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Salvage of Complex Bimalleolar Ankle Fracture Non-union after Failed Tibiotalocalcaneal and Charnley Arthrodesis using Fibular Strut Grafting and Ilizarov Fixation: A Case Report

Kirubakaran Pattabiraman[1], Anirudh Dwajan[2], Jagdish Menon[1], B Karthikeyan[1], Amber Agarwal[2], Nibras Chereykkatt[1]

Learning Point of the Article:

Complex ankle non-union following failed internal fixation and failed arthrodesis can be successfully managed with fibular strut grafting and Ilizarov circular fixation in carefully selected patients.

Abstract

Introduction: Non-union following ankle fractures is uncommon but can result in significant pain and functional impairment when it occurs. Management becomes particularly challenging after failure of internal fixation and subsequent salvage procedures such as tibiotalocalcaneal (TTC) and Charnley compression arthrodesis. Circular external fixation combined with biological augmentation may offer a limb-salvage option in such complex scenarios.

Case Report: A 39-year-old male presented with persistent pain and inability to bear weight following a bimalleolar ankle fracture initially treated with open reduction and internal fixation at an outside hospital. He developed established non-union and subsequently underwent TTC arthrodesis and Charnley compression arthrodesis at an outside institution; however, both procedures failed to achieve fusion. In view of persistent symptoms and aseptic non-union, limb salvage was undertaken using an autologous fibular strut graft combined with Ilizarov circular external fixation. Progressive consolidation was achieved, and the frame was removed after 6 months. At 1-year follow-up, the patient was pain-free, ambulatory without support, and radiographs confirmed solid union with maintained alignment.

Conclusion: This case demonstrates that even after failed internal fixation and failed arthrodesis, limb salvage is achievable in complex ankle fracture non-unions. The combination of fibular strut grafting and Ilizarov circular external fixation provides a reliable mechanical and biological solution and should be considered in selected young, high-demand patients before amputation.

Keywords: Ankle fractures, fracture non-union, arthrodesis, Ilizarov technique, bone grafting.

Introduction

Non-union following ankle fractures is relatively uncommon owing to the favorable cancellous bone environment and robust vascularity of the ankle region. Reported non-union rates after operative fixation of malleolar fractures range from <1% to approximately 5%, with increased risk in the presence of compromised soft tissues, infection, metabolic comorbidities, smoking, and inadequate mechanical stability. When non-union does occur, it can result in persistent pain, deformity, instability, and substantial functional impairment [1, 2, 3].

Revision internal fixation with or without bone grafting remains the standard treatment for ankle fracture non-unions. However,

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Author's Photo Gallery


Dr. Kirubakaran Pattabiraman


Dr. Anirudh Dwajan


Dr. Jagdish Menon


Dr. B Karthikeyan


Dr. Amber Agarwal


Dr. Nibras Chereykkatt

[1]Department of Orthopaedics, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India,
[2]Department of Orthopaedics, All India Institute of Medical Sciences, Bilaspur, Himachal Pradesh, India.

Address of Correspondence:
Dr. Anirudh Dwajan,
Department of Orthopaedics, All India Institute of Medical Sciences, Bilaspur, Himachal Pradesh, India.
E-mail: anirudhdwajan@gmail.com

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Figure 1: Immediate post-operative anteroposterior and lateral radiographs of the right ankle following open reduction and internal fixation for a bimalleolar fracture, showing plate fixation of the lateral malleolus and screw fixation of the medial malleolus.

repeated surgical interventions may compromise local biology, diminish bone stock, and increase the risk of further failure, thereby limiting the effectiveness of conventional revision strategies [4]. In advanced cases with joint destruction or instability, tibiotalocalcaneal (TTC) arthrodesis is frequently employed as a salvage procedure. Despite its role as a definitive solution, TTC arthrodesis is associated with considerable complication and non-union rates, particularly in revision settings and in patients with poor bone quality or altered biomechanics [5,6].

In cases of failed TTC arthrodesis or when conventional fusion strategies are no longer viable, circular external fixation using the Ilizarov method has emerged as a viable salvage option. The Ilizarov technique provides multiplanar stability, allows controlled compression across non-union sites, and facilitates correction of alignment or soft-tissue issues, thereby improving the likelihood of union [5,7].

The addition of a fibular strut graft – serving both as a mechanical support and a biological stimulus – has been described as an effective adjunct in complex limb salvage settings, especially when bone loss or poor local biology is present [8].

While recent case reports have documented the use of external fixation with bone graft in distal tibial non-union contexts, there is limited literature on its application in ankle fracture non-union following failed internal fixation and failed TTC arthrodesis. This case report describes a patient with a bimalleolar ankle fracture non-union, sequential failure of screw fixation and TTC arthrodesis, and successful salvage using a fibular strut graft combined with Ilizarov ring fixation – demonstrating an effective limb-preserving strategy in a difficult clinical scenario.

Case Report

A 39-year-old male manual laborer presented to our institution with persistent pain and inability to bear weight on his right ankle following multiple surgical interventions performed elsewhere. He had sustained a closed bimalleolar fracture of the right ankle after a road traffic accident approximately 18 months earlier and was initially treated at an outside hospital with open reduction and internal fixation (Fig. 1). The post-operative course was complicated by failure of fracture union, resulting in established bimalleolar non-union (Fig. 2).

Subsequently, at the same outside institution, he underwent TTC arthrodesis as a salvage procedure. However, this also failed to achieve fusion, and the patient continued to experience pain and functional limitation (Fig. 3). A further attempt at salvage using a Charnley compression arthrodesis was performed at the outside hospital, which again failed to result in union (Fig. 4).

The patient then presented to our center for further management. Radiological evaluation demonstrated persistent non-union with ankle deformity (Fig. 5). Clinical examination revealed tenderness around the ankle with pathological

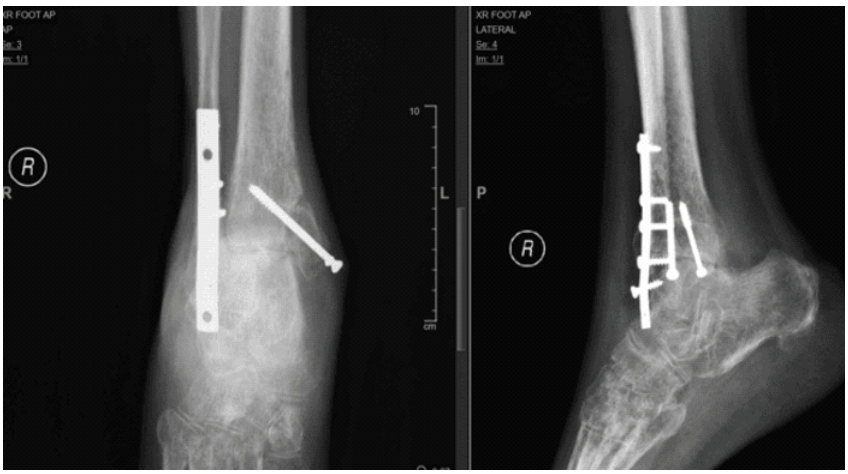

Figure 2: Follow-up anteroposterior and lateral radiographs of the right ankle demonstrating persistent non-union of the bimalleolar fracture with retained internal fixation hardware and features of ankle instability.

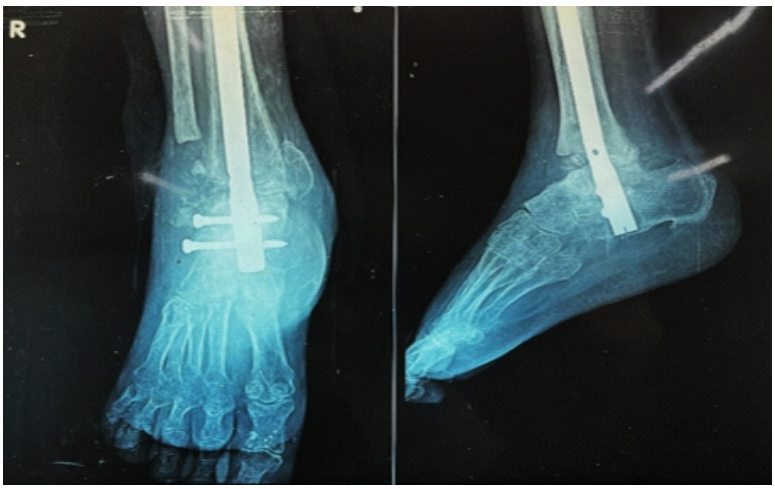

Figure 3: Anteroposterior and lateral radiographs of the right ankle demonstrating failed tibiotalocalcaneal arthrodesis with an intramedullary hindfoot nail in situ and absence of fusion at the ankle and subtalar joints.

mobility. The overlying skin was healthy, with no signs of infection, and distal neurovascular status was intact. Laboratory investigations, including inflammatory markers, were within normal limits, supporting a diagnosis of aseptic non-union.

Given the failure of multiple prior procedures performed elsewhere, a definitive limb-salvage approach was planned at our institution. The patient underwent thorough debridement of the non-union sites followed by reconstruction using an autologous fibular strut graft combined with Ilizarov circular external fixation (Fig. 6). Controlled compression was applied across the arthrodesis site to enhance stability and promote fusion.

The post-operative course was uneventful. Gradual progression to weight bearing was permitted under frame protection. Serial radiographs demonstrated progressive consolidation. The Ilizarov frame was removed after 6 months once union was achieved (Fig. 7). At final follow-up, 1 year after frame removal, the patient was pain-free, ambulating independently without support, and able to perform activities of daily living. Follow-up radiographs confirmed solid union with maintained alignment (Fig. 8).

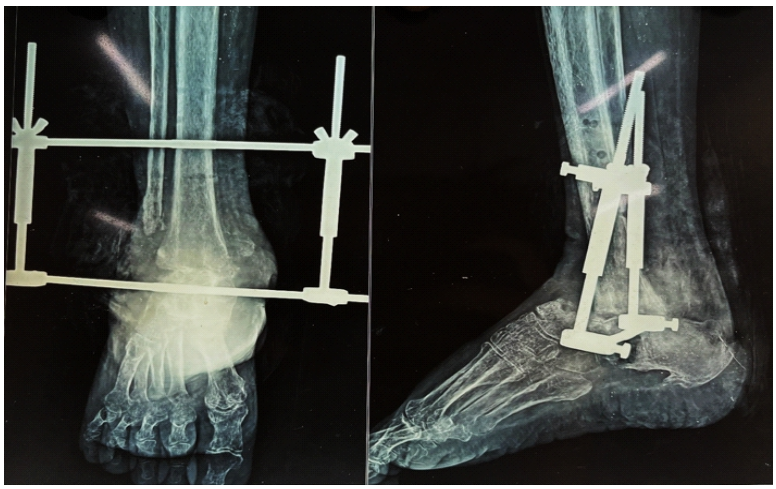

Figure 4: Anteroposterior and lateral radiographs of the right ankle showing Charnley compression arthrodesis with external fixator in situ and absence of radiological fusion at the ankle joint.

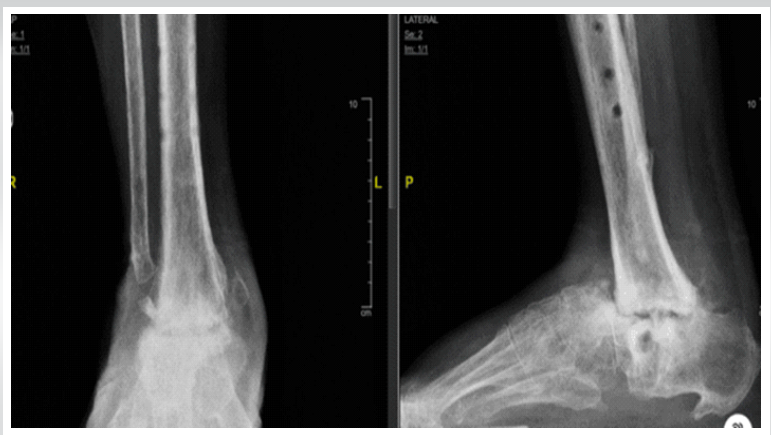

Figure 5: Anteroposterior and lateral radiographs of the right ankle at presentation to our center demonstrating persistent ankle non-union with deformity following failed prior fixation and arthrodesis procedures.

Discussion

Non-union remains one of the most challenging complications following ankle fractures, particularly when compounded by multiple failed surgical interventions. The biological and mechanical factors contributing to non-union are complex and interdependent, involving impaired vascularity, inadequate stability, and repeated surgical insult to local tissues, as highlighted in contemporary non-union research [1]. In ankle fractures, although union rates are generally favorable, functional outcomes can deteriorate significantly when union is delayed or fails to occur, leading to persistent pain and disability [2].

Management of malleolar fracture non-union requires careful consideration of both stability and biology. Recent evidence supports revision fixation with adequate mechanical support and biological augmentation as the primary strategy for most malleolar non-unions [3]. However, when repeated fixation attempts fail, local bone stock is compromised and joint mechanics deteriorate, limiting the effectiveness of further conventional fixation strategies [4]. In such settings, salvage procedures become necessary.

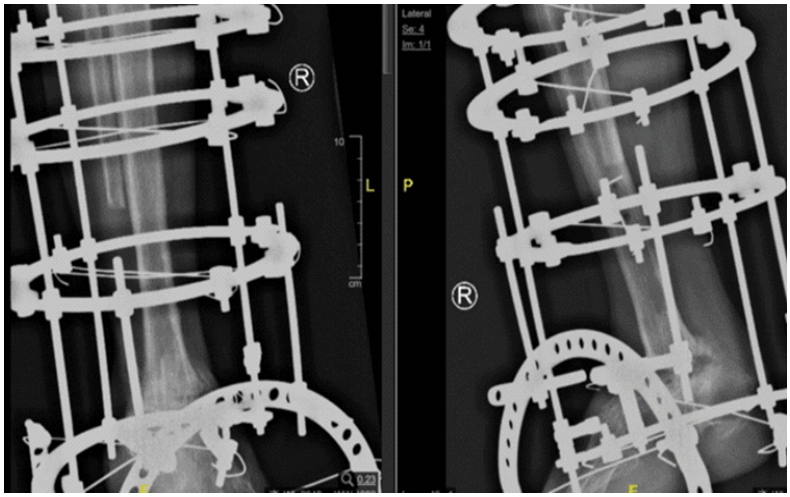

Figure 6: Immediate post-operative anteroposterior and lateral radiographs of the right ankle showing definitive arthrodesis using Ilizarov circular external fixation with application of controlled compression across the ankle joint.

advantages. The Ilizarov frame provides multiplanar stability, allows controlled compression across non-union sites, facilitates gradual correction of deformity, and permits early functional weight bearing. These biomechanical benefits make it particularly suitable for managing complex ankle and distal tibial non-unions, as demonstrated in recent case reports [7].

In cases of persistent non-union following TTC arthrodesis, external compression techniques such as Charnley compression arthrodesis have historically been employed as a further salvage measure. While Charnley fixation provides rigid compression across the ankle joint, its effectiveness is limited in the presence of poor bone quality, deformity, or multiple prior surgeries, and failure rates remain significant in complex revision scenarios. Failure of both intramedullary and compression arthrodesis

TTC arthrodesis is frequently employed as a salvage option in cases of complex ankle pathology, providing pain relief and stability by eliminating motion at the ankle and subtalar joints. Nevertheless, TTC arthrodesis is associated with considerable complication and non-union rates, particularly in revision settings and in patients with altered bone biology or alignment [5]. Recent reports, especially in high-risk populations, continue to demonstrate that even TTC nailing may fail to achieve reliable fusion, underscoring the limitations of intramedullary fixation alone in compromised environments [6].

Figure 7 Follow-up anteroposterior and lateral radiographs of the right ankle demonstrating progressive consolidation at the arthrodesis site with Ilizarov circular external fixation in situ.

Failure of TTC arthrodesis presents a difficult limb-salvage dilemma, often leaving limited options short of amputation. In this context, circular external fixation using the Ilizarov method offers distinct

Figure 8: Anteroposterior and lateral radiographs of the right ankle at 1-year follow-up after removal of the Ilizarov frame, demonstrating solid arthrodesis with maintained alignment.

techniques leaves few limb-salvage options short of amputation [8].

Biological augmentation plays a crucial role in achieving union in resistant non-unions. The use of an autologous fibular strut graft provides both structural support and osteogenic stimulus, acting as a biological scaffold while enhancing stability across the non-union site. Recent literature has shown favorable outcomes with the combined use of fibular grafting and Ilizarov fixation in refractory distal tibial non-unions after multiple failed procedures [9]; however, the present case is distinct in that it originated from a bimalleolar ankle fracture and progressed through failed TTC and Charnley compression arthrodesis, representing a more advanced and uncommon salvage scenario. This approach allowed

preservation of limb length, restoration of alignment, and achievement of union without reliance on further internal fixation. Recent studies continue to support the role of circular external fixation as a reliable limb-salvage strategy in complex ankle and hindfoot reconstruction when conventional methods have failed [10, 11, 12, 13]

Furthermore, contemporary evidence suggests that external fixation may reduce the risk of deep infection and hardware-related complications in revision settings, particularly when soft-tissue conditions are compromised or bone quality is poor [14]. Long-term outcomes reported in recent series indicate satisfactory functional recovery and acceptable complication profiles with circular fixation-based salvage procedures [15, 16].

This case highlights the importance of individualized treatment planning in complex ankle non-unions. Even after failed TTC arthrodesis, limb salvage using circular external fixation combined with biological augmentation can provide a reliable alternative to amputation in selected young, high-demand patients.

Limitations

This report has several limitations. As a single-patient case report describing a rare sequence of failed internal fixation, failed TTC arthrodesis, and failed Charnley compression arthrodesis, the findings cannot be generalized to a broader patient population. Follow-up was limited to 1 year after frame removal and, therefore, does not permit assessment of long-term durability of fusion, adjacent joint degeneration, or late complications.

Conclusion

Bimalleolar ankle fracture non-union with sequential failure of internal fixation, TTC arthrodesis and Charnley's procedure represents a complex salvage challenge with limited treatment options. This case demonstrates that limb salvage using a combination of fibular strut grafting and Ilizarov circular external fixation can achieve reliable union and functional recovery even after failed arthrodesis. In young, high-demand patients, circular fixation with biological augmentation should be considered a viable alternative to further internal fixation or amputation.

Clinical Message

In complex ankle non-unions after failed internal fixation and failed arthrodesis, fibular strut grafting combined with Ilizarov circular fixation can be considered as a limb-salvage option to achieve stable fusion and preserve function in carefully selected patients.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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