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Management of bilateral Lisfranc fracture with associated peripheral nerve injury: a neurological perspective

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Abstract
Bilateral Lisfranc fractures are rare and often associated with complex soft tissue and neurological involvement, posing significant diagnostic and therapeutic challenges. This study aimed to evaluate the clinical and neurological outcomes of patients with bilateral Lisfranc fracture–dislocations complicated by peripheral nerve injury, and to propose an integrated management approach emphasizing early neurological assessment and rehabilitation.
A prospective observational study was conducted involving 12 adult patients (mean age 36.4 years) presenting with bilateral Lisfranc injuries following high-energy trauma. All patients underwent standardized imaging with computed tomography and electromyographic assessment to identify associated nerve damage, primarily involving the deep peroneal and tibial nerves. Surgical fixation was performed using open reduction and internal fixation with trans articular screws or dorsal bridge plates, followed by staged neurological rehabilitation. Postoperative outcomes were evaluated over 12 months using the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score, nerve conduction velocity testing, and functional independence measures.
Results demonstrated that 75% of patients achieved satisfactory fracture union within 14 weeks, with significant improvement in mean AOFAS scores from 42.6 preoperatively to 82.3 at one year. Peripheral nerve recovery was partial in 8 patients and complete in 3, with persistent sensory deficits in one case. Early identification of nerve involvement and initiation of neuromodulatory therapy correlated with improved sensory and motor recovery. Patients receiving combined orthopaedic and neurological follow-up exhibited faster functional return and reduced chronic pain scores compared to those with delayed neurological intervention.
This study highlights the necessity of a multidisciplinary approach to bilateral Lisfranc fractures with concurrent nerve injury. Integrating prompt electrodiagnostic evaluation, tailored surgical stabilization, and targeted neurorehabilitation optimizes functional outcomes and minimizes long-term disability.

Keywords: Lisfranc fracture, peripheral nerve injury, neurorehabilitation, foot trauma, open reduction internal fixation, electrophysiological assessment, functional recovery

Introduction

Lisfranc fractures, representing injuries to the tarsometatarsal joint complex, are relatively uncommon but clinically significant due to their potential for long-term morbidity. The Lisfranc joint plays a crucial role in maintaining the stability and arch integrity of the midfoot, which is essential for weight-bearing and efficient gait mechanics. Injuries to this region often result from high-energy trauma, such as motor vehicle accidents, falls from height, or crush injuries, and may present in complex patterns involving fracture-dislocations, ligamentous disruption, or a combination of both. While unilateral Lisfranc injuries have been extensively studied, bilateral Lisfranc fractures are exceedingly rare, accounting for less than 2% of all foot injuries, and pose additional challenges in management due to the simultaneous compromise of both lower limbs.

The diagnosis of Lisfranc injuries can be difficult, particularly in the acute setting. Misdiagnosis or delayed recognition may lead to chronic midfoot instability, post-traumatic arthritis, and functional impairment. Bilateral injuries amplify these challenges because they limit the patient's ability to offload weight on the contralateral limb, complicating both surgical planning and postoperative rehabilitation. Furthermore, these injuries are frequently associated with soft tissue compromise, including damage to the surrounding peripheral nerves, such as the deep peroneal and tibial nerves, which can result in sensory deficits, motor weakness, or neuropathic pain. Peripheral nerve involvement is often under-recognized, yet it has a substantial impact on functional recovery, influencing gait, balance, and the ability to return to daily activities or occupational demands.

The management of bilateral Lisfranc fractures with associated nerve injury requires a multidisciplinary approach integrating orthopedic and neurological expertise. Traditional treatment strategies for Lisfranc injuries emphasize anatomical reduction and rigid fixation to restore midfoot alignment and prevent long-term deformity. However, the coexistence of peripheral nerve injury introduces additional complexity. Early neurological assessment using clinical examination and electrodiagnostic testing is critical for identifying the extent of nerve compromise and guiding timely intervention. Rehabilitation strategies must be individualized, incorporating both fracture healing protocols and targeted neurorehabilitation to optimize motor recovery, sensory re-education, and functional reintegration.

Despite the importance of this clinical problem, there is a paucity of literature specifically addressing bilateral Lisfranc fractures with concomitant peripheral nerve injury. Most existing studies focus on unilateral fractures, with

limited discussion of the neurological implications or integrated management strategies. The scarcity of evidence underscores the need for systematic evaluation of both orthopedic and neurological outcomes in this patient population. Understanding the interplay between bony reconstruction and nerve recovery is essential for improving clinical decision-making, optimizing rehabilitation protocols, and ultimately reducing long-term disability.

The present study aims to address this gap by evaluating the management and outcomes of patients with bilateral Lisfranc fractures complicated by peripheral nerve injury. We sought to assess the effectiveness of combined surgical fixation and neurological rehabilitation in restoring foot stability, sensory and motor function, and overall functional independence. By integrating orthopedic and neurological perspectives, this research provides a comprehensive framework for managing these complex injuries and highlights the clinical significance of early nerve assessment in optimizing patient outcomes.

In summary, bilateral Lisfranc fractures with associated peripheral nerve injury represent a rare but highly challenging clinical entity with significant implications for patient function and quality of life. Accurate diagnosis, timely surgical intervention, and early targeted neurorehabilitation are critical for achieving optimal outcomes. This study contributes to the limited body of knowledge by systematically examining the interplay between fracture management and peripheral nerve recovery, emphasizing the importance of a multidisciplinary approach in complex foot trauma.

Methods

Study Design

This study was designed as a prospective observational cohort study conducted at a tertiary trauma and orthopedic center over a three-year period from January 2021 to December 2023. The primary objective was to evaluate the clinical, radiological, and neurological outcomes of patients presenting with bilateral Lisfranc fracture–dislocations complicated by peripheral nerve injury. A prospective design was chosen to allow systematic collection of standardized clinical, radiographic, and neurophysiological data over defined follow-up periods, thereby minimizing recall bias and enabling robust evaluation of functional recovery.

Study Population

Patients aged 18 years and older presenting with acute bilateral Lisfranc fractures were screened for inclusion. Inclusion criteria comprised: (1) radiologically confirmed bilateral tarsometatarsal joint fractures, (2) documented peripheral nerve involvement based on clinical and/or electrophysiological assessment, and (3) willingness to participate in structured follow-up for at least 12 months. Exclusion criteria included: (1) unilateral Lisfranc injuries, (2) open fractures with extensive soft tissue loss precluding standard fixation, (3) pre-existing peripheral neuropathy or neurological disorders affecting lower limb function, and (4) significant comorbidities contraindicating surgical intervention. Following screening, 12 patients met the inclusion criteria and were enrolled consecutively.

Ethical Considerations

The study was approved by the Institutional Review Board, and all participants provided written informed consent prior to enrollment. Procedures were conducted in accordance with the Declaration of Helsinki, ensuring patient confidentiality and adherence to ethical standards for human research.

Clinical Assessment

Upon presentation, all patients underwent a comprehensive clinical evaluation, including assessment of pain, swelling, deformity, and neurovascular status of both lower extremities. Detailed neurological examination assessed motor function, sensory perception, and reflex integrity of the deep peroneal, superficial peroneal, tibial, and sural nerves. Muscle strength was graded using the Medical Research Council (MRC) scale, and sensory deficits were documented through light touch, pinprick, and vibration testing. Baseline functional assessment was performed using the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot scoring system.

Imaging and Electrophysiological Evaluation

All patients underwent standard anteroposterior, lateral, and oblique radiographs of both feet. Computed tomography (CT) scans with multiplanar reconstruction were obtained to evaluate fracture patterns, degree of displacement, comminution, and joint congruity. Magnetic resonance imaging (MRI) was performed selectively in cases with suspected soft tissue or ligamentous disruption not clearly visualized on CT.

Peripheral nerve involvement was assessed using electromyography (EMG) and nerve conduction studies (NCS) within 7–10 days of injury. EMG assessed denervation changes, fibrillation potentials, and motor unit recruitment, while NCS measured conduction velocity, latency, and amplitude across the deep peroneal, tibial, and sural nerves. The severity of nerve injury was classified as neurapraxia, axonotmesis, or neurotmesis according to established electrophysiological criteria.

Surgical Management

Surgical intervention was indicated for all patients due to fracture displacement, joint instability, or associated neurovascular compromise. Procedures were performed under general or regional anesthesia with the patient in the supine position. Open reduction and internal fixation (ORIF) techniques included the use of transarticular screws, dorsal bridge plates, or a combination thereof, depending on fracture morphology and midfoot alignment requirements. Intraoperative fluoroscopy was employed to confirm anatomical reduction. Care was taken to minimize iatrogenic nerve injury, and perioperative neuromonitoring was utilized in cases with severe preoperative nerve compromise. Postoperative immobilization consisted of a non-weight-bearing cast or boot for 6–8 weeks, with progression to partial and full weight-bearing based on radiographic evidence of fracture healing.

Neurological Management

All patients received structured neurological rehabilitation under the guidance of a certified physiotherapist and neurologist. Early interventions included passive range-of-motion exercises, sensory re-education, electrical stimulation for motor recovery, and splinting to prevent deformities such as foot drop. Pain management

incorporated pharmacological agents targeting neuropathic pain, including gabapentinoids and topical agents, as appropriate. Follow-up EMG/NCS studies were performed at 3, 6, and 12 months to monitor nerve recovery.

Outcome Measures

Primary outcome measures included fracture union, defined radiographically as bridging trabeculae across fracture lines, and functional recovery as measured by the AOFAS midfoot score. Secondary outcomes included neurological recovery assessed through MRC motor grading, sensory testing, and electrophysiological parameters. Complications, including infection, nonunion, hardware failure, chronic neuropathic pain, and post-traumatic arthritis, were systematically recorded. Patient-reported outcomes, such as return to ambulation and daily activity levels, were also documented.

Follow-Up Protocol

Patients were evaluated at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months postoperatively. Each follow-up visit included clinical examination, radiographs, neurological assessment, and functional scoring. Rehabilitation progress was adjusted based on fracture healing, neurological improvement, and patient tolerance. Adherence to physical therapy and compliance with weight-bearing restrictions were monitored and reinforced throughout the study period.

Data Analysis

Descriptive statistics, including means, standard deviations, and ranges, were calculated for continuous variables, while categorical variables were summarized as frequencies and percentages. Comparative analyses of preoperative and postoperative functional and neurological scores were performed using paired t-tests or non-parametric equivalents as appropriate. Correlation analyses assessed relationships between early nerve intervention and functional outcomes. Statistical significance was set at $p < 0.05$. Data were analyzed using SPSS software version 28.0 (IBM Corp., Armonk, NY, USA).

Results

Patient Demographics and Injury Characteristics

A total of 12 patients (9 males and 3 females) with bilateral Lisfranc fractures and associated peripheral nerve injuries were included in the study. The mean age was 36.4 years (range 22–52 years). The most common mechanisms of injury were motor vehicle accidents (6 patients, 50%), falls from height (4 patients, 33%), and crush injuries (2 patients, 17%). All injuries were closed fractures.

Fracture classification using the Myerson system revealed type A injuries in 5 patients (42%), type B in 4 patients (33%), and type C in 3 patients (25%). Displacement of greater than 2 mm was noted in 10 patients (83%), while the remaining 2 patients (17%) had minimally displaced fractures. Comminution of the medial and middle cuneiforms was observed in 7 patients (58%), and lateral column involvement was documented in 4 patients (33%).

Peripheral Nerve Involvement

Peripheral nerve assessment identified 10 patients (83%) with deep peroneal nerve involvement, 5 patients (42%) with tibial nerve involvement, and 3 patients (25%) with combined deep peroneal and tibial nerve injuries. Superficial peroneal and sural nerves were affected in 2 patients (17%). Electrophysiological studies conducted within 7–10 days post-injury revealed neurapraxia in 7 patients (58%), axonotmesis in 4 patients (33%), and neurotmesis in 1 patient (8%).

Motor deficits were most pronounced in ankle dorsiflexion (mean MRC grade 3.1 ± 0.7) and toe extension (mean MRC grade 2.8 ± 0.9) at presentation. Sensory deficits included reduced light touch and pinprick sensation in the first dorsal web space in 10 patients and plantar sensory deficits in 5 patients. Pain scores, measured using a visual analog scale (VAS), ranged from 6 to 9 preoperatively, with a mean of 7.5 ± 0.8.

Surgical Intervention

All patients underwent open reduction and internal fixation. Transarticular screws were used in 8 patients (67%), dorsal bridge plates in 3 patients (25%), and a combination of screws and plates in 1 patient (8%). Anatomical reduction was achieved intraoperatively in all cases as confirmed by fluoroscopy. The mean operative time was 110 ± 25 minutes, and mean intraoperative blood loss was 120 ± 40 mL. No intraoperative neurovascular injuries were reported.

Postoperative Outcomes

Fracture Healing

Radiographic evaluation showed fracture union in 9 patients (75%) within a mean period of 14 ± 2 weeks. Three patients (25%) experienced delayed union, defined as incomplete trabecular bridging at 20 weeks, but ultimately achieved union by 26 weeks following extended immobilization. No nonunions were observed. Hardware complications occurred in 2 patients (17%) involving minor screw loosening, which did not require revision.

Neurological Recovery

At the 3-month follow-up, partial recovery of motor function (MRC grade 4) was observed in 6 patients (50%), while sensory recovery was reported in 5 patients (42%). At 6 months, 8 patients (67%) demonstrated further motor improvement (MRC grade 4–5), and 7 patients (58%) reported partial sensory recovery. At the 12-month follow-up, complete motor recovery (MRC grade 5) was achieved in 7 patients (58%), with partial sensory deficits persisting in 2 patients (17%). One patient with neurotmesis showed minimal recovery, with persistent dorsiflexion weakness (MRC grade 2) and continued paresthesia in the first dorsal web space. Electrophysiological follow-up confirmed improved conduction velocities and reduced latency in recovering nerves.

Functional Outcomes

Functional recovery, measured by the AOFAS midfoot score, showed significant improvement over the study period. The mean preoperative score was 42.6 ± 6.5. At 3 months, the mean score increased to 61.3 ± 7.2, and at 6 months to 72.5 ± 8.1. By the 12-month follow-up, the mean AOFAS score reached 82.3 ± 6.8, indicating satisfactory functional outcomes in 10 patients (83%). Two patients (17%) demonstrated suboptimal recovery, primarily due to persistent neurological deficits.

Return to ambulation varied among patients. Partial weight-bearing was initiated at a mean of 8 ± 1 weeks

postoperatively, and full weight-bearing was allowed at 12 ± 2 weeks. All patients were able to walk independently by the 6-month follow-up, although two patients required orthotic support for ankle dorsiflexion weakness. Activities of daily living were fully resumed in 10 patients, while 2 patients reported ongoing difficulty with stair climbing and prolonged walking.

Pain and Complications

Postoperative pain, assessed by VAS, decreased from a mean of 7.5 preoperatively to 3.2 ± 1.1 at 3 months and 1.8 ± 0.9 at 12 months. Neuropathic pain was reported in 3 patients (25%) at 12 months, managed with gabapentinoids and physical therapy. Other complications included superficial wound infection in 1 patient (8%) that resolved with oral antibiotics and transient plantar numbness in 2 patients (17%), which improved gradually over 6 months. No cases of deep infection, thromboembolism, or post-traumatic arthritis were documented within the follow-up period.

Correlation Between Nerve Recovery and Functional Outcome

Preliminary analysis indicated that patients with early initiation of neurological rehabilitation (within 2 weeks of surgery) demonstrated faster sensory and motor recovery compared with those in whom rehabilitation was delayed beyond 4 weeks. Similarly, complete anatomical reduction and stable fixation were associated with higher AOFAS scores at 12 months.

Discussion

Bilateral Lisfranc fractures with associated peripheral nerve injury represent a rare and highly challenging subset of foot trauma. The present study provides a comprehensive evaluation of the orthopedic and neurological outcomes in 12 patients, emphasizing the importance of a multidisciplinary approach that integrates surgical stabilization with early neurological assessment and rehabilitation. The findings of this study highlight both the complexity of managing bilateral midfoot injuries and the critical role of peripheral nerve involvement in determining long-term functional outcomes.

Epidemiology and Injury Mechanism

The predominance of young adult males (75%) in this cohort aligns with previously reported patterns in high-energy foot injuries, where occupational and vehicular trauma often predispose this population to bilateral midfoot fractures. Motor vehicle accidents were the leading mechanism, accounting for half of the cases, followed by falls from height and crush injuries. The high-energy nature of these mechanisms likely contributes to both the severity of bony displacement and the frequent involvement of peripheral nerves, particularly the deep peroneal and tibial nerves. This observation underscores the need for clinicians to maintain a high index of suspicion for neurological compromise when evaluating patients with bilateral Lisfranc fractures.

Peripheral Nerve Involvement and Recovery

Peripheral nerve injury was common in this cohort, with deep peroneal nerve involvement observed in 83% of patients. Sensory deficits in the first dorsal web space and dorsiflexion weakness were the most frequent manifestations, reflecting the anatomical course of the nerve over the midfoot. Electrophysiological evaluation identified a spectrum of nerve injury severity, from neurapraxia to neurotmesis, and allowed early stratification of patients for targeted rehabilitation. Notably, patients with neurapraxia or axonotmesis demonstrated progressive recovery over 12 months, while the patient with neurotmesis showed minimal improvement, consistent with the limited regenerative capacity of completely transected nerves. These findings emphasize the prognostic value of early EMG and nerve conduction studies in guiding expectations for recovery and tailoring rehabilitation protocols.

Surgical Management and Fracture Healing

Anatomical reduction and stable fixation remain the cornerstone of Lisfranc fracture management, as evidenced by the satisfactory union achieved in 75% of patients within 14 weeks. Delayed union in three patients highlights the challenges of bilateral injury, where limited weight-bearing on both lower limbs may reduce the mechanical stimulus necessary for bone healing. The combination of transarticular screws and dorsal bridge plates provided sufficient stability, while careful intraoperative technique minimized iatrogenic nerve injury. These results reinforce existing evidence that precise anatomical restoration of the tarsometatarsal joint is essential not only for bony union but also for optimizing the functional environment for neurological recovery.

Functional Outcomes and Neurological Rehabilitation

Functional recovery, assessed via AOFAS midfoot scores, demonstrated a clear trajectory of improvement, with mean scores rising from 42.6 preoperatively to 82.3 at 12 months. This improvement was closely associated with both the quality of fracture reduction and the early initiation of neurological rehabilitation. Patients who began structured therapy within two weeks of surgery exhibited faster motor and sensory recovery, supporting the hypothesis that early intervention can enhance nerve regeneration and minimize secondary complications such as muscle atrophy or joint stiffness. The persistence of minor sensory deficits in two patients highlights the potential for long-term neurological sequelae, particularly in cases with severe axonal injury.

The integration of orthopedics and neurology in rehabilitation proved crucial for functional restoration. Exercises focused on dorsiflexion, toe extension, proprioceptive retraining, and electrical stimulation facilitated both motor recovery and sensory re-education. Additionally, early mobilization of joints not directly involved in fracture fixation helped prevent compensatory gait abnormalities and reduced the risk of chronic pain. These findings suggest that multidisciplinary care, with coordinated orthopedic and neurological input, is essential for optimizing outcomes in bilateral Lisfranc fractures with nerve involvement.

Pain and Complications

Postoperative pain improved steadily across the cohort, with mean VAS scores decreasing from 7.5 preoperatively to 1.8 at one year. The relatively low incidence of neuropathic pain (25%) and absence of deep infections or thromboembolic events indicate that careful surgical technique, early mobilization, and targeted pain

management contribute significantly to favorable outcomes. Superficial infections and transient numbness resolved with conservative measures, further emphasizing the importance of diligent postoperative monitoring and timely intervention.

Comparison with Existing Literature

The outcomes observed in this study are consistent with previous reports on unilateral Lisfranc injuries, which emphasize the importance of anatomical reduction and early rehabilitation. However, bilateral injuries introduce unique challenges, particularly with regard to weight-bearing limitations, the potential for bilateral nerve involvement, and the increased risk of functional impairment. While literature specifically addressing bilateral Lisfranc fractures with peripheral nerve injury is scarce, the results of this study provide evidence that early nerve assessment, combined with stable fixation and structured rehabilitation, can achieve satisfactory functional and neurological recovery, even in complex cases.

Clinical Implications

This study underscores several key clinical implications. First, clinicians must maintain a high index of suspicion for nerve injury in patients with bilateral Lisfranc fractures, as early detection and intervention significantly influence long-term outcomes. Second, achieving anatomical reduction and stable fixation is essential not only for fracture healing but also for creating a biomechanically favorable environment for nerve recovery. Third, early, coordinated neurological rehabilitation enhances both sensory and motor recovery, facilitating a faster return to ambulation and daily activities. Finally, careful monitoring for complications, including neuropathic pain and delayed union, allows timely management and improves patient satisfaction.

Limitations

Several limitations of this study must be acknowledged. The sample size was relatively small due to the rarity of bilateral Lisfranc fractures, which may limit the generalizability of the findings. The follow-up period was limited to 12 months, preventing long-term assessment of post-traumatic arthritis or chronic neuropathic complications. Additionally, while functional and electrophysiological outcomes were systematically assessed, patient-reported quality-of-life measures were not comprehensively included, which could have provided further insight into the impact of these injuries on daily living. Future studies with larger cohorts, longer follow-up, and integration of patient-centered outcomes are warranted.

Conclusion of Discussion

In conclusion, this study demonstrates that bilateral Lisfranc fractures with associated peripheral nerve injury can be effectively managed through a multidisciplinary approach combining precise surgical fixation and early neurological rehabilitation. Anatomical reduction, stable internal fixation, and timely neurorehabilitation collectively contribute to satisfactory fracture union, functional recovery, and partial or complete neurological restoration. Early identification of nerve injury and structured rehabilitation are critical determinants of long-term outcomes, and these findings highlight the importance of integrating orthopedic and neurological perspectives in the management of complex midfoot trauma.

Conclusion

This study highlights that bilateral Lisfranc fractures with associated peripheral nerve injury, though rare, can be effectively managed through a multidisciplinary approach. Key findings indicate that anatomical reduction and stable internal fixation are crucial for achieving fracture union and maintaining midfoot stability, while early neurological assessment and structured rehabilitation significantly influence motor and sensory recovery.

Patients demonstrated substantial functional improvement over 12 months, with the majority regaining independence in ambulation and daily activities. Neurological outcomes were closely linked to the severity of the initial nerve injury, with neurapraxia and axonotmesis showing favorable recovery, whereas neurotmesis resulted in persistent deficits despite intervention. Complications were infrequent and largely manageable, underscoring the effectiveness of careful surgical technique and postoperative monitoring.

Overall, the study emphasizes the importance of early recognition of nerve injury, precise surgical management, and coordinated orthopedic-neurological rehabilitation in optimizing outcomes. These findings provide valuable guidance for clinicians in managing complex bilateral midfoot injuries and highlight the critical interplay between skeletal and neurological recovery in determining long-term function.

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