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Ilizarov-Based Segmental Transport for Reconstruction of an Infected Post-Chondrosarcoma Tibial Defect Following Failed Allograft: A Case Report

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Abstract-- Chondrosarcomas, malignant bone tumors characterized by a cartilaginous matrix, pose significant treatment challenges due to their resistance to chemotherapy and the high risk of complications following surgical resection. This case report describes the successful management of a 61-year-old male with a 9 cm tibial defect resulting from an infected, failed massive allograft following low-grade chondrosarcoma resection. A two-stage surgical protocol was employed, initially focusing on infection control and debridement, followed by segmental bone transport using the Ilizarov method for reconstruction. An antibiotic-loaded cement spacer was utilized to manage dead space and chronic infection. Post-operative follow-up demonstrated successful bone consolidation, preservation of tibial alignment, and absence of infection or tumor recurrence over two years. This case underscores the efficacy of a staged approach combining bone transport and antibiotic spacers in managing complex tibial defects in orthopedic oncology.

Keywords: Chondrosarcoma, Bone transport, Osteomyelitis, External fixator

1. Introduction

Segmental bone defects resulting from tumor resection remain one of the most demanding challenges in orthopedic oncology. Wide en bloc excision is essential for achieving local tumor control; however, it often leaves extensive skeletal voids that

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compromise limb stability, function, and biomechanics.¹ Successful reconstruction must therefore restore both structural integrity and biological potential for long-term durability. Over the years, multiple techniques—including massive allografts, vascularized bone transfers, distraction osteogenesis, and endoprosthetic replacement—have been employed, each with distinct advantages and limitations.^{2,3} Despite advances in surgical planning and biomaterials, optimal management of these large defects continues to be debated, underscoring the need for further research and innovation in this complex field.

The challenges associated with reconstructing segmental defects after tumor resection underscore the importance of developing effective surgical strategies. Techniques such as the Ilizarov method for distraction osteogenesis have shown promise in addressing these complex cases^{4,5}. Additionally, managing complications, such as infections, is critical to the success of these procedures^{5,6}. This highlights the need for ongoing research and refinement of surgical techniques to enhance patient outcomes.

We suggest that bone transport is a reliable method to fill massive bone defects after complicated oncological surgery.

2. Case Report

A sixty-one year old male presented with a two-year history of a chronic non-healing wound and a persistent fistula overlying the surgical scar on his left tibia. The patient had previously undergone wide resection and reconstruction with a massive bone graft and internal fixation, specifically plating, for a low-grade chondrosarcoma of the proximal left tibia. Clinical findings included persistent drainage, erythema, and soft tissue induration at the surgical site. Microbiology confirmed the presence of *Staphylococcus hominis* via Polymerase Chain Reaction. Radiological findings demonstrated implant failure, specifically a broken internal plate, non-union at the allograft-host junction, and osteolysis consistent with chronic osteomyelitis.

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Fig 1 (AP and lateral roentgenography on admission: Implant fracture + nonunion)

The operative strategy involved a two stage approach. Stage one focused on infection control and defect preparation. The initial surgery focused on aggressive debridement. The broken plate and all necrotic and infected bone, including the failed allograft segment, were resected. This resulted in a critical tibial bone defect measuring nine centimeters. An antibiotic loaded cement spacer was placed to control the infection and death space management. A temporary external fixator was applied for stabilization.

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Fig 2 (AP and lateral roentgenography after stage one: resection of the affected tibial segment - 9cm D1, bone cement spacer, and stabilization with a temporary external fixator)

During the second stage segmental bone transport over nail, was performed after infection markers normalized. A reamed intramedullary nail was inserted to provide axial mechanical stability and maintain alignment. A circular external fixator of the

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Ilizarov type was then mounted. A proximal osteotomy was performed to create a mobile bone segment - the transported segment.

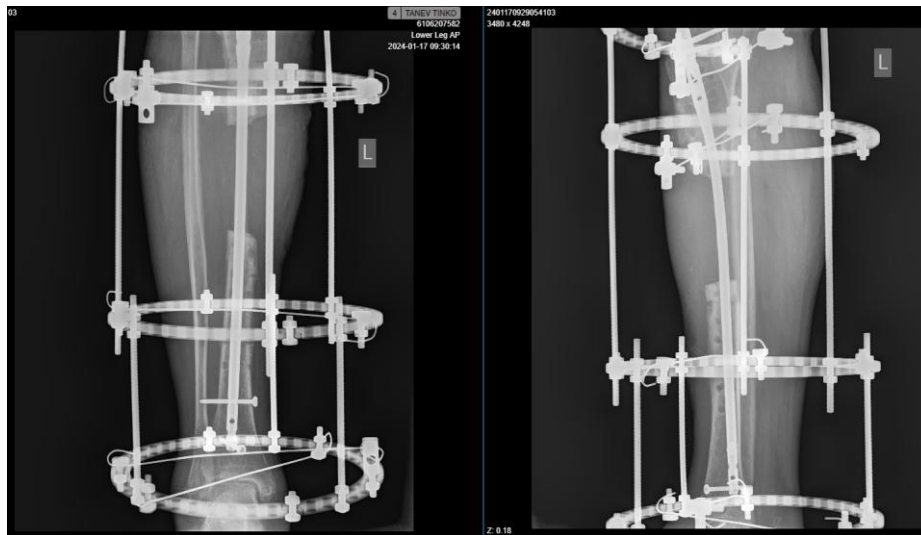


Fig 3 (AP and lateral roentgenography after stage two)

Bone transport was initiated on day ten post-operatively at a rate of one millimeter per day, typically divided into four zero point twenty-five millimeter increments. The transport segment was gradually translated distally, closing the nine centimeter defect.

Regarding the outcome and follow up, the patient underwent a total external fixation duration resulting in an External Fixation Index of thirty-five point fifty-five days per centimeter. Stable regenerate bone consolidation was achieved at the docking site and within the distraction gap. The tibial alignment was preserved. There was no recurrence of infection or tumor throughout the follow up period. The docking site achieved union following the application of bone glass and a plate, to accelerate consolidation. Crucially, at two years of follow-up, there were no signs of infection or tumor recurrence.

3. Discussion

Infection following malignant bone tumor surgery constitutes one of the most severe complications, with reported incidence rates three to ten times higher than those observed in general orthopedic surgery⁵. A heightened risk stemming from the necessity for extensive surgical reconstruction involving bone, ligaments, tendons, nerves, and vessels, prolonged operative times, and the frequent use of biomaterials⁶. Furthermore, while chondrosarcoma patients often lack the effect of adjuvant therapy, they are subject to comparable or even higher infection rates, especially in locations requiring extensive resection.⁷

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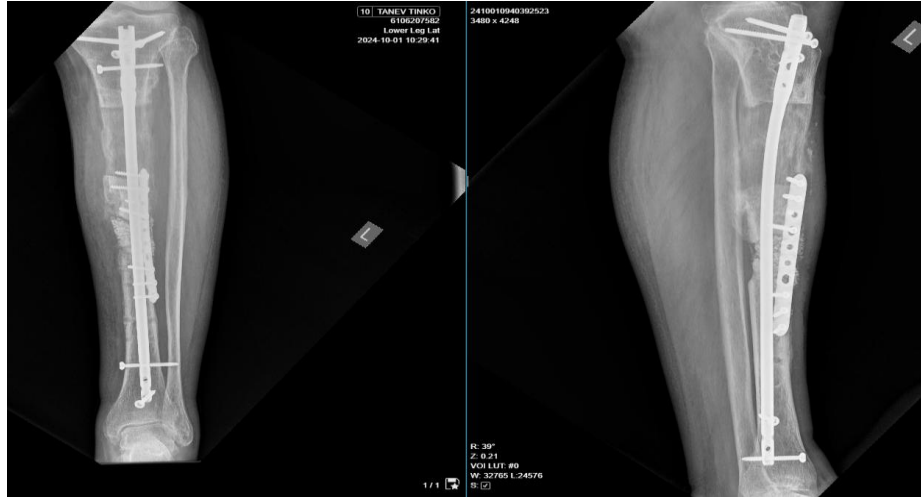


Fig 4 (Two years follow up roentgenography - signs of consolidation)

The successful management of such complex cases underscores several critical principles in orthopedic oncology and bone reconstruction. The necessity of a two-stage surgical protocol for infected non-union with bone loss is affirmed, particularly given the elevated risk of infection in post-oncologic settings⁸⁻⁹. Our case demonstrates the challenge posed by biofilm-forming Coagulase-Negative Staphylococci which necessitates the complete removal of all foreign material (broken implants) and aggressive debridement to achieve infection and biofilm eradication.⁹

A critical element contributing to the successful outcome in this infected non-union case was the management of the significant residual void following débridement. This involved the strategic use of an antibiotic-loaded cement spacer between Stage 1 and Stage 2, which addresses both dead space and chronic infection, forming the cornerstone of the Masquelet technique. The widely accepted standard for this is the two-stage protocol, often referred to as the Belfast technique, as initially described by McNally et al.¹⁰ This staged approach is beneficial because it minimizes surgical complexity and patient morbidity by isolating the necessary procedure for infection eradication from the subsequent process of restoring skeletal structure and function. Applying an antibiotic-loaded cement spacer has become the most common strategy to eliminate dead space, delay bone reconstruction and control over infection.¹¹

Following the successful eradication of the chronic infection and dead space management using the antibiotic-loaded cement spacer the subsequent challenge was the reconstruction of the 9 cm critical tibial bone defect. For reconstruction, traditional methods like autologous corticocancellous bone grafting are generally limited to small defects, typically less than 4cm in size.² Another option, the vascularized fibular graft, can be technically demanding to perform. Furthermore, the difference in cross-sectional diameter between the tibia and the fibula (mismatch) contributes to a high rate of refracture, which restricts vascularized fibular graft's clinical utility.²

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In contrast, Ilizarov bone transport is a versatile and highly recommended technique for managing tibial nonunion, particularly those involving substantial bone loss. Evidence supporting its efficacy is robust, as demonstrated by Laursen et al., who reported high rates of successful outcomes in a series of 16 patients, characterized by an average external fixation frame time of 182 days and critically, the absence of infection recurrence or subsequent refracture across the entire cohort, affirming its established academic standing as a definitive reconstructive procedure.¹² . Bone transport excels at providing a large volume of bone with a preserved blood supply to fill the defect. Beyond simply reconstructing the bone, this method is also capable of concurrently correcting associated issues, including deformity, limb shortening, soft tissue deficits, and adjacent joint contractures¹³.

However, these benefits are counterbalanced by significant disadvantages. Prolonged external fixation time represents the major drawback, contributing to patient discomfort, psychological burden, and delayed rehabilitation^{14,15}. Frame-related complications—most commonly pin-tract infections—are frequent and require vigilant monitoring¹⁵. Additional challenges include delayed consolidation of regenerate bone, docking-site nonunion often necessitating secondary procedures, and the need for high patient compliance over an extended treatment period¹⁶. Consequently, while Ilizarov bone transport is an effective and versatile reconstructive strategy after tibial osteomyelitis, careful patient selection and experienced multidisciplinary management are essential to optimize outcomes and mitigate its inherent limitations.

Bone transfer creates a docking site when the segment arrives at its destination. As union is frequently affected by interposed fibrous tissue¹⁴, achieving successful consolidation requires active intervention, achieved in this case through targeted bone grafting (bone glass) at the junction to facilitate the final bony union. Despite the usage of different methods the rate of delayed union or non-union on the docking site may reach 74%.¹⁷ Lovisetti et al. compared union at the docking site using closed versus open strategies, and found that index lengthening with a closed strategy was 2.04 months/cm, while that with an open strategy was 1.73 month/cm¹⁸. In the context of this specific case, the surgical approach yielded an External Fixator Index of 35.55/cm. The use of bioglas on the docking site significantly accelerated the consolidation process.

According to the Universal Long Bone Defect Classification described by Solomin et al., the tibial defect in our patient was classified as 4T2 C3.3. Following successful infection eradication after the first stage, there was no residual skin or soft-tissue defect at the time of reconstruction. Given this classification, the absence of a soft-tissue deficit after the second stage, and the need for durable biological reconstruction of a critical-sized defect, distraction osteogenesis using the Ilizarov technique was considered the most appropriate reconstructive option.¹⁹

5. Conclusion

This case report details the successful two-stage limb salvage protocol for a 9 cm tibial defect stemming from an infected, failed massive allograft following chondrosarcoma resection. The Ilizarov bone transport combined with an antibiotic spacer is a safe and effective method for threatening tibial nonunion.

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