



ISSN (P): 2521-3466  
ISSN (E): 2521-3474  
© Clinical Orthopaedics  
[www.orthoresearchjournal.com](http://www.orthoresearchjournal.com)  
2022; 6(1): 22-25  
Received: 13-11-2021  
Accepted: 17-12-2021

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## Study of a novel economical method of surgical management of complex distal tibia fractures with hybrid external fixator

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**DOI:** <https://doi.org/10.33545/orthor.2022.v6.i1a.344>

### Abstract

**Background and Objectives:** Fractures of the distal tibia, especially complex open fractures have been historically difficult to manage due to the poor soft tissue envelope around the bone and the precarious blood supply. In this study, we aim at devising an economical model of a hybrid external fixator for complex distal tibia fractures by using reused Ilizarov rings and A O rods after adequate methods of sterilization and study the functional outcome, time to union and complications associated with it.

**Objectives:** To devise an economical model of hybrid external fixator for the management of complex distal tibia fractures and to study the Functional outcome, Time to union and associated complications.

**Methods:** Total 16 patients with complex distal tibia [AO type 43(A1-A3, B1-B3, C1-C3)] fractures were treated in our institution with an economical model of hybrid external fixator using reused Ilizarov rings and A O rods after adequate methods of sterilization between June 2019 to December 2021. Patients were followed up every 6 weeks till 6 months and then at the end of 1 year. Patients were evaluated for functional and radiological outcome using the Ovadia and Beals scoring criteria. Time to union and Immediate and late complications were analyzed.

**Results:** Total 16 patients were evaluated postoperatively for functional and radiological outcome using Ovadia and Beals criteria which showed 3 patients (18.75%) had well to excellent and 13(81.25%) patients had fair outcome. The average duration for fracture union was 33.25 weeks. 6(37.5%) patients had pin tract infection which was treated with adequate antibiotics and pin tract care. No deep infections were noted. There were 7(43.75%) cases of joint stiffness, 5(31.25%) cases of mal union and 2(12.5%) cases of delayed union. Reusing the non invasive components of the fixator helped us in reducing the overall operating cost of the surgery by 35-40%.

**Interpretation and Conclusion:** In our study, we found that reusing the non invasive components of a hybrid external fixator is an economical treatment option for complex distal tibia fractures when combined with minimal internal fixation of fibula fracture, adequate antibiotic coverage, wound and pin tract care and aggressive physiotherapy.

**Keywords:** Hybrid external fixator, complex distal tibia fracture

### Introduction

Fractures of the tibial pilon are difficult to treat because of the severity of most injuries and the associated soft tissue injury. They are caused by high-energy compression stresses and frequently result in comminution and impaction of the distal tibia's weight-bearing surface [1]. The fracture is frequently an open injury with degloving of the soft tissue around the bone. Because the blood supply to the lower end of the tibia is tenuous, an open reduction of the fracture fragments in these fractures might result in nonunion as well as a high rate of wound complications [2].

The goal of treatment is to achieve articular congruence, alignment, adequate stability, soft tissue preservation, and early joint motion since the weight bearing articular portion of the tibia is implicated [1, 3, 4].

Whichever method of stabilization is chosen, the construct should be sufficiently stable to maintain the reduction. For this difficult fracture, hybrid external fixation with limited open reduction has proven to be a safe, repeatable, and effective treatment option [5].

In our study, we aim at devising an economical model of a hybrid external fixator for complex distal tibia fractures by using reused Ilizarov rings and A O rods after adequate methods of sterilization and study the functional outcome, time to union and complications associated with it.

### Objectives

To devise an economical model of hybrid external fixator for the management of complex distal tibia fractures and to study the functional outcome, Time to union and associated complications.

### Materials and Methods

The Prospective study included Patients presenting with complex fractures of distal tibia to our institution from June 2019 to December 2021. Adults Males and females (aged more than 18 years) with Complex fractures of the distal tibia (AO Classification 43(A1-A3,B1-B3,C1-C3) were included in the study. Patients with associated fractures of calcaneum, talus, other talar bones and metatarsals, and congenital abnormalities around the ankle joint were excluded from the study. Associated injuries are noted. Fractures were classified according to AO and Gustilo Anderson classification systems. Clinical and radiological investigations were carried out to get fitness for surgery. 16 Patients underwent hybrid external fixation for the sustained fracture with or without internal fixation for the fibula after informed consent for reuse of the non invasive components of the fixator. Patients were followed up at 6 weekly intervals till fracture union and once at 1 year after surgery.

### Operative Procedure

All patients were operated under Sub arachnoid block in supine position. Fracture site was thoroughly debrided and cleaned using copious amount of normal saline. Under C-arm guidance, provisional reduction was checked after manual traction and fixation of fibula fracture was done with minimal internal

fixation if permitted. the periarticular fragment was first secured using 3 olive wires passed through safe corridors under C-arm guidance attached to a 3/4<sup>th</sup> Ilizarov ring and tensioned accordingly. The diaphyseal fragment was secured using 3 4.5mm Shanz pins placed about 3cm apart in anteromedial aspect of tibia perpendicular to the tibia and connected to each other by AO rod and clamps. Fracture reduction was achieved using manual traction and the Ilizarov ring was connected securely to the Shanz pin using AO rods, male Ilizarov post and modified AO Clamp. Fracture stability was analyzed under fleuroscopy and final tightening of all connections were done. Open wound was sutured using non absorbable suture material.

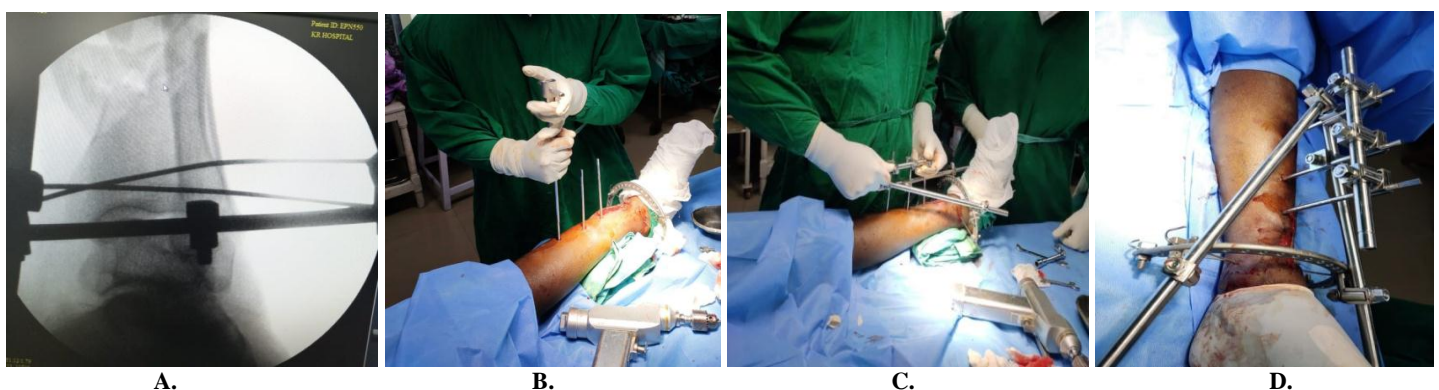
### Post-Operative Period

Active mobilization of the ankle, knee and non-weight bearing walking using standard walking frame was done from the second post operative day under the supervision of a physiotherapist. Intravenous antibiotic regimen was continued for 12-14 days after the surgery. Another 5 days of oral antibiotics were advised. Regular cleansing of the pin exit points and tightening of the connections was done. Patients were encouraged to do non weight bearing walking.

### Follow UP

Patients were followed up once in 6 weeks until fracture union and at the end of 1 year. Patients were assessed for Functional and radiological outcome using Ovidia and Beals criteria, time to union and complications. Fixator removal was done after radiological evidence of union. After fixator removal, posterior slab was given for a period of two weeks, when all the pin tracts healed well; patients were allowed for full weight bearing with ankle splint. Ankle splint was discontinued once patient has regained pain free range of movements.

### Operative Photographs



**Fig 1:** A) Securing periarticular fragment with tansfixation wires B) Securing diaphyseal fragment with Shanz pins C) fracture reduction and frame assembly D) final frame assembly





**Fig 2:** E) Gustilo Anderson Type II open fracture F) Pre operative Xray G) Post operative Xray H) Bony union at 6 months follow up I)Range of movements at 6 months follow up

## Results

Out of the 16 patients, majority were in the age group of 41-50(43.75%). Male patients were more in number (82.35%) compared to females. Road traffic accidents were the main mode of injury (87.5%). Right lower limb was involved in 11(68.75%) cases and left was involved in 5(31.25%)cases. AO type 43 A-3(43.75%) was the most common fracture type. Gustilo Anderson type II (43.75) was the commonest form of open injury. All the fractures were operated between 2-5 days post admission. The time required for union ranged from 26-40 weeks with an average of 33.25 weeks. Ovidia and Beals scoring system was used to assess the functional and radiological outcome. In this study, Objective evaluation showed 3(18.75%) good to excellent results and 13(81.25%) fair results. Subjective evaluation showed 4(25%) good to excellent results and 12(75%) fair results. There were no poor results. We had 7(43.75%) cases of joint stiffness, 6(37.5%) pin tract infections, 5(31.25%) cases of malunion and 2(12.5%) cases of delayed union. Reusing the non-invasive components of the fixator reduced the overall operating cost by 35-40%.

## Discussion

Distal tibia fractures are one of the most difficult fractures to treat. The soft tissue status, the degree of comminution and articular damage sustained determines the final results. The aim of surgery is to obtain anatomic reduction of the articular surface and provide adequate stability. This should be accomplished using procedures that decrease osseous and soft tissue devascularization. Hybrid external fixator is one such modality. The present study was under taken to determine the efficacy of an economical variant of Hybrid external Fixator in treatment of the complex fractures of the distal tibia in terms of functional outcome, time to union and complications encountered. We evaluated our results and various factors are discussed.

Our study revealed the average age of patients with such injuries to be 43.4 years (Range 28 to 60 years) which is comparable to that of other studies. In our study, the male preponderance were high 82.35% compared to the study by Barbieri *et al.* [6], which was 59%. In our study, road traffic accident (87.5%) was the predominant mode of violence which correlates with the study conducted by Aggarwal *et al.* [7] who had 87% patients with high energy injuries. Our study shows that clinical outcome of patients were fair to good mainly because of persistent mild swelling around the ankle and delayed union time. Study by Barbieri *et al.* showed 9% A1, 9% A2, 10% A3, 16% C1, 32% C2 and 24% C3. We had 56.25% patients with extra articular fractures (Type A), 12.5% with partial articular (Type B) and 31.25% with complete articular (Type C) fractures, of which the

functional outcome was better in the extraarticular group of fractures whereas the articular extension and comminution significantly reduced the functional outcome mainly due to ankle stiffness, low grade pain while walking on uneven surfaces and presence of chronic edema. All patients had fracture of fibula. Fibular length restoration was done in fractures where the fracture level is at or below the level of syndesmosis as suggested by several studies [8]. In fractures where the fibular fixation was not possible due to wound condition the final results showed malunion and change in the tibiotalar axis. The average time for fracture union in various studies conducted using various was 13-25 weeks. Our study had an average fracture union of 33.25 weeks which were comparable with the study conducted using the hybrid external fixator by Mayil Natarajan *et al.* [9]. Gaudinez *et al.* [10] had an average of 13 weeks for union of distal tibia. The prolonged time for union in the present study could be due to the sole inclusion of open fractures where soft tissue injuries could have jeopardized the vascularity around the already poorly vascularised distal tibia, compared to other studies which included a fair share of closed fractures as well. Other factors include lack of rotational stability in fractures where the fibula was not fixed and poor patient adherence to frame care including regular tightening of the frame components which resulted in loss of alignment and reduction.

**Table 1A:** Comparison of time to union with other studies

Study	Time to union(weeks)
Barberi <i>et al</i>	16
Tornetta <i>et al</i>	17
Guandinez <i>et al</i>	13
Anglen <i>et al</i>	20
Mayil Natarajan	28
Present study	33.25

**Table 1B):** Comparison of functional outcome with other studies

	Excellent	Good	Fair	Poor
Aggarwal <i>et al</i>	26%	50%	14%	10%
Zeman <i>et al</i>	26%	32%	26%	16%
Mayil Natarajan <i>et al</i>	50%	20%	15%	15%
Present study	0	18.75%	81.25%	0

Using the technique of hybrid external fixator, Tornetta *et al.* [11] accomplished 69% good results in the high energy injuries and major complications were avoided. There was one deep infection, one superficial infection, one malunion and three pin tract infections. In Barbieri *et al.* s study of 37 distal tibial fractures managed by hybrid external fixator, 5 patients (14%)

had pin tract infections, 3 patients (9%) with non union, 3 patients (9%) had loss of reduction requiring re alignment and 5 patients (15%) had post traumatic tibio-talar arthritis. In the present study, there were 6 cases (37.5%) of pin tract infections which healed with regular dressings and antibiotics, 7(43.75%) cases of ankle stiffness, 5 cases (31.25%) of varus malunions, and 2 cases (4%) of delayed union. Pin tract infections were seen repeatedly in patients who were not adherent to pin tract care. Lack of fibular fixation and non adherence to vigorous physiotherapy regime could be the cause of the increase in number of malunion and ankle stiffness respectively. Zeman *et al.* [12] in a study of using hybrid external fixators for periarticular fractures of the tibia obtained 5 excellent (26%), 6 very good (32%), 5 satisfactory (26%) and 3 poor results (16%). The economical model of the fixator was devised by reusing the non invasive components such as the ilizarov rings and AO connecting rods after meticulous sterilization to avoid any chance of iatrogenic contamination or infection. Comparing the cost expenditure to the patients who underwent hybrid fixation for similar fractures in the hospital, we found an average deduction in the operating cost of 35-40% when the non invasive components like Ilizarov rings and AO rods were reused.

At the end of the study ,we found that hybrid fixators can provide adequate stable fixation in open fractures without causing much soft tissue injury and can maintain length and alignment of the distal tibia while spanning the comminuted fracture region. The use of olive wires from opposite directions helps in achieving interfragmentary compression and to an extent help in maintaining articular congruity. However, Non-ankle spanning hybrid fixators does not provide enough stability against shear forces produced by the weight of the distal segment including the ankle and foot, especially in hefty and well built individuals. Hybrid fixators almost always require some form of limited internal fixation for the fibular fracture in both bone fractures and failure to address it leads to significant axial and rotatory instability. Hybrid fixators, unlike well-constructed multi-ring fixators, do not provide enough stability for early weight bearing.

### Conclusion

The present case series though small in number shows that Hybrid external fixator is an effective treatment method for distal tibial complex fractures in terms of union time and complications rate when combined with adequate internal fixation of associated fibula fracture, adequate patient compliance and aggressive physiotherapy.

**Funding:** None

**Conflict of interest:** None declared

**Ethical approval:** Considered and taken

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