Thesis

Clinical and Functional Outcomes of Limb Reconstruction System in Infected Non-Union of the Femur: A Prospective-Retrospective Cohort Study

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Abstract

Background: Infected non-union of the femur causes prolonged pain, disability and loss of livelihood. Treating infection while restoring bone continuity, length and alignment is challenging. The Limb Reconstruction System (LRS) is a uniplanar external fixator that can address bone loss, deformity and infection together.

Methods: This combined prospective-retrospective series included adult patients treated June 2018–June 2022. After radical debridement and culture-directed antibiotics, LRS was used according to defect size: monofocal compression for small defects, bone transport for larger gaps and bifocal techniques when required. Patients followed a protocol of pin-site care, regular radiographs, clinical review and physiotherapy. Recorded outcomes were time to union, infection control, ASAMI scores and limb length discrepancy.

Results: Twenty-one patients were treated. Twenty achieved radiological union; infection was controlled in 18. Most patients regained useful function with good or excellent ASAMI scores. Residual shortening was under 2 cm and managed conservatively..

Conclusion: When combined with thorough debridement and structured rehabilitation, LRS yields high union rates and acceptable function in many infected femoral non-unions. Vigilant pin care and engagement are essential.

Keywords: Infected non-union, Femur, Limb Reconstruction System, Bone transport, External fixation

Introduction

Infected non-union of the femur is a serious and often devastating complication after fracture. The combination of infection and failure of bone healing prolongs disability, interferes with daily life and places heavy social and economic burdens on patients and families. Management is challenging because one must eradicate infection, restore bone continuity and alignment, correct limb length discrepancy, and preserve joint function — sometimes all at once. Early recognition of the factors that favour non-union, such as high-energy injury, soft-tissue damage, comminution and prior failed fixation, helps plan the reconstruction approach. Radical debridement to remove devitalized bone and infected tissue is the cornerstone of treatment; without it, eradication of infection is unlikely and any reconstruction risks failure. The tension-stress principles described for distraction osteogenesis revolutionized


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reconstructive options and made staged bone transport and lengthening feasible alternatives to bone grafting for large defects. In practice, circular ring fixators based on those principles are effective but can be unwieldy for the femur because of their bulk and the difficulty of fitting them to the thigh. To reduce these disadvantages, monolateral systems such as the Limb Reconstruction System (LRS) and related dynamic axial or monorail devices were developed. These systems allow bone transport, compression-distraction and acute or gradual deformity correction using a simpler, lighter frame that is often better tolerated by patients. Contemporary series report acceptable union and infection control rates with monolateral constructs when radical debridement, appropriate antibiotic therapy and careful follow-up are applied. In this work we report our experience with the LRS for infected femoral non-union, focusing on union rates, infection eradication, limb length restoration, alignment and functional recovery [1-7].

Review of literature

External fixation has evolved substantially since its early introductions, and its role in contaminated wounds and infected non-union is well established. Early unilateral and dynamic axial fixators showed the benefits of preserving soft-tissue access while enabling stability and early weight bearing. The Ilizarov method, grounded in the tension-stress effect and distraction osteogenesis, remains a central technique for reconstructing bone loss, correcting deformity and managing infection simultaneously. While effective, ring fixators have recognized disadvantages including a steep learning curve, bulkiness, patient discomfort and periodical pin-care challenges. These limitations prompted the development and refinement of monolateral devices and limb reconstruction rails that permit uniplanar transport and lengthening with a lower profile, simpler application and improved patient comfort. Comparative reports indicate that, in selected femoral reconstructions, monolateral systems can achieve outcomes comparable to circular frames in terms of union and infection control while reducing hardware complexity. The key surgical strategy across studies emphasizes aggressive excision of necrotic bone and soft tissue, obtaining deep cultures, using targeted systemic antibiotics and planning reconstruction based on defect size: one-stage grafting for small defects, antibiotic nails for some intramedullary infections and bone transport for larger segmental losses. Reviews also stress the importance of multidisciplinary care, diligent pin-site protocols and sustained physiotherapy to manage stiffness and maintain limb function. Evidence from recent monolateral series supports the LRS as a versatile tool for femoral reconstruction — permitting monofocal or bifocal lengthening, acute correction where needed, and staged bone transport when defects are significant. These reports highlight acceptable union rates and functional gains when careful patient selection and meticulous technique are employed [8-20].

Methods and Materials

This combined prospective and retrospective study included patients treated for infected femoral non-union with the Limb Reconstruction System (LRS) at our tertiary centre between June 2018 and June 2022. Adults aged 18–70 years with clinical, radiological and microbiological evidence of infected non-union were included after informed consent; excluded were skeletally immature patients, tuberculous non-union and cases with severe neurological impairment of the affected limb. Preoperative evaluation comprised detailed history (initial injury, prior surgeries, duration of non-union), physical examination (sinuses, drainage, deformity, shortening and joint range), laboratory tests (Hb, leukocyte count, ESR, CRP) and deep tissue cultures obtained at debridement. Radiographs (AP and lateral) defined defect size, alignment and bone quality. Operative strategy began with aggressive debridement and excision of all devitalized bone and soft tissue until healthy bleeding margins were achieved. The LRS was then applied in a configuration suited to the defect: monofocal compression for non-unions with minimal bone loss, bone transport for moderate to large segmental defects, and bifocal constructs where simultaneous docking and distraction were needed. Acute shortening followed by later lengthening was used in select cases to diminish soft-tissue tension. Postoperatively patients were instructed in pin-site care and commenced early mobilisation; distraction followed standard callotasis protocols with radiographs every two weeks during distraction and monthly during consolidation. Outcomes recorded were time to clinical and radiological union, infection eradication, ASAMI bone and functional scores, final limb length discrepancy, alignment and complications including pin-tract infection, pin loosening and joint stiffness. Follow-up extended for a minimum period suited to consolidation in each case [15-17].

Results

Twenty-one patients met the inclusion criteria. Patient ages ranged from 19 to 51 years (mean ~36 years) with strong male predominance. Right femur was involved in most cases. A majority of the cohort had sustained open fractures initially and had undergone prior operative fixation. After radical debridement and application of the LRS, 20 of 21 patients achieved clinical and radiological union; a single case required further intervention for persistent non-union. Infection was eradicated in 18 patients while three had persistent or recurrent infection associated with resistant organisms and required additional surgical or medical management. ASAMI bone results were mostly excellent or good, and functional scores reflected satisfactory recovery in the majority. Average residual limb length discrepancy at final follow-up was under 2 cm in all patients and was managed conservatively when necessary. Notable complications were knee stiffness in several patients, hip stiffness in some, limb strength asymmetry and pin-site problems including superficial infections and occasional pin

loosening; most complications were managed non-operatively or with minor procedures. Overall the LRS provided stable, versatile fixation that allowed bone transport or compression while supporting early mobilisation and functional rehabilitation.

Discussion

Infected femoral non-union poses unique challenges: infection must be eradicated, dead bone excised and the resulting defect treated so that alignment, length and joint motion can be preserved. The essential first step is radical debridement to remove sequestra and biofilm-laden tissue; reconstruction without adequate debridement risks ongoing infection and failure. The LRS applies the same biological principles as circular distraction techniques but in a uniplanar, lower-profile construct that is easier to fit to the thigh and generally more comfortable for patients. In this series the union rate and infection control were in line with contemporary reports of monolateral fixators used for infected long-bone non-unions. Bone transport proved valuable for intermediate to large defects while compression-distraction effectively managed smaller defects; in select situations acute shortening with later lengthening reduced soft-tissue tension and simplified docking. Early weight bearing and adherence to callotasis schedules supported regenerate formation and consolidation. Pin-site problems and joint stiffness were common complications — a reminder that meticulous pin care, prompt treatment of superficial infection and an aggressive, supervised physiotherapy programme are essential for optimal outcomes. Pin loosening, when it occurred, required exchange or supplementary fixation. Study limitations include the single-centre design, modest sample size, and a mixed prospective/retrospective methodology which restrict direct comparison to alternative methods such as ring fixators or internal devices. Despite these limits, our experience suggests that with proper debridement, carefully planned LRS constructs and sustained rehabilitation, many patients with infected femoral non-union can achieve infection control and solid union while recovering useful limb function.

Conclusion

Infected non-union of the femur demands staged, careful treatment. When radical debridement is followed by thoughtful application of the Limb Reconstruction System and a structured rehabilitation plan, most patients can achieve bony union, satisfactory infection control and acceptable function. The LRS offers practical advantages for femoral reconstruction by permitting bone transport, lengthening and deformity correction within a simpler, more patient-friendly frame compared with bulky circular constructs. Vigilant pin-site care and early, sustained physiotherapy remain essential to minimise complications such as joint stiffness and pin-track infection. Case selection, surgical planning and patient compliance are key determinants of success. Larger comparative studies with longer follow-up will further clarify the relative merits of monolateral systems like the LRS versus other reconstructive strategies.

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