Section: Orthopaedics

Original Research Article

# OUTCOME OF DISTAL TIBIA FRACTURES USING HYBRID EXTERNAL FIXATOR AS DEFINITIVE MANAGEMENT

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## Abstract

**Background:** Distal tibial fractures pose challenges for orthopaedic surgeons due to soft tissue injuries, with debates on prioritising anatomic reduction, articular congruity, or soft tissue healing. Hence, the present study analysed the radiological and functional outcome of managing distal tibial fractures treated with a hybrid external fixator. **Materials and Methods:** This prospective observational study was conducted at Mahatma Gandhi Memorial Government Hospital, Trichy, from January 2019 to August 2020, on twenty-five patients with distal tibial fractures. All patients were evaluated in the emergency room as per ATLS protocol. Careful history-taking and methodical examination were done. Patients were followed up once every three weeks until fracture union and once every three months. **Result:** Of 25 patients, 20 (80%) were males, and 5 (20%) were females, showing male preponderance because of travelling and outdoor work. The age of the patients ranged from 21-80 years, with the fracture being most common in the 5th decade, and the mean age was 43.6 years. 19 (76%) patients sustained injury following a motor vehicle accident. 14 (56%) cases were open fractures, and 11 (44%) were closed fractures. In objective evaluation, 44% had good, and 32% had excellent results. In subjective evaluation, 40% had excellent, and 40% had good results. There were no intra-operative complications, and none of the patients had ankle stiffness, delayed union, osteomyelitis, septic arthritis or DVT. **Conclusion:** Hybrid fixation is a viable method for distal tibia fractures, providing access to soft tissue and wound care, preventing malunion, and effectively managing open fractures.

## INTRODUCTION

Distal tibial fractures, encompassing pilon fractures, pose a significant challenge for orthopaedic surgeons, primarily due to the associated soft tissue injuries.[1,2] There remains an ongoing debate regarding the prioritisation of achieving anatomical reduction and articular congruity versus focusing on soft tissue healing. The distal tibial region presents challenges due to reduced vascularity, a limited soft-tissue envelope, and accompanying soft-tissue injuries, which can lead to complications like malunions, delayed union, and wound-related issues.[3,4] The primary objectives in managing these fractures involve achieving an anatomically precise reduction of the articular surface, realigning the bones, and facilitating early ankle joint mobilisation.

A range of treatment modalities is employed for addressing these fractures, including open reduction and internal fixation, initial utilisation of a joint-spanning external fixator, and application of the Ilizarov fixator.[5] Regardless of the chosen method, it is crucial for the construct to offer sufficient stability to sustain the achieved reduction. Hence, this study analysed radiological and functional outcomes in managing distal tibial fractures treated with a hybrid external fixator.

## MATERIALS AND METHODS

This prospective observational investigation was conducted at Mahatma Gandhi Memorial Government Hospital, Trichy, from January 2019 to August 2020. The study cohort consisted of twenty-five individuals diagnosed with distal tibial fractures. Ethical clearance was obtained in advance from the Institutional Ethical Committee. Each participant received a comprehensive explanation regarding the


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nature and purpose of the study, and their informed consent was duly obtained.

**Inclusion Criteria**

Inclusion criteria comprised individuals aged 18 years and older, presenting with distal tibial AO/OTA types A–C fractures involving the distal 5cm of the tibia. Additionally, open (compound) fractures of the distal tibia, excluding TYPE IIIc Gustilo-Anderson classification, were included, provided the patient demonstrated the capacity to ambulate without external aid before the injury.

**Exclusion Criteria**

Skeletally immature individuals, polytrauma patients with distal tibial fractures necessitating extended Intensive Care Unit (ICU) stay (with an Abbreviated Injury Scale (AIS) score greater than 3 for head and chest injuries), patients unwilling to undergo external fixation, as well as those with Type IIIc Gustilo-Anderson classification of distal tibial fractures were excluded.

All 25 cases in this study presented with an associated fibula fracture. In one patient, there was an additional fracture at the lower end of the radius on the same side as the injury. This radius fracture was treated using closed reduction and external fixation through ligamentotaxis. All patients underwent evaluation in the emergency room following the Advanced Trauma Life Support (ATLS) protocol. Thorough history-taking and systematic examinations were conducted. Once the patient's condition was stabilised, radiographic assessments of the injured leg and ankle were performed.

**Management of Open Fractures**

Open fractures (n=16) were classified according to Gustilo and Anderson's system for open fractures. Patients received Tetanus toxoid injections and intravenous antibiotics (third-generation cephalosporin and aminoglycosides). After initial radiographs were obtained, patients with type I and II open fractures underwent wound irrigation with copious normal saline. In some cases, hydrogen peroxide was used for decontamination if dirt and grease were present. The wound was treated with Povidone iodine, and primary wound closure was performed. The limb was immobilised using a posterior splint and elevated. All Type III open fractures were immediately debrided, removing devitalised tissue, extensive wound irrigation, and a posterior splint until definitive hybrid fixation. In two patients, an initial joint-spanning fixator was applied and kept for approximately five days until the Hybrid fixator was applied after managing co-morbid conditions. Three patients with open fractures presented with plaster casts and had well-healed wounds; they were categorised as open fractures in the study. All other open fractures were surgically treated the following day in an elective operating room, and the Hybrid fixator was applied within 48 hours under Image intensifier control.

**Management of Closed Fractures**

Closed fractures (n=11) were assessed for skin condition, discolouration, swelling, deformity, local temperature, and paraesthesia. Fractures were classified according to the AO/OTA classification system. Initial treatment consisted of manual traction, followed by applying a posterior above-knee splint and elevation of the limb to promote soft tissue healing. Closed fractures with intact skin and favourable conditions were surgically treated on average 4.1 days after the injury (ranging from one to eight days).

**Time Interval between Injury and Surgery:**

The mean time interval between injury and surgical intervention was 4.1 days (1 to 8 days), and for open fractures, it was 24.9 hours (ranging from 8 to 72 hours). Delay in treating open fractures was attributed to the patient's poor general condition, co-morbidities, and alcohol intoxication at the presentation time.

**Surgical Technique**

All eligible patients were admitted, and a preoperative work-up was performed. Surgeries were conducted in an elective operating room under anaesthesia and fluoroscopic imaging. The preoperative assessment included a detailed medical history, information on co-morbid conditions, drug allergies, and prior treatments. The local skin condition, tendon function, and neurovascular status were documented. Electrocardiograms (ECG) and chest X-rays were taken, routine blood tests were performed, and screenings for HIV and HBsAg were conducted. Patients were educated about the procedure, and written consent was obtained. The injured limb was prepared beforehand, and instruments were checked and sterilised the day before surgery.

**Anesthesia Mode**

Most patients underwent surgery under regional anaesthesia, specifically lumbar subarachnoid block. Preoperative test doses of anaesthetic and antibiotic drugs were administered.

The surgical technique employed a hybrid fixator construct consisting of a single-ring external fixator, tensioned transfixation wires in the distal fragment, a tubular external fixator, and Schanz pins for proximal fracture stabilisation. The procedure involved the patient being positioned on the operating table, undergoing fracture manipulation under fluoroscopic control, and fibular fixation through open reduction and plating or intramedullary K-wires. The restoration of a periarticular fragment involved its reduction, fixation with three Ilizarov wires, and evaluation for potential tendon impalement. For diaphyseal fragments, strategically placed Schanz pins were used on the anteromedial aspect of the tibia, inserted perpendicularly to the tibia, creating holes through both cortices. The Schanz pins were inserted using a T-handle to ensure bi-cortical purchase. Fracture reduction and frame assembly included ligamentotaxis and adjustments to the angulations in the distal fragment. An AO rod was connected to the ring, and additional AO rods could be inserted for stability.


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For patients with type 3 fractures (4 cases), stabilisation of the coronal fracture of the distal tibia with intra-articular extension was achieved using percutaneously applied compression screws. The postoperative regimen included active ankle and knee mobilisation, non-weight-bearing walking, intravenous antibiotics for 5-7 days, additional oral antibiotics for five days, regular cleaning of pin exit points, and encouragement of non-weight-bearing walking.

**Follow-Up**

Patients were followed up once every three weeks until fracture union and once every three months. Fracture union was defined as bridging callus at the fracture site in three cortices, as seen in anteroposterior and lateral radiographic views. Fixator removal occurred after radiological evidence of union and pain-free partial weight-bearing. Following removal, a posterior splint was applied for two weeks, and patients were allowed full weight-bearing with an ankle splint. The splint was discontinued once a pain-free range of motion was achieved.

**Outcome Assessment**

The Ovadia and Beals objective and subjective scoring system was used to assess outcomes. All patients were periodically evaluated for bony union, deformities, infections, and the range of motion of adjacent joints. The study had a mean follow-up duration of 12.5 months. Statistical analysis involved data entry into MS Excel and presentation as frequencies and percentages.

## RESULTS

Among the cohort of 25 patients, a notable predominance of males was observed, constituting 80% (n=20), while females represented 20% (n=5). This male preponderance can be attributed to occupational factors, such as increased engagement in travel and outdoor activities, that may elevate the risk of distal tibial fractures.

The age range of the patients spanned from 21 to 80 years, demonstrating a wide spectrum of age groups affected by these fractures. Notably, fractures were most prevalent in the fifth decade of life. The mean age of the patients was calculated to be 43.6 years, indicating a central tendency towards this age group.

Most patients, accounting for 76% (n=19), experienced the onset of their fractures after motor vehicle accidents. Meanwhile, 20% (n=5) of the cases were attributed to falls, signifying another significant etiological factor. One patient (4%) reported a history of falling from a height, significantly impacting the lower limb.

Of the 25 cases examined, 56% (n=14) presented with open fractures, while 44% (n=11) were characterised as closed fractures. Further subclassification of the 14 open fractures according to the Gustilo Anderson classification yielded the following distribution: 50% (n=7) were type I compound fractures, 36% (n=5) were type II compound fractures, and 14% (n=2) were type III compound fractures. The classification of fracture patterns was conducted utilising the AO/OTA classification system specific to distal tibia fractures. Among the 25 cases under scrutiny, 33% (n=6) were classified as Type A1, 48% (n=11) as A3, two cases fell under Type B, 14% (n=5) were categorised as C1, and one case (5%) was identified as a C3 type of fracture [Table 1].

In the objective assessment, 44% of cases exhibited good outcomes, while 32% demonstrated excellent results, as outlined in [Table 2]. There were no reported intra-operative complications. However, regarding postoperative complications, one patient (4%) experienced a superficial pin tract infection, effectively managed through a regimen of daily dressings, targeted antibiotic administration, and appropriate oral or intravenous antibiotics based on pus culture and sensitivity results. The infection was subsequently resolved with outpatient treatment. Patients and their attendants' active engagement and motivation played a pivotal role in minimising the incidence of pin tract infections.

None of the patients exhibited ankle stiffness or experienced delayed union. Cases of joint stiffness were attributed to non-adherence to the prescribed physiotherapy regimen and the presence of intra-articular extensions in these specific fractures. Furthermore, a single case (4%) demonstrated valgus malunion in a patient who underwent internal fixation without maintaining fibular length. Importantly, none of the patients developed complications such as osteomyelitis, septic arthritis, or deep vein thrombosis (DVT).


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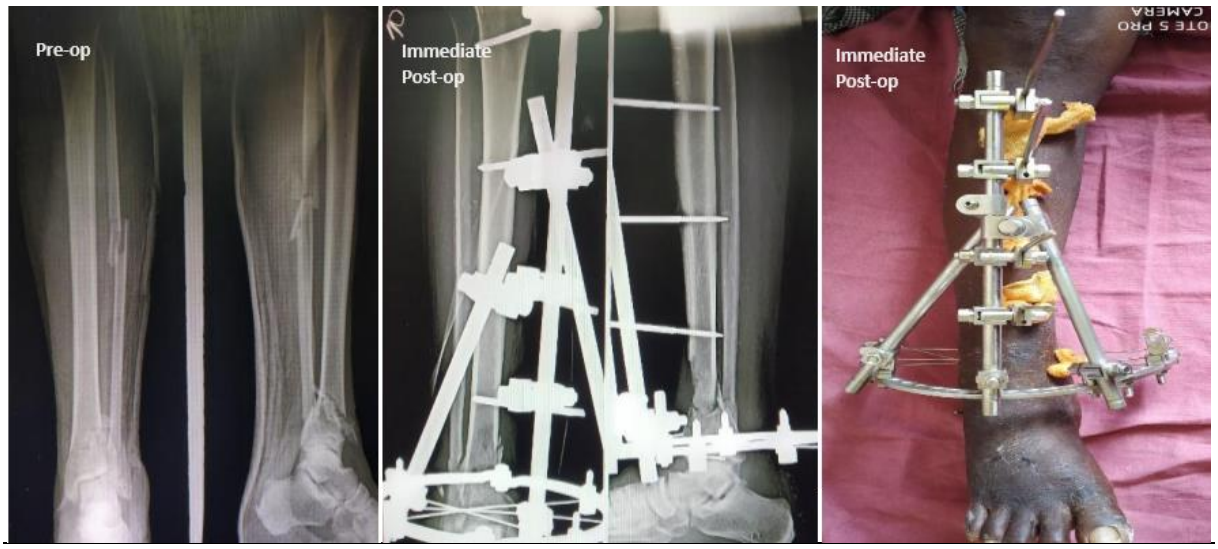


**Figure 1 Pre and Immediate post-operative images**


**Figure 2 Follow-up images at 3 and 6 months**

**Table 1: Demographic data of the study**

| | | Number | Percentage |
|---|---|---|---|
| Gender | Male | 20 | 80% |
| | Female | 5 | 20% |
| Age in years | 21-30 | 2 | 8% |
| | 31-40 | 6 | 24% |
| | 41-50 | 8 | 32% |
| | 51-60 | 5 | 20% |
| | >60 | 4 | 16% |
| Mode of Injury | Road traffic accident | 19 | 76% |
| | Fall from height | 5 | 20% |
| | Fall of a heavy object | 1 | 4% |
| Type | Open | 14 | 56% |
| | Closed | 11 | 44% |
| AO/OTA | Type A1 | 6 | 24% |
| | Type A3 | 11 | 44% |
| | Type B 1 | 2 | 8% |
| | Type C1 | 5 | 20% |
| | Type C3 | 1 | 4% |

**Table 2: Objective and subjective evaluation**

| Result | | Number | Percentage |
|---|---|---|---|
| Objective evaluation | Excellent | 8 | 32% |
| | Good | 11 | 44% |
| | Fair | 5 | 20% |
| | Poor | 1 | 4% |


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| | | | |
|---|---|---|---|
| Subjective evaluation | Excellent | 10 | 40% |
| | Good | 10 | 40% |
| | Fair | 4 | 16% |
| | Poor | 1 | 4% |

## DISCUSSION

Our investigation unveiled that the mean age of patients afflicted with such injuries stood at 43.6 years, with a range spanning from 21 to 80 years. Notably, a substantial male preponderance of 80% was observed in our study, surpassing the 59% reported by Barbieri et al.[6] A noteworthy observation was that 12% of our patients were aged above 60 years and yet achieved favourable outcomes, indicating that tensioned wires can provide a stable fixation even in the presence of osteoporotic bone conditions.

In a study by Gaudinez et al,[7] 93% of fractures were classified as high-energy injuries. In contrast, Ovadia and Beals,[8] attributed only 46% of such injuries to high-energy causes. Our present investigation aligns more closely with the findings of Agarwal et al,[9] where 87% of patients presented with high-energy injuries. Our study's predominant mode of violence was road traffic accidents, accounting for 80% of cases.

Our study featured 64% open injuries, comparable to that found in Guadinez et al.'s research.[7] In contrast, Ovadia and Beals8 reported a substantially lower percentage of open injuries at 20%, while Barbieri et al. noted 30% open injuries in their series. Clinical outcomes for patients with open fractures fell within the fair-to-good range, primarily attributed to persistent mild swelling around the ankle and delayed union times.

Barbieri et al,[6] study revealed a distribution of fracture types, with 9% being Al, 9% A2, 10% A3, 16% C1, 32% C2, and 24% C3. Pugh Kevin J et al,[10] reported a similar fracture type distribution in their study. Of particular note, 68% of patients with extra-articular fractures (Type A) in our investigation achieved excellent results. In stark contrast, patients with Type C fractures demonstrated fair to good results, primarily due to issues such as ankle stiffness, low-grade pain while ambulating on uneven surfaces, and chronic oedema. It's worth noting that all patients in our study presented with a concomitant fibula fracture. In closed fractures where the fracture level was at or below the syndesmosis level, restoration of fibular length was undertaken, consistent with the recommendations of several studies. However, in open fractures where the condition of the wound impeded fibular fixation, the outcomes exhibited malunion and alterations in the tibiotalar axis.

The mean duration for fracture union in various studies utilising various methods ranged from 13 to 25 weeks. In our study employing the hybrid external fixator, the average fracture union period was 21.12 weeks, akin to other studies using a similar approach. Specifically, Barbieri et al,[6] reported an average fracture union time of 16 weeks, Gaudinez et al,[7] achieved 13 weeks for distal tibial fractures, French and Tornetta12 saw 17 weeks, Anglen JO13 noted 20 weeks, and Natarajan MV14 et al. recorded 28 weeks. In our investigation, type B fractures exhibited prolonged union times due to metaphyseal bone defects, necessitating primary bone grafting. This delay in union time may be attributed to a higher prevalence of compound fractures and the limited use of bone grafting as a primary intervention. Guadinez et al,[7] in their study of 14 distal tibial fractures treated with a hybrid external fixation, documented varus malalignment in one patient (14%) and pin tract infections in eight patients (57%). Barbieri et al,[6] study, which included 37 distal tibial fractures managed with a hybrid external fixator, reported five patients (14%) with pin tract infections, three patients (9%) with non-union, and three patients (9%) necessitating realignment due to loss of reduction. Additionally, five patients (15%) experienced post-traumatic tibiotalar arthritis.

Our study encountered 16 cases (64%) of pin tract infections, all resolved with routine dressings and antibiotic treatment. We also observed 06 cases (24%) of ankle stiffness, 1 case (4%) of valgus malunion, 1 case (4%) of tendon impalement, and one case (4%) of non-union. Remarkably, pin tract infections were recurrent in patients who did not adhere to pin tract care practices.

In a study that established open reduction with plate and screw fixation as the standard, Ruedi and Allgower15 achieved 74% acceptable results in 84 patients. Mast JW et al.16 reported 78% satisfactory results in 37 patients with a minimum follow-up interval of 6 months. However, less favourable outcomes were reported when larger high-energy injuries were included in the analysis. For instance, Bourne et al,[17] studied 42 patients with tibial plafond fractures, of whom 62% were victims of high-energy trauma. Among the 16 Ruedi type III fractures treated with open reduction and internal fixation, only 44% achieved satisfactory results. Many of these fractures were complicated by non-union (25%), infection (13%), and arthrodesis (32%).

Collinge et al,[18] in a study focusing on high-energy distal metaphyseal fractures, managed through minimally invasive plating, reported an average fracture healing time of 35 weeks, with acceptable alignment restoration in nearly all cases. However, two patients (7%) experienced a loss of fixation, and 9 (35%) required secondary surgeries to achieve union. Bone LB et al,[19] reported on their series of distal tibia fractures treated using limited open reduction and internal fixation of the articular surface. This was followed by neutralising the fracture with an external fixator placed across the ankle joint. In this study, all fractures healed, with only two patients (10%) achieving poor clinical


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results. Complications were minimal, encompassing two cases of pin tract infection (20%), no deep infections, and no instances of skin sloughing.

Bonar and Marsh,[20] employed a hinged trans-articular external fixator for pilon fractures, yielding minimal postoperative complications. Specifically, there were no superficial or deep wound dehiscence cases, although five cases of pin tract infection were reported. Importantly, no instances of osteomyelitis were observed. Regarding clinical results, 69% were classified as good, 20% as fair, and 11% as poor. French and Tornetta12 achieved 69% good results in the context of energy injuries and successfully averted major complications using the hybrid external fixator technique. However, there was one case each of deep infection, superficial infection, malunion, and pin tract infection. Likewise, Barbieri et al,[6] reported 67% good results with the hybrid external fixator.

In our present study, which encompassed 25 distal metaphyseal fractures managed using a hybrid external fixator, nearly all fractures except one achieved union in an average of 21.12 weeks. The outcomes were distributed as follows: 17 cases (68%) exhibited good to excellent results, five cases (20%) yielded fair results, and one case (4%) resulted in poor outcomes. Incidentally, we encountered one pin tract infection (4%) and 1 case (4%) of valgus malunion.

## CONCLUSION

Hybrid fixation is a technique for managing distal tibial fractures that stabilise fractures without additional harm to soft tissues. This method proves effective in open fractures in the distal tibia, offering enhanced accessibility for soft tissue management and wound care. Additionally, concurrent fixation of the fibula aids in averting malunion. Therefore, hybrid external fixation is viable for treating distal tibial fractures, particularly in compromised soft tissues and open fractures.

**Limitations:** Although a valuable approach in addressing distal tibial fractures, hybrid fixation has specific constraints. One limitation is obtaining clear radiographic images of the articular surface when the fixator is positioned. Furthermore, hybrid fixators lack the capacity for dynamic adjustments to the construct, which may be a drawback in certain scenarios. In contrast to well-engineered multi-ring fixators, hybrid fixators might not furnish adequate stability for early weight-bearing. However, a small set of clinical cases suggests that hybrid external fixation remains a viable therapeutic option for distal tibial fractures, particularly in open fractures, as it exhibits comparable rates of union and complications to other reported studies.

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