevated inflammatory markers (ESR and CRP). Microbiological cultures identified *Staphylococcus aureus*, sensitive to vancomycin, which was administered intravenously for 6 weeks under infectious disease specialist supervision.

### Stage 2: Diagnosis of Infected Non-Union

At 5 months post-injury, despite infection control measures and external fixation, there was no radiological evidence of callus formation. The patient continued to experience pain on weight-bearing and had a persistently draining sinus tract at the surgical site. Blood parameters (elevated CRP at 28 mg/L, ESR at 65 mm/hr) and radiographic imaging indicated infected non-union. CT scan and MRI were used to further evaluate the extent of bone necrosis and soft tissue involvement.

Diagnosis was made according to Non-Union Scoring System (NUSS) criteria and supported by clinical, radiological, and microbiological data. A multidisciplinary team—including orthopedic surgeons, infectious disease specialists, and plastic surgeons—was assembled to plan definitive reconstruction.

### Stage 3: Preoperative Planning for Definitive Reconstruction

**Preoperative planning included:**

- **Laboratory investigations:** Complete blood count, ESR, CRP, renal and liver function tests.

- **Radiological evaluation:** X-rays, CT scan for segmental bone loss measurement (~6.5 cm).

- **Donor site assessment:** Imaging of both fibulae to evaluate suitability for graft harvest.

**Anesthetic and surgical risk assessment**
Informed consent was obtained after a detailed discussion with the patient regarding surgical risks, donor site morbidity, duration of recovery, and the possibility of requiring future procedures. Psychological counseling and nutritional support were also initiated.

**Stage 4: Definitive Surgery – Fibular Grafting and Internal Fixation**
At 6 months post-injury, once infection was clinically and biochemically controlled, the patient underwent definitive reconstructive surgery. The procedure was performed under general anesthesia with the patient in the lateral decubitus position for ease of access to both the femoral defect and fibular donor site.

**Surgical steps included**

1. **Debridement and Preparation of the Recipient Site:**
- Longitudinal incision over the anterolateral thigh.
- Removal of the external fixator and infected fibrous tissue.
- Resection of necrotic bone ends until healthy, bleeding bone (paprika sign) was visualized.
- Lavage with pulsatile saline irrigation.
- Measurement of the bone defect (6.5 cm).

2. **Harvesting the Fibular Graft**
- Ipsilateral fibula was selected as the donor site.
- A 10-cm segment of the middle third of the fibula was harvested subperiosteally using standard lateral approach techniques, ensuring preservation of the proximal and distal tibiofibular joints to prevent instability.
- The graft was carefully shaped to fit the defect and predrilled for ease of insertion.

3. **Internal Fixation and Graft Placement**
- A locking compression plate (LCP) (12-hole, 4.5 mm) was contoured and applied to the lateral aspect of the femur.
- The fibular graft was interposed into the defect and secured using cerclage wires and compression through the plate.
- Autologous cancellous bone chips, harvested from the ipsilateral iliac crest, were packed around the graft to augment healing.

4. **Wound Closure and Drainage**
- A closed suction drain was placed.
- Layered closure of muscle, fascia, and skin.
- Sterile dressing applied.

**Stage 5: Postoperative Care and Rehabilitation**
Postoperative antibiotics (vancomycin and levofloxacin) were administered for 2 weeks intravenously, followed by 4 weeks of oral therapy based on infectious disease consultation. The surgical site was monitored daily for signs of infection, wound dehiscence, or graft rejection. Drains were removed after 48 hours.
Postoperative radiographs confirmed appropriate graft placement and alignment. The patient was kept non-weight-bearing on the affected limb for 6 weeks, followed by gradual progression to partial and then full weight-bearing over a 6-month period based on radiographic evidence of union and clinical improvement.
Physiotherapy was initiated early to maintain joint range of motion, prevent muscle atrophy, and encourage functional recovery. The patient was followed up monthly with repeat radiographs, laboratory monitoring (CRP, ESR), and clinical evaluation.

**Outcome Assessment**
The primary outcome was radiological union of the femoral shaft, defined as:
- Bridging callus in at least three of four cortices on biplanar radiographs.
- Absence of pain or tenderness at the fracture site upon weight-bearing.
- No recurrence of infection (confirmed by normalization of ESR and CRP, and sterile cultures from needle aspiration at 10 months).

**Secondary outcomes included**
- Limb length discrepancy.
- Range of motion of hip and knee joints.
- Functional assessment using the Lower Extremity Functional Scale (LEFS).
- Donor site morbidity, such as ankle instability or sensory loss.

**Ethical Considerations**
This case report was conducted in accordance with the Declaration of Helsinki and institutional ethical standards. The patient provided written informed consent for publication of all clinical data and images. Identifying details were anonymized to protect confidentiality.

**Results**
**Initial Presentation and Emergency Management**
The patient, a 28-year-old male, was brought to the emergency department after a high-velocity road traffic accident. The right thigh presented with a large open wound measuring approximately 12 cm, contaminated with road debris, and associated with bone fragments visible at the site. The limb was shortened, externally rotated, and deformed, suggestive of a diaphyseal fracture. Peripheral pulses were intact, and capillary refill time was less than 2 seconds. Sensation and motor function were preserved distally.
Radiographic imaging (anteroposterior and lateral views) confirmed a comminuted midshaft femoral fracture (AO/OTA 32-C3) with cortical disruption and segmental bone loss. Based on clinical and radiographic findings, the injury was classified as a Gustilo-Anderson Grade 3A open fracture, warranting urgent surgical intervention.
The patient underwent initial debridement and external fixation within 6 hours of injury. Cultures taken intraoperatively grew *Staphylococcus aureus* within 48 hours. Despite early empirical antibiotic coverage, the patient developed wound discharge by day 5, requiring a second debridement. Over the course of the next four weeks, inflammatory markers (CRP, ESR) remained elevated, and the wound showed signs of chronic infection, including sinus formation.

**Progression to Infected Non-Union**

At 5 months post-injury, the patient presented with persistent pain, inability to bear weight, and purulent drainage from the surgical site. Repeat radiographs showed a lack of callus formation, sclerotic bone ends, and lucency at the fracture site, indicating non-union. MRI revealed osteomyelitis involving the fracture ends, and CT confirmed a 6.5 cm segmental bone defect.

**Laboratory investigations showed**

- **CRP:** 27 mg/L
- **ESR:** 64 mm/hr
- **WBC:** 11,800 /µL
- **Hemoglobin:** 11.2 g/dL

A diagnosis of infected non-union of the femoral shaft was made based on clinical, radiological, and serological evidence. The external fixator remained in place, but was inadequate for promoting healing or controlling infection. Microbiological analysis continued to show *Staphylococcus aureus* sensitive to vancomycin.

The Non-Union Scoring System (NUSS) score was calculated as 44/100, suggesting a biologically and mechanically unfavorable environment for healing, and guiding the decision for surgical reconstruction.

**Definitive Surgical Reconstruction Using Non-Vascularized Fibular Graft**

Once clinical signs of infection were controlled and laboratory values showed declining inflammatory markers (CRP down to 12 mg/L), the patient underwent definitive surgery for reconstruction using a non-vascularized fibular graft and internal fixation.

**Intraoperative Findings and Procedures**

- Extensive fibrosis and necrotic bone were encountered around the fracture site.
- Approximately 2.5 cm of proximal and distal bone ends were debrided until healthy, bleeding bone was exposed.
- A 6.5 cm bone gap was confirmed intraoperatively.
- A 10 cm segment of the ipsilateral fibula was harvested through a separate lateral approach with care to preserve the proximal and distal tibiofibular joints.
- The fibular graft was shaped and inserted into the femoral gap.
- Autologous cancellous bone grafts from the iliac crest were packed around the fibular strut.
- The construct was stabilized using a 12-hole 4.5 mm locking compression plate (LCP).
- Cerclage wires were used to augment fixation and ensure the fibular graft remained seated within the intramedullary canal.
- A closed suction drain was inserted and removed on postoperative day 2.

**Postoperative Course and Follow-up**

**In-Hospital Recovery (First 2 Weeks)**

- IV antibiotics (vancomycin and levofloxacin) were continued based on microbial sensitivities.
- The surgical wound healed uneventfully with no signs of dehiscence or drainage.
- Postoperative radiographs showed proper alignment, graft integration, and fixation.

**Early Rehabilitation (2 Weeks to 6 Weeks)**

- The patient was maintained non-weight-bearing for 6 weeks.
- Range of motion (ROM) exercises for the hip and knee were initiated from postoperative day 3.
- Muscle strengthening and quadriceps activation exercises were introduced by week 4.
- CRP dropped to 5 mg/L by the end of week 6.

**Intermediate Follow-Up (6 Weeks to 6 Months)**

Serial radiographs at 6-week intervals were used to assess graft incorporation and callus formation.

- **6 Weeks:** Early callus formation was visible on the lateral cortex. Fibular graft remained structurally intact. No signs of infection recurrence.
- **3 Months:** Bridging callus seen on two cortices. The patient began partial weight-bearing with assistance.
- **4.5 Months:** Bridging visible on three cortices. Clinical union suggested by decreased pain and improved mobility. Full weight-bearing allowed with walker support.

**Laboratory parameters at 4.5 months**

- **CRP:** 2.1 mg/L
- **ESR:** 18 mm/hr
- **WBC:** 7,400 /µL

**Radiographic and Clinical Union (10 Months Post-Surgery)**

**At 10 months post-reconstruction**

- Radiographs demonstrated solid union with bridging callus in all cortices.
- The fibular graft showed signs of remodeling and integration into the host femur.
- No signs of loosening, plate failure, or graft resorption.
- The patient was ambulating independently with a near-normal gait pattern.
- No recurrence of infection or sinus formation was noted.
- The surgical wounds and donor site remained well-healed.

**Functional Outcomes**

**Limb Function**

- **Hip ROM:** Flexion 0–125°, extension 0–10°
- **Knee ROM:** Flexion 0–115°, extension 0°
- **Limb Length Discrepancy (LLD):** <1 cm, clinically negligible
- **LEFS (Lower Extremity Functional Scale):** 72/80, indicating near-complete functional restoration

**Pain and Activity**

- **VAS Pain Score:** 1/10 at rest, 2/10 during prolonged walking
- Return to daily activities, including cycling and stair climbing, without assistance
- No restrictions in self-care or occupational activities at 12 months

**Donor Site Morbidity**

- No significant complications at the fibula harvest site
- Full ankle range of motion preserved

- No sensory deficits in the distribution of the superficial peroneal nerve
- No ankle instability or valgus deformity reported
- The patient resumed weight-bearing on the donor limb within 3 weeks post-surgery

**Final Outcome (12-Month Follow-up)**
- **Radiological Outcome:** Complete bony union without complications
- **Clinical Outcome:** No infection, excellent limb function, and full return to work
- **Functional Score (LEFS):** 75/80
- **Patient Satisfaction:** High – reported full satisfaction with the outcome and quality of life
- No further surgical intervention was required

**Summary of Key Outcomes**

| Parameter | Outcome |
|---|---|
| Time to Union | 10 months |
| Bone Gap Length | 6.5 cm |
| Graft Used | Non-vascularized fibular autograft |
| Infection Control Achieved | Yes (no recurrence during follow-up) |
| Limb Length Discrepancy | <1 cm (clinically insignificant) |
| LEFS Score (12 months) | 75/80 |
| Return to Work | Yes, full-time |
| Donor Site Morbidity | None significant |
| Number of Surgeries | 5 totals (including debridements) |
| Hospital Stay (post-reconstructive) | 12 days |

**Discussion**
The successful management of an infected non-union of a Grade 3A open femoral shaft fracture remains a significant orthopedic challenge, particularly in resource-limited settings. This case illustrates the feasibility and effectiveness of using a non-vascularized fibular graft combined with internal fixation in reconstructing a large femoral diaphyseal defect. The patient achieved union at 10 months with near-complete restoration of limb function, no infection recurrence, and minimal donor site morbidity.

**Interpretation of Results**
The healing of long bone non-unions depends on addressing three fundamental principles: mechanical stability, biological enhancement, and infection control (Giannoudis *et al*., 2005) [4]. In this case, each of these principles was systematically addressed in a staged fashion:
- Infection control was achieved through radical debridement, extended antibiotic therapy guided by culture sensitivities, and the removal of infected hardware.
- Mechanical stability was provided through the application of a rigid locking compression plate, offering a load-sharing environment favorable to union.
- Biological augmentation was accomplished by implanting an autologous, non-vascularized fibular graft and packing cancellous bone chips around it, enhancing osteoconduction and osteoinduction.

The time to union—10 months—falls within the expected range for complex non-unions treated with grafting (Calori *et al*., 2011) [1]. The patient's Lower Extremity Functional Scale (LEFS) score of 75/80 at 12 months indicated near-normal functionality, consistent with other reports utilizing autologous fibular grafts in femoral reconstruction (El-Gammal *et al*., 2002) [3].

**Comparison to Existing Literature**
Management strategies for infected femoral non-unions vary widely. Traditional methods include:
- Masquelet technique (induced membrane),
- Ilizarov method (distraction osteogenesis), and
- Vascularized fibular grafting.

The Masquelet technique, though biologically favorable due to the induced membrane, requires a two-stage procedure and is often less effective in large segmental defects >5 cm (Pelissier *et al*., 2004). In contrast, distraction osteogenesis using the Ilizarov method allows for bone lengthening and infection control simultaneously but requires prolonged use of external fixators, which can be uncomfortable for patients and prone to complications like pin tract infections (Paley, 1990).
Vascularized fibular grafts are ideal for reconstructing large segmental defects due to their intrinsic blood supply, which enhances healing, especially in avascular or infected environments (Pho *et al*., 1988). However, they require microsurgical expertise and longer operative times, making them less accessible in many settings.
Non-vascularized fibular grafts, as used in this case, provide an excellent alternative for bridging large defects, particularly in settings where microsurgical capability is limited. They are mechanically strong, osteoconductive, and relatively easy to harvest. Several studies have reported high union rates using this method in femoral reconstructions, with acceptable complication rates and good functional outcomes (Jain *et al*., 2010; Tscherne *et al*., 2000) [5].
In our case, the graft successfully bridged a 6.5 cm defect, consistent with studies that suggest non-vascularized fibular grafts are suitable for defects up to 6–8 cm (Myerson *et al*., 2001) [6]. The graft showed radiological incorporation and remodeling by 10 months, supporting the literature that non-vascularized grafts, when adequately fixed and biologically supported, can perform similarly to vascularized grafts in select scenarios.

**Advantages of the Approach Used**
- **Simplicity and feasibility:** The procedure does not require microsurgical equipment or skills, allowing broader application.
- **Structural integrity:** The fibular graft is strong enough to support partial load during healing.
- **Low donor site morbidity:** No significant complications were noted at the donor site, corroborating studies that show minimal long-term effects from fibular harvest (Delloye *et al*., 2007) [2].
- **Cost-effectiveness:** Compared to limb-lengthening or vascularized grafts, this method reduces costs and surgical time.

**Limitations and Challenges**
Despite its advantages, the technique is not without limitations:
- **Delayed union:** Healing is often slower than with vascularized grafts due to the lack of intrinsic vascularity.

- **Graft resorption:** Although not observed in this case, there is a known risk of graft resorption, especially in infected environments (Calori *et al*., 2011) [1].

- **Length mismatch:** In larger defects, the fibular graft may not be sufficient, necessitating additional graft material or staged reconstruction.

Additionally, the success of the fibular graft technique relies heavily on the quality of the host bed, proper mechanical fixation, and meticulous infection control. Inadequate debridement or early weight-bearing may compromise outcomes.

**Implications for Clinical Practice**

This case contributes valuable insight into the role of non-vascularized fibular grafting as a viable, resource-conscious option in treating infected femoral non-unions. In centers where microsurgery or advanced reconstruction methods are unavailable, this technique allows orthopedic surgeons to achieve excellent results with proper planning and execution.

Furthermore, this case emphasizes the importance of multidisciplinary collaboration, including orthopedic surgeons, infectious disease specialists, and physiotherapists. Without coordinated care, outcomes in complex non-unions can be suboptimal.

**Future Directions**

More robust prospective studies and randomized controlled trials are needed to compare non-vascularized fibular grafts directly with other reconstruction techniques. Additional investigation into adjunctive therapies—such as bone morphogenetic proteins (BMPs), PRP, and synthetic scaffolds—could also enhance outcomes and reduce healing times.

**Conclusion**

Infected non-union of the femoral shaft following a Grade 3A open fracture represents one of the most demanding scenarios in orthopedic trauma management. This case demonstrates that successful union and functional recovery can be achieved using a non-vascularized fibular autograft, combined with meticulous debridement, rigid internal fixation, and comprehensive postoperative rehabilitation.

The patient in this case achieved complete radiological union at 10 months, excellent functional recovery (LEFS score of 75/80), and no recurrence of infection. The fibular graft successfully bridged a 6.5 cm femoral defect with no significant donor site complications, affirming its utility in such challenging reconstructions.

Compared to more complex and resource-intensive options such as vascularized grafting or distraction osteogenesis, the method used in this case offers a cost-effective, practical solution for reconstructing large femoral defects in infected fields, especially in resource-limited settings.

The successful outcome reinforces key principles of non-union management: eradication of infection, restoration of mechanical stability, and biological augmentation. It also highlights the importance of individualized, staged treatment planning in complex orthopedic trauma.

Future research and long-term follow-up studies are necessary to better define the indications, limitations, and optimal protocols for using fibular grafts in non-union management. Nonetheless, this case adds to the growing evidence that with appropriate technique and multidisciplinary care, non-vascularized fibular grafting remains a reliable and effective tool in the orthopedic reconstructive armamentarium.

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