ADVANCED BONE TRANSPORT FOR MANAGING POST-TRAUMATIC TIBIAL NON-UNION: A CASE REPORT

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ABSTRAK

Non-union tibia pascatrauma merupakan kondisi ortopedi kompleks yang sering kali memerlukan teknik bedah tingkat lanjut untuk mencapai hasil yang sukses. Kondisi ini dapat secara signifikan mengganggu kualitas hidup dan aktivitas sehari-hari karena nyeri kronis dan keterbatasan fungsional, yang menyebabkan prognosis yang buruk jika tidak ditangani dengan tepat. Seorang wanita berusia 38 tahun datang dengan non-union tibia kiri setelah kecelakaan lalu lintas. Penanganan awal meliputi reduksi terbuka dan fiksasi eksternal (OREF) untuk menstabilkan fraktur. Namun, pencitraan tindak lanjut menunjukkan penyembuhan tulang yang tidak memadai, ditandai dengan pembentukan kalus yang buruk dan cacat tulang yang signifikan. Karena kegagalan proses remodeling tulang alami, intervensi sekunder menggunakan teknik transportasi tulang dilakukan. Metode ini, berdasarkan osteogenesis distraksi, melibatkan transportasi segmen tulang secara bertahap untuk mendorong pembentukan tulang baru dan menutup cacat. Prosedur transportasi tulang, dikombinasikan dengan fiksasi eksternal, secara efektif mengatasi cacat tulang besar yang diakibatkan oleh kegagalan OREF. Sepanjang tindak lanjut, regenerasi tulang progresif diamati, dengan pasien melaporkan perbaikan baik dalam nyeri maupun fungsi. Kasus ini menyoroti pentingnya strategi bedah adaptif untuk menangani non-union dan peran transportasi tulang dalam mengobati fraktur tibialis yang kompleks.

Kata kunci: Transportasi tulang, osteogenesis distraksi, fiksasi eksternal, trauma ortopedi, non-union tibialis.

ABSTRACT

Post-traumatic tibial non-union is a complex orthopedic condition that often requires advanced surgical techniques to achieve successful outcomes. This condition can significantly impair quality of life and daily activities due to chronic pain and functional limitations, leading to a poor prognosis if not properly managed. A 38-year-old female presented with non-union of the left tibia following a road traffic accident. Initial management included open reduction and external fixation (OREF) to stabilize the fracture. However, follow-up imaging revealed inadequate bone healing, characterized by poor callus formation and a significant bone defect. Due to the failure of the natural bone remodeling process, a secondary intervention using the bone transport technique was undertaken. This method, based on distraction osteogenesis, involved gradual bone segment transport to promote new bone formation and close the defect. The bone transport procedure, combined with external fixation, effectively addressed the large bone defect that resulted from the failure of OREF. Throughout follow-up, progressive bone regeneration was observed, with the patient reporting improvements in both pain and function. This case highlights the importance of adaptive surgical strategies for managing non-union and the role of bone transport in treating complex tibial fractures.

Keywords: *Bone transport, distraction osteogenesis, external fixation, orthopedic trauma, tibial non-union.*

INTRODUCTION

Post-traumatic non-union of the tibia presents significant challenges, particularly when initial interventions fail to stimulate adequate bone healing. Tibial fractures are common in orthopedic trauma, and while open reduction and external fixation (OREF) are frequently employed, complications like non-union can arise. In some cases, despite proper stabilization with external fixation, the natural process of callus formation and remodeling may not occur

effectively. This failure can leave the patient with persistent bone defects and continued functional impairment, highlighting the limitations of relying solely on the body's natural bone healing processes. The failure of callus remodeling necessitates more advanced surgical interventions to promote proper bone healing and recovery.(Hadeed et al., 2023; Jiang et al., 2021; Tripathy et al., 2021)

When callus formation and remodeling fail to adequately heal the bone, bone transport, a technique developed by Gavriil Ilizarov, becomes an essential alternative. Bone transport uses the principle of distraction osteogenesis to stimulate new bone formation by gradually transporting bone segments across a defect with the help of an external fixation device. This method enables controlled and progressive bone regeneration in areas where natural healing processes are insufficient. Although bone transport can be associated with complications like pin-site infections, it is recognized as one of the most effective techniques for treating large bone defects, particularly in cases where OREF alone does not achieve the desired outcomes.(Jiang et al., 2021; Pentela, 2023; Zaman et al., 2017)

In the case presented, the patient initially underwent OREF for a tibial fracture, but subsequent follow-up revealed that callus formation and remodeling had not progressed as expected. Imaging showed a large bone defect that persisted despite the initial surgery, and natural healing was deemed insufficient to resolve the issue. As a result, bone transport was selected as the next step in the treatment plan. This decision was based on the need for a more controlled and active approach to bone regeneration, addressing the limitations of the previous intervention. The implementation of bone transport in this case allowed for gradual bone regeneration and eventual union, illustrating the success of this technique in managing complex non-union cases where callus remodeling fails. This sequential approach highlights the importance of adapting treatment strategies to the patient's specific needs and the challenges posed by non-union.(Khaled et al., 2022; Oh et al., 2015; Papagiannis et al., 2022) The case underscores the value of bone transport in cases where the body's natural healing processes are inadequate, emphasizing the role of advanced surgical techniques in achieving optimal outcomes in orthopedic trauma care.

CASE REPORT

The patient, a 38-year-old female, presented with post-traumatic non-union of the left tibia following a road traffic accident eight months prior. She had undergone an initial procedure of open reduction and external fixation (OREF) to stabilize the fracture. However, her main concern remained persistent pain and difficulty with weight-bearing due to inadequate bone healing. She had no significant family or psychosocial history, and her past medical history was unremarkable. On the first day post-OREF, radiological imaging confirmed a complete fracture of the left tibia and fibula with significant displacement and soft tissue swelling.

Figure 1. Severe trauma to the lower leg, characterized by multiple lacerations and exposed tissue around the ankle and foot.

Despite the initial intervention, follow-up imaging revealed poor callus formation and a significant bone defect at the fracture site, leading to a diagnosis of non-union. This failure of natural bone remodeling necessitated further surgical management. Radiographic evaluations consistently showed a persistent gap in the bone structure, with minimal regeneration, indicating that the OREF had failed to stimulate sufficient healing. Laboratory assessments before the subsequent bone transport procedure indicated stable parameters, with slightly improved hemoglobin levels and no signs of systemic infection.

Figure 2. (a) Fracture Completa os Tibia et Fibula Sinistra (b) Malunion following OREF (c) Bone Transport Procedure

Bone transport, based on distraction osteogenesis, was selected as the secondary intervention to address the non-union. This technique involves using external fixation to gradually transport bone segments across the defect, promoting new bone formation. The bone transport approach was chosen for its effectiveness in treating large bone defects, especially when traditional methods, such as OREF, were unsuccessful. Post-operative care included wound management and close monitoring for potential complications, such as infection, a common risk associated with external fixation.

The follow-up outcomes were positive, with progressive bone regeneration observed through imaging and gradual closure of the bone defect. The patient reported significant improvements in both pain and functional ability, which aligned with radiographic evidence of successful bone healing. There were no significant adverse events during the recovery period,

and the patient's post-operative pain was effectively managed with medication. The absence of complications such as infection or hardware failure further underscored the success of the bone transport procedure in addressing the complex tibial non-union.

DISCUSSION

The approach to managing post-traumatic tibial non-union in this case highlights both the strengths and limitations of sequential surgical interventions, particularly the transition from open reduction and external fixation (OREF) to bone transport. One of the key strengths of this approach is its adaptability. When the initial OREF procedure failed to promote adequate callus formation and bone healing, bone transport provided an alternative solution that addressed the persistent bone defect. This sequential strategy allowed for a flexible treatment plan that could be modified based on the patient's evolving condition. However, one of the limitations encountered was the inherent complexity of bone transport, which requires precise surgical execution and carries risks such as pin-site infections and prolonged recovery times. The success of this approach heavily depended on close postoperative monitoring and the patient's adherence to follow-up care.(Deng et al., 2014; Liu et al., 2020; Yin et al., 2015)

The use of bone transport in managing non-union and large bone defects is well-supported in the medical literature. Gavriil Ilizarov's pioneering work on distraction osteogenesis forms the theoretical foundation for this technique, which has been extensively applied in cases where conventional methods fail to achieve bone union. Studies have shown that bone transport, particularly with the use of external fixation, can lead to successful outcomes in complex fractures and non-unions. The method leverages the body's natural ability to regenerate bone, with gradual mechanical distraction stimulating osteogenesis at the fracture site. However, the challenges associated with this technique including a higher incidence of complications such as pin-site infections, delayed union at the docking site, and the psychological burden on patients due to the lengthy duration of treatment.(Hamiti et al., 2022; Hemeda & Essawy, 2022; Looi et al., 2017)

The rationale for choosing bone transport in this case was based on the failure of OREF to stimulate bone healing. Non-union, particularly in weight-bearing bones like the tibia, can lead to significant functional impairment and requires a treatment approach that not only stabilizes the fracture but also promotes bone regeneration. Bone transport was selected because of its ability to address the large bone defect that remained after the failed OREF. This technique allowed for controlled bone lengthening and the gradual closure of the defect, providing a solution where traditional bone grafting methods might not have been sufficient due to the size of the defect and the patient's previous lack of healing. The choice of bone transport was further supported by the patient's overall good health and ability to tolerate the prolonged recovery process associated with this intervention.(Boksh et al., 2022; Nain, 2023; Tang et al., 2023)

Despite the success of the bone transport procedure in this case, the approach highlights the importance of patient selection and close monitoring. Bone transport is a resource-intensive procedure that requires significant patient commitment to follow-up care and rehabilitation. Additionally, the risk of complications, such as infection and delayed union at the docking site, necessitates ongoing vigilance from both the patient and the healthcare team. The decision to proceed with bone transport must therefore be carefully weighed against the potential risks, and alternative treatment options should be considered for patients who may not be able to tolerate the prolonged course of treatment. Nonetheless, when executed properly and in the right patient population, bone transport can achieve remarkable results in cases of complex non-union.(Fahad et al., 2019; Özpolat, 2021; Wani & Syed, 2015)

CONCLUSION

This case underscores the adaptability and effectiveness of bone transport as a solution for managing post-traumatic tibial non-union after the failure of OREF. The primary lesson from this case is the importance of a flexible and individualized approach to treatment, where interventions are tailored to the patient's evolving needs. The success of bone transport in this case emphasizes the potential of this technique to address large bone defects and achieve bone union in challenging cases, provided that the risks are carefully managed and the patient is closely monitored throughout the process.

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