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Original Research Article

Study of functional and radiological outcome of percutaneous bridge plating of extra articular fibula fracture for management of distal tibia type III open fracture

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ABSTRACT

Background: Fractures of the distal tibia account for 7 to 9% of lower extremity fractures, with the fibula fractured in about 85% of these cases. Management of fibula fracture in the distal third fracture setting is essential as it facilitates the reduction of tibia fracture. The management of distal third tibia and fibula fracture vary from intramedullary nail in the tibia fracture and plating for the fibula fracture to dual plating with minimally invasive percutaneous plate osteosynthesis (MIPPO) in the Tibia and fibula and depending on local tissue condition. This study aimed to evaluate the outcome of percutaneous bridge plating of fibula fracture in the setting of concomitant open type III distal tibia fracture.

Methods: A prospective clinical study of patients with distal tibia type III open fractures with extra-articular fibula fractures at the department of orthopaedics, SMS medical college, Jaipur, Rajasthan, India from June 2023 to May 2024 were subjected to percutaneous bridge plating for the fibula with appropriate management for the tibia fracture, Outcomes assessed using the lower extremity functional scale (LEFS), proportional length difference, talocrural angle, and fracture healing. Complications post-surgery was also evaluated.

Results: Studies have shown that appropriate fixation of the fibula aids in the reduction and stabilization of tibial fractures, improving overall outcomes. The use of percutaneous bridge plating offers benefits in terms of soft tissue preservation and mechanical stability.

Conclusions: The treatment chosen and the outcomes after a fracture seem to be satisfactory. Further studies and detailed analyses are required to establish long-term benefits and compare with other fixation methods.

Keywords: Distal tibia fracture, Fibula fracture, Percutaneous bridge plating, Lower extremity functional scale, Talocrural angle, Fracture healing

INTRODUCTION

Distal tibial fractures account for approximately 7-9% of all lower limb fractures, with fibular involvement reported in nearly 85% of these cases.[1-4] These fractures can occur due to either low-energy mechanisms, such as rotational forces, or high-energy trauma like road traffic accidents and falls from height.[4] Managing the fibular component in distal tibia fractures is crucial, as it not only aids in the reduction of the tibia but also addresses commonly associated syndesmotic injuries, which are often missed on plain radiographs. Failure to recognize and treat these can lead to poor functional outcomes and long-term morbidity, particularly once patients begin weight-bearing due to the resulting misalignment and instability of the ankle joint.

Treatment decisions for these injuries are heavily influenced by the status of the soft tissue envelope, including swelling, blistering, and the presence of open wounds. In closed fractures with minimal soft tissue damage, tibial fixation is typically performed using an intramedullary nail, while the fibula is fixed with a plate through the posterolateral approach. For intra-articular distal tibial fractures, a dual plating strategy using MIPPO for the tibia and posterolateral plating for the fibula is often employed. However, this approach has been associated with higher rates of superficial infections, wound dehiscence, implant exposure, and delayed/non-union.[5-7]

In cases presenting with excessive swelling, blistering, or significant open injuries, temporary stabilization using a spanning external fixator across the tibial fracture is preferred until soft tissue conditions improve. During this phase, fibular fixation can be performed using minimally invasive techniques. Anatomical reduction of the fibula may be prioritized to aid in aligning the tibial fracture and restoring overall lower limb alignment. Fibular fixation options in such scenarios include K-wires, rush nails, reconstruction plates, and dynamic compression plates. Among these, K-wires and Rush nails are often selected due to their smaller incisions and limited soft tissue disruption.[8,9] They provide good mechanical stability, especially in osteoporotic bone, and may help reduce complication rates, although there remains a risk of rotational instability and malalignment in certain cases.[10,11]

Open plating of fibular fractures facilitates anatomical reduction, maintains length, and ensures rotational stability. However, it can compromise the soft tissue envelope and is technically more challenging in comminuted fractures, potentially hindering optimal tibial fixation. Titanium elastic nails (TENs), while commonly used for pediatric long bone fractures, are seldom applied in adult populations.[2-5] Initially developed for femoral fractures in children, TENs offer a balance between conservative and surgical interventions, providing favorable outcomes with minimal complications. Nevertheless, they share similar limitations with Rush nails and K-wires, including possible instability and imperfect reduction.[12,13]

From a soft tissue preservation and biomechanical standpoint, percutaneous bridge plating has been explored in the management of distal fibular fractures, particularly Weber type B and C patterns.[14,15] In fibular fractures associated with ankle injuries, precise reduction is essential to restore fibular length and maintain distal tibiofibular joint congruency. Weber type B fractures, occurring at the level of the syndesmosis, and type C fractures, which carry a higher risk of syndesmotic disruption, both demand accurate articular alignment and rotational stability, best achieved through open reduction techniques.

Therefore, for extra-articular distal fibular fractures not involving the ankle, percutaneous bridge plating may offer a valuable solution by combining the benefits of minimal soft tissue disruption with the mechanical advantages of traditional internal fixation.

METHODS

This prospective observational study was conducted at the department of orthopaedics, SMS medical college, Jaipur, from June 2023 to May 2024 to evaluate the functional and radiological outcomes of percutaneous bridge plating for extra-articular fibula fractures in the management of distal tibia type III open fractures. A total of 53 patients with open fractures of the distal tibia (Gustilo-Anderson type III) associated with extra-articular fibula fractures at the same level were included. Patients aged 18 years and above who underwent percutaneous bridge plating for fibular fractures were enrolled, while those with intra-articular tibial fractures (Pilon fractures), multiple long bone fractures, pathological fractures, or loss to follow-up were excluded.

Surgical procedure

All procedures were performed under either regional or general anaesthesia, depending on the patient’s condition and surgical requirements. A thorough wound debridement was carried out to remove all necrotic and non-viable tissues, ensuring a clean surgical field. If primary closure was feasible after debridement, it was performed immediately. However, in cases where significant soft tissue loss prevented primary closure, a staged approach was adopted, and patients underwent secondary procedures such as flap coverage or skin grafting at a later stage.

Tibial fractures were stabilized based on the condition of the surrounding soft tissues. If the soft tissue status was poor or there was extensive contamination, an external fixator was applied as a temporary or definitive fixation method. In cases where soft tissue conditions permitted, intramedullary nailing was performed as the primary stabilization technique. Fibular fractures were managed using percutaneous bridge plating with a 3.5-mm locking compression plate (LCP). This technique was performed using small incision and under fluoroscopic guidance to ensure accurate reduction while minimizing soft tissue trauma. The choice of percutaneous plating aimed to preserve the periosteal blood supply and reduce additional surgical insult to the already compromised soft tissue.

Postoperatively, all patients received intravenous antibiotics for 5-7 days, depending on the severity of the injury and the presence of any contamination. Analgesia and thromboprophylaxis were provided as per institutional protocols.

Early mobilization was encouraged; however, weight-bearing was restricted until early signs of fracture union were observed. Patients were followed up at 6, 12, and 24 weeks, during which clinical and radiological evaluations were conducted.

Figure 1 (A-C): Wound management and healing progress over time.

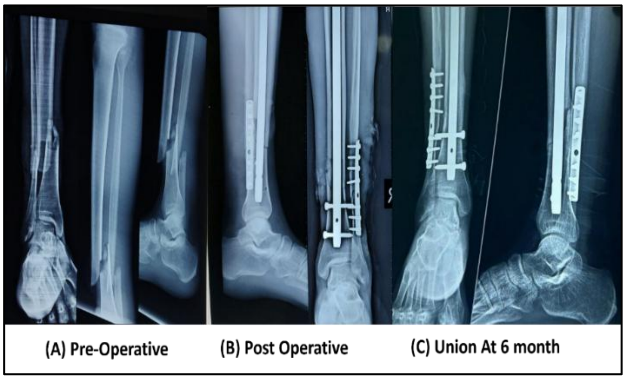

Figure 2 (A-C): Radiological outcome (union achieved in 79%).

Figure 3 (A-C): Functional outcome assessment.

Outcome assessment and statistical analysis

The primary outcome measures included fracture union rates and time to union, while secondary outcomes assessed LEFS scores, talocrural angle for ankle alignment, and complications such as non-union, infections, and soft tissue issues. Descriptive statistical analysis was performed using SPSS software version 26.0 (IBM Corp, Armonk, NY, USA). Continuous variables such as age, time to union, and operation time, etc., were presented as mean±SD, whereas categorical variables such as gender distribution, mode of injury, and complications were expressed as frequencies and percentages.

This study was conducted following the STROBE (Strengthening the reporting of observational studies in epidemiology) guidelines and was approved by the institutional ethics committee of SMS medical college, Jaipur. Written informed consent was obtained from all participants before enrolment.

RESULTS

In this study of 53 patients, the majority were male (79.2%) with a mean age of 46 years (Table 1). The left side was more frequently affected (54.7%) than the right (45.3%), with road traffic accidents being the most common cause of injury (75%) (Table 2).

Table 1: Age group of the study population, (n=53).

Variables	Mean±SD	Min	Max
Age (in years)	46±10.512	25	66

Table 2: Baseline characteristics and injury mechanisms in study population.

Parameters	N (%)
Gender	Male- 42 (79.2%)
	Female-11(20.8%)
Mode of injury	Road traffic accident-40 (75.5%)
	Fall from height-11 (20.8%)
	Fall of heavy object-02 (3.8%)
Side of injury	Right-24 (45.3%)
	Left-29 (54.7%)

Table 3: Surgical timing and procedural metrics in distal tibia fracture management.

Parameters	Observation (Mean±SD)
Mean fibula plating (in days)	0.66±1.055
Mean duration of definitive surgery of tibia	10.47±7.8
Operation time (in minutes)	52.87±10.72
Fluoroscopic time (sec)	49.06±17.35

The mean duration for fibula fixation was 0.66 days, while the mean time to definitive tibia surgery was 10.47 days. Tibial union was achieved in 86.8% of cases, while 13.2% experienced non-union. The mean fibula union time was 21.85 days. The average surgical duration was 52.87 minutes, with a mean fluoroscopic time of 49.06 seconds (Table 3).

Table 4: Surgical management and healing outcomes in open distal tibia fractures.

Parameters	Observation (%)
Mode of primary treatment of tibia	External fixator-39 (73.6%)
	IM nail-14 (26.4%)
Primary wound management	Flap-39 (73.6%)
	Primary closure-14 (26.4%)
Secondary surgery of the tibia	None-14 (26.4%)
	IM nail-37 (69.8%)
	DTLCP-2 (3.2%)
The outcome of tibia fracture	Union-46 (86.8%)
	Non-union-7 (13.2%)

The majority of tibia fractures were initially managed with external fixation (73%), while intramedullary nailing was performed in 26.4% of cases. Wound management primarily involved flap coverage (73.6%), whereas primary closure was done in 26.4% of cases. Among patients requiring secondary surgery, intramedullary nailing was the preferred method (69.8%), with DTLCP used in 3.2% of cases (Table 4).

Table 5: Radiological and functional outcome parameters.

Parameters	Observation (Mean±SD)
Union time of fibula (weeks)	21.85±4.48
Proportional length difference (%)	0.6545±0.88
Talocrural angle	78.58±1.67
LEFS	72.3±6.73

Table 6: Postoperative outcomes and complications in distal tibia fracture management.

Outcome	N (%)
Uneventful	79.2
Non-union	9.4
infection	3.8
Non-union, infection	3.8
Flap necrosis, infection	1.9
Wound dehiscence, infection	1.9

Radiological and functional outcomes showed a minimal mean proportional length difference of 0.65%, while the mean talocrural angle measured 78.58 degrees. Functional recovery, assessed using the LEFS score, had a mean of 72.3 (Table 5). Most patients (79.2%) had an uneventful recovery, while 20.8% experienced complications, with non-union being the most common (9.4%).

Additional surgical interventions were required in 10 cases. Bone grafting was performed for non-union, debridement with antibiotics was done for infections, and a combination of debridement and bone grafting was required for cases with both non-union and infection. All patients showed satisfactory recovery following these additional procedures (Table 6).

DISCUSSION

Open fractures of the distal tibia associated with fibula are usually caused by high-energy trauma such as traffic accidents or falling from high places. The role of fibular fixation in the treatment of distal tibiofibular syndesmosis injury and Pilon fractures has been well-defined[16] in concordance with the good functional outcome, hence during surgery for type III open fractures of the distal tibia, when concurrent fibular fractures present at the same level, when managed with open reduction and internal plate fixation, raises the concerns of the wound contamination, limited soft tissue envelope and poor vascularity, superficial infections.

For distal fibular fractures, intramedullary nailing has been utilized as a less invasive approach to avoid further soft tissue damage and associated problems.[17-20] Percutaneous bridge plating has been used in multiple studies for distal fibular fractures, including Weber type B or C fibular fractures, to preserve soft tissue and maintain mechanical qualities. Nonetheless, the fibula's length and the distal tibiofibular joint's congruency must be precisely lowered to minimize the fibular fracture associated with the ankle injury. Given that Weber type B affects the distal tibiofibular joint and type C may result in syndesmotic damage, anatomical articular reduction or open reduction is the recommended treatment for Weber type B. For fibular fractures, minimally invasive plate osteosynthesis (MIPO) has recently been developed, albeit its clinical and radiological indications are still unclear.[21-23]

Although open reduction and internal fixation are currently the gold standard for treating distal fibular fractures, soft tissue problems after fibular fractures treated with open plating are fairly common and have been recorded in as many as 30% of patients. Intramedullary nailing is a beneficial procedure, especially in elderly adults and patients with medical comorbidities with osteoporotic bone or perilous skin conditions of lateral malleolus.[24-26]

Therefore, this study was conducted to study the functional and radiological outcome of percutaneous bridge plating of extra-articular fibula fracture for management of distal tibia type III open fracture, which included 53 patients.

In our study, the mean age of the participants was 46±10.51 years. The age groups were distributed with the majority in the 41-50 years (35.8%) group studies by Court-Brown et al and Gustilo et al indicate that open tibia fractures were common in middle-aged adults, which aligns with our age distribution findings.[27,28]

The gender distribution was 79.2% of the patients being male (n=42) and 20.8% being female (n=11) in our study. Research by Court-Brown et al and MacKenzie et al showed a higher incidence of open fractures in males, which was consistent with our gender distribution data.[27,29]

We observed the side of injury, with 54.7% of the injuries occurring on the left side and 45.3% on the right side. Regarding the mode of injury, road traffic accidents were the most common cause at 75.5%, followed by falls from height at 20.8%, and falls of heavy objects at 3.8%. Similar to our study, studies by Court-Brown et al and Gustilo et al consistently reported road traffic accidents as the most common cause of tibial fractures.[26,28]

In the present study, we noted the timing of fibular plating, with a mean duration of 0.66±1.05 days. Most patients (58.5%) had no delay in plating, while 28.3% had plating done after 1 day, and fewer patients had plating done at 2,3,4, or 5 days post-injury. Similar to our study, in the Jung et al study, the mean time from injury to fibular plating was 0.3±0.6 days.[26] Also, Early fixation is generally recommended in the literature for optimal outcomes. Studies by Bhandari et al support early intervention in the management of fractures.[30]

In our study, the primary treatment mode for tibia fractures was external fixation, which was used in 73.6% of cases, and nailing in 26.4%. Similarly, external fixation is commonly used in open fractures, especially in emergency settings, as noted by studies like Gustilo et al and Bhandari et al.[28,30] Intramedullary nailing is also a well-documented treatment option for tibial fractures in the Court-Brown et al study.[27]

Wound management with flap procedures was performed in 73.6% of cases and primary closure in 26.4% in our study. Flap coverage is recommended for severe open fractures to prevent infection and promote healing, consistent with literature by Godina and Gopal et al.[20-21]

In our study, the secondary surgery of the tibia involved intramedullary nailing in 69.8% of patients, while dynamic compression plates were used in 3.8%, and 26.4% had no secondary surgery and the use of intramedullary nailing as a secondary procedure was common, as supported by studies by Court-Brown et al and Bhandari et al which is consistent with our finding.[27,30]

The mean time to definitive tibia surgery in our study was 10.47±7.86 days, which was in concordance with the Jung et al. study, where they found a mean time to definitive surgery of tibia was 6.4±6.0 days. Delays in definitive fixation can be due to the need for initial stabilization and wound management. Studies by Bhandari et al highlight similar time frames in clinical practice.[30]

In the current study, the outcomes of tibia fractures, with union were achieved in 86.8% of patients and non-union in 13.2%. The union time of the fibula had a mean of 21.85±4.48 weeks. Comparatively, at an average of 20.7±6.3 weeks, all patients achieved fracture union in the fibula in the study by Jung et al and six cases of tibia non-union were categorized as either oligotrophic avascular non-union or necrotic non-union in their study.[31] Also, union rates reported by Bhandari et al and Court-Brown et al were similar, with union rates typically around 80-90% for open fractures managed with modern techniques.[27,30]

The LEFS scores in our study had a mean of 72.3±6.73. The proportional length difference had a mean of 0.6545±0.88%. The talocrural angle had a mean value of 78.58±1.67 degrees. LEFS scores are used to measure recovery, and scores in your study indicate moderate to good functional recovery, consistent with other studies on fracture outcomes as illustrated by Bhandari et al.[30] Similarly, Jung et al observed that at the final follow-up, the mean LEFS score was 74.0±3.70 points and the talocrural angle's mean value was found to be 79.11 degrees in the final examination.[31] Length discrepancies are a concern in fracture management, and our findings were within acceptable ranges as reported in the literature by Court-Brown et al.[26]

We observed the mean operation time, of 52.87±10.72 minutes, and the fluoroscopic time, had a mean of 49.06±17.35 seconds. Meanwhile, the average fluoroscopic time was 40.5±25.1, and the average operation time for fibular fractures was 46.8±5.8 min in the Jung et al studies.[31]

The complications occurred in 20.8% of patients in our study. Specific complications included non-union (9.4%), infection (3.8%), non-union with infection (3.8%), flap necrosis with infection (1.9%), and wound dehiscence with infection (1.9%). On the other hand, Jung et al observed that in the distal part of the fibula, two patients experienced superficial wound dehiscence.[31] Three individuals experienced superficial skin necrosis on the skin bridge between the open wound from the tibia fracture and the fibular incision in their research.

We also noted that 7.6% of patients required bone grafting, another 7.6% underwent debridement with antibiotics, and 3.8% had debridement with bone grafting in our study. Comparatively, in the Jung et al study, debridement and repeated administration of moist form dressings were performed on their patients.[31]

For open tibia fractures, twenty-nine patients had soft tissue coverage procedures performed, such as anterolateral thigh free flap, random-pattern flap, or distally based sural artery fasciocutaneous flap in their study.

Limitations

This study has certain limitations. The sample size of 53 patients and the study's single-centric nature may restrict the results' generalizability. Multicentric studies with larger cohorts must validate these findings and provide broader applicability. Additionally, functional outcomes were assessed using the LEFS score, a subjective tool that may be influenced by individual patient perception. Including objective outcome measures could have strengthened the assessment and offered a more comprehensive evaluation of functional recovery.

CONCLUSION

In this Hospital based prospective clinical case study, the percutaneous bridge plating could be applied for extra-articular distal fibular fractures when combined distal tibia type III open fractures were treated with external fixator/IM nail, given satisfactory radiological outcomes with union in both tibia and fibula, satisfactory fibular length, talocrural angle, good overall functional outcome in form of satisfactory LEFS score without serious complications, and good overall soft tissue healing.

We can conclude that with the perspective of minimizing soft tissue problems due to high-energy trauma, the application of percutaneous bridge plating for the treatment of concurrent fibular fractures can be an alternative to conventional methods. This study underscores the effectiveness of percutaneous bridge plating in managing complex fractures but also highlights the need for early intervention and comprehensive management to optimize outcomes. Future research should focus on larger, multi-centric prospective studies with longer follow-up periods to validate these findings and explore the impact of various treatment strategies on patient outcomes. With utmost importance given to soft tissue condition and coverage, timing of surgery, and modality of fixation of tibia.

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