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# A novel technique of managing compound tibia fractures with severe bone defects using the Ilizarov technique: A case series

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**Abstract**
**Introduction:** One of the commonly encountered surgical dilemmas for most orthopaedic trauma surgeons is the management of compound tibia fractures with significant bone defects. We used the Ilizarov technique to solve this complex problem using an ilizarov fixator over an intramedullary tibia nail. We present a case series of five such patients with compound tibia fractures with significant bone loss managed by bone transport over nail using Ilizarov technique.
**Materials and Methods:** This was a prospective study conducted between November 2013 and September 2016. A total of five patients with open type 3B fracture of tibia classified as per Gustilo-Anderson classification with bone loss of more than 5 cm following a road traffic accident who presented to us in the emergency department of JSS Hospital, Mysore were included in this study
**Results:** The mean duration of application of the external fixator was 9.2 months. All fractures united in 13.2 months, ranging 9-17 months. The mean external fixator index was 1.4months/cm. The mean follow up period was 9 months, ranging 7 to 24 months. The most common complication encountered was pin tract infection. One patient in our series had knee joint stiffness. The functional and radiological outcome was graded by the operating surgeon as excellent in two patients and good in three patients as per Paley criteria.
**Conclusion:** Our technique combining distraction osteogenesis and bone transport over nail using Ilizarov technique successfully treated tibial fractures with bone loss in a small group of patients. This technique had favourable bone union time, external fixator time, EFI, and clinical results compared with reported parameters in studies of other approaches mentioned.

**Keywords:** Bone transport, compound tibia fracture, severe bone defect, Paleys criteria, Ilizarov fixator

## 1. Introduction
One of the commonly encountered surgical dilemmas for most orthopaedic trauma surgeons is the management of compound tibia fractures with significant bone defects. The basic principles of treatment in such a situation would be to maintain the viability of the limb (vascular injury), to obliterate the bone defect with union at fracture site, to prevent infection and to restore original limb length [1, 2]. External fixators have been used with limited success due to it being an unstable construct resulting in a significant angular defect and non-union due to the fact that there is no compression at the fracture site. [1, 2] Intramedullary nails have also been used, but it doesn't solve the problem of limb length discrepancy and incidence of non-union is high.
Raschke *et al* [3] described a technique of segmental transport of the tibia over an intramedullary nail to provide a more comfortable bone transport process, to shorten the external fixation period, and to provide internal support for the regenerated bone. This technique is being accepted by a wider school of surgeons due to the improvement in patient cooperation and comfort. The two important drawbacks of this procedure are the inability to correct associated complex deformities and the risk of introducing infections especially from pin tracts into the medullary cavity. We used the novel technique to solve this complex problem using an ilizarov fixator over an intramedullary tibial nail. We present a case series of five such patients with compound tibia fractures with significant bone loss managed by primary nailing and bone transport over nail using Ilizarov technique.

## 2. Material and Methods

This was a prospective study conducted between November 2013 and September 2016. A total of five patients with open type 3B fracture of tibia classified as per Gustilo-Anderson classification with bone loss of more than 5 cm following a road traffic accident who presented to us in the emergency department of JSS Hospital, Mysore were included in this study.

In the emergency room before splinting the extremity, gentle wound wash with copious amount (3-5litres) of saline was done and wound was covered with sterile dressing.

**2.1 Operative technique:** Prophylactic intravenous third generation cephalosporin was given half an hour before surgery to all patients. All patients were operated within six to ten hours of injury. Aggressive debridement that involved exploration of wound, excision of devitalized tissues and removal of foreign materials was performed in a meticulous fashion. An unreamed 9mm intramedullary tibia nail was inserted with 2 proximal and 2 distal interlocking screws. Antibiotic impregnated (vancomycin 2 gm) cement beads were inserted at wound site in three patients. The soft tissue was temporarily approximated with stay sutures to cover bone. Finally an above knee slab was applied to immobilize the limb. In two patients, wound coverage was done with crossed leg flap, rotation flap in 1 case, skin graft in 2 cases. After 3 weeks when the wound was healthy, antibiotic beads were removed and Ilizarov ring fixator was applied under C-arm guidance. Two Ilizarov wires were passed into proximal tibial plateau initially. An olive wire was then passed in the middle third of tibia posterior to tibia nail. Finally a 4mm Schanz pin was passed in the antero-posterior direction medial to nail. In the distal tibia, two olive wires were passed lateral to medial posterior to nail. Using these wires a three ring Ilizarov fixator were constructed (proximal, middle, distal). Corticotomy was performed between proximal and middle ring in the proximal tibial metaphyseal region with drilling the site using 3.2 mm drill bit and corticotomy completed using thin osteotome. (Figure 1) Distraction at corticotomy site was initiated from day 5 between proximal and middle ring at rate of 0.25mm, four times daily in regular intervals. Compression between middle and distal ring performed at a rate of 0.25 mm twice daily, which was initiated after ten days. (Figure 2, 3) The ankle joint was not immobilized. Foot ring was not used in any of the patients. Patients were mobilized full weight bearing with support from the first post-operative day.

Regular follow up was done at fifteen days interval with check x-ray of leg including knee and ankle. Iliac bone grafting to fracture site performed in 2 cases, iliac bone marrow injection was used in three patients, four months after initial surgery. The Ilizarov fixator was removed when the proximal tibial regenerate consolidated well. (Figure 3)

We evaluated external fixation time, external fixation index (defined as the duration of external fixation in months divided by the total amount of bone transported and/or the amount of lengthening in centimetres), and time to union on plain radiographs, clinical results using the Paley bone and functional assessment scores, and postoperative complications from chart review. Conventional radiographs were taken every 2 weeks during the distraction phase and once a month during the consolidation phase. AP and lateral radiographs of the tibia were used to determine bone union and consolidation. (Figure 2, 3) Antero-Posterior and lateral radiographs of the tibia were taken for all patients. All radiological measurements and functional and bone assessment scores were determined at the final follow-up by the same surgeon. External fixator time was defined as the interval from the application of the fixator to removal of the fixator. External fixation index was defined as the duration of external fixation in months divided by the total amount of bone transported and/or the amount of lengthening in centimetres. Radiographic union was defined as the presence of callus in three of the four cortices as seen on AP and lateral radiographs (Figure 3)

Paley's criteria were used to assess the final functional outcome of the limb and radiological union of the fracture of tibia. The bone healing was graded, according to Paley's criteria, [4] as excellent when union was achieved along with absence of infection, a deformity less than 7° and limb length discrepancy<2.5 cm. It was graded as good when there was union along with any two of the other three criteria and fair when only one of the three criteria was fulfilled along with union. Nonunion along with a persistent or recurrent infection was considered a poor result.

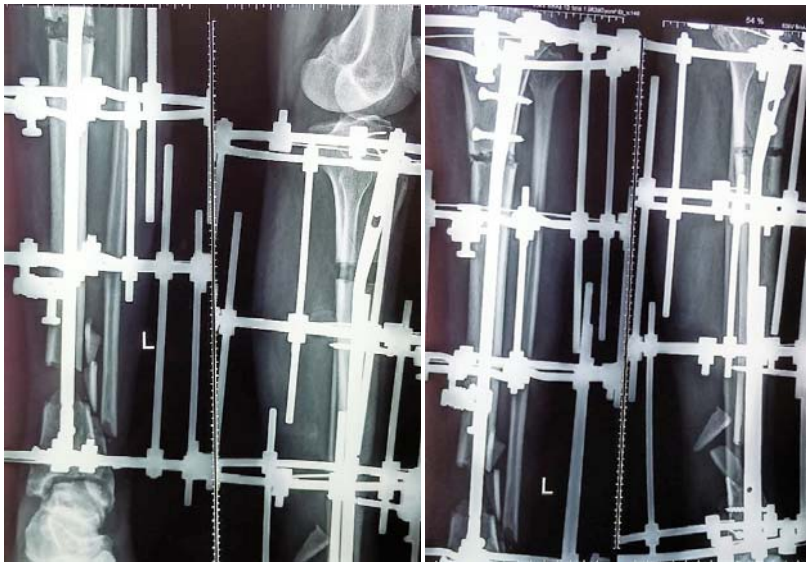


**Fig 1:** X-ray of the leg demonstrating Corticotomy done at proximal tibia level.

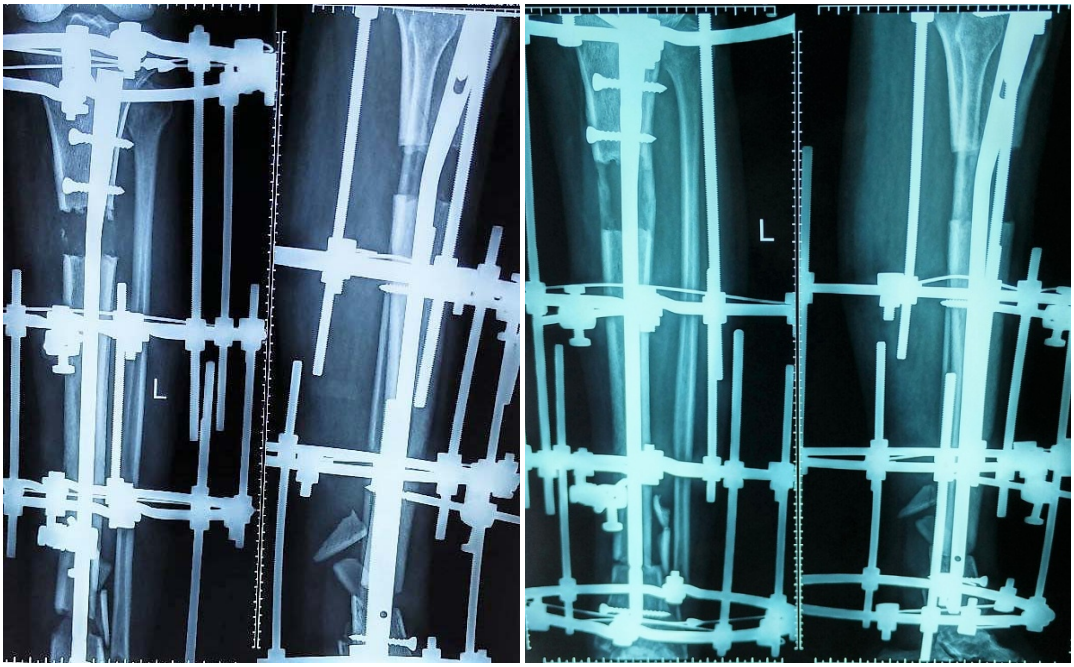


**Fig 2:** X-ray of the leg showing regenerate developing at the corticotomy site and compression at the fracture site.

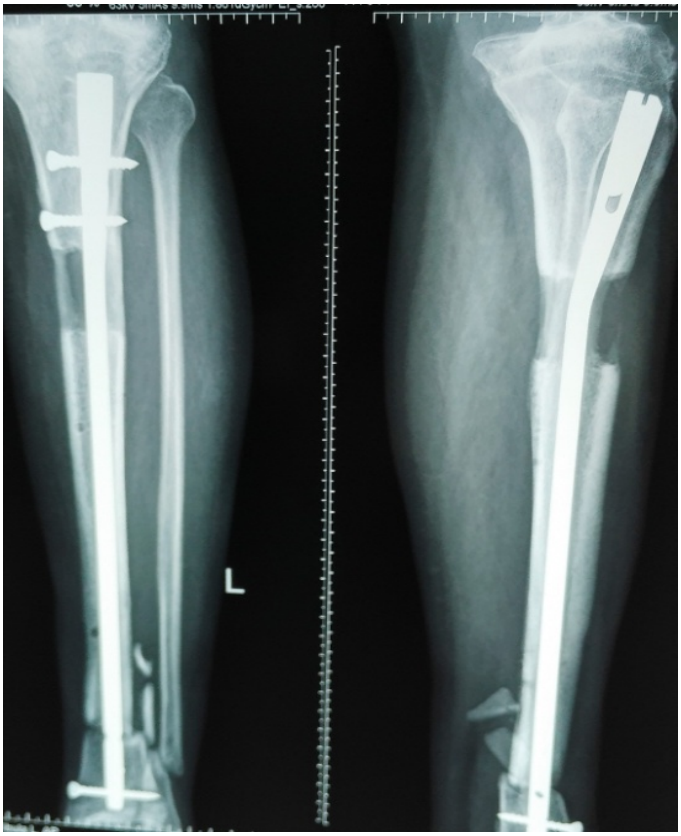


**Fig 3:** X-ray showing distal fracture site and proximal tibial regenerate healing in progress.

**Fig 4:** Clinical photograph showing the range of motion of the affected limb and knee joint.

## 3. Results

Our case series included five patients. All the patients were males. The mean age of the patients in our case series was 39 years, ranging from 23 to 52 years of age. All fractures were classified as type 3 B according to Gustilo-Anderson classification at the time of primary injury. The mechanism of injury in all our patients was road traffic accidents. All patients presented to emergency within 6 hours of injury. The mean size of the bone defect observed in our series was 6.4cm, ranging 5 to 8cm. the level of fracture of the tibia was distal third in three patients and mid third in two patients. The mean duration of application of the external fixator was 9.2 months. All fractures united in 13.2 months, ranging 9-17 months. The mean external fixator index was 1.4months/cm. The mean follow up period was 9 months, ranging 7 to 24 months. The most common complication encountered was pin tract infection. One patient in our series had knee joint stiffness. The functional and radiological outcome was graded by the operating surgeon as excellent in two patients and good in three patients as per Paley's criteria.

## 4. Discussion

Open fractures of the tibia have been a surgical challenge for orthopaedic surgeons especially in such injuries associated with significant bone defects and soft tissue loss. Among many complications, arguably the biggest challenge for the surgeon is to find a solution to counter the bone gap and achieve soft tissue coverage keeping healthy bony union as the ultimate goal in mind. Deep infection, compartment syndrome, deep vein thrombosis, non-union are notorious problems complicating these injuries [1, 5]. An effective answer to these challenges is the Ilizarov fixator as it corrects angulation at the fracture site, extremely stable construct, allows to cover bone defect and finally it allows the surgeon to perform a flap or a skin graft to cover the soft tissue defect. Ilizarov fixators are also applied percutaneously with minimal injury to soft tissues. Muscle flap has been widely used for coverage of large soft tissue defects. They provide a barrier against infection and also prevent desiccation of fracture fragments [1, 6].

We present our case series of five patients where the patients were operated using an intramedullary tibial nail initially following wound debridement and lavage. After three weeks, the Ilizarov fixator was used using a bifocal approach to allow the closure of the bone defect distally with regenerate occurring proximally. The intramedullary nail acted as an internal splint to prevent fracture displacement and also to maintain the tibial length. Once the flap healed, then the Ilizarov fixator was used to cover the bone defect based on the principle of distraction histiogenesis.

Distraction histiogenesis has been used as a technique to gradually obliterate soft tissue defects and certain schools of thoughts advocate them as an effective technique [1, 9]. However in our case series we used fasciocutaneous or muscle flaps in three of our cases. In two patients we used cross leg flap from the opposite limb. In one patient we used a rotational gastrocnemius rotational flap from the same leg. The decision to use flaps was taken due to the size of the defects being more than five centimeters in all the patients, and due to the availability of plastic surgery expertise in handling these complex cases.

The use of intramedullary nail in combination with ilizarov external fixator in such injuries is helpful in overcoming the challenges like shortening, plastic deformation, angular deformity, and fracture of regenerated bone [10]. In our case series bone apposition at docking site was achieved in 5 months. In a similar study by Gulabi *et al*, apposition at docking site was achieved in a meantime of 21.2 days [10]. This combination of nail and ilizarov fixator helps in decreasing the duration of usage of external fixator, External fixator index (EFI) and consolidation index (CI). In our series the mean duration of use of external fixator was 9.2 months. The mean EFI was 1.4 months/cm and the mean CI was 0.6 months/cm. The mean bone loss was 6.4 cm. In a study by Cierny and Zorn [10], the EFI was calculated as1.6 months/cm for a mean bone loss of 6.4 cm, Saleh and Rees [11] reported an EFI of 2.04 months/cm for a mean bone defect of 4.7 cm, Eralp *et al* [12] reported EFI as0.45 months/cm for a mean defect of 7 cm by using the combination of external fixator with intramedullary nail, Sala *et al* [13]. reported EFI as 2.0 ± 0.9 months/cm for a mean defect of 8.0 ± 2.6 cm using the Taylor Spatial Frame (Smith & Nephew, Memphis, TN, USA), and El-Rossay [14] reported EFI as 1.3 months/cm for a mean lengthening of 4.9 cm. Gulabi *et al* in his study, demonstrated EFI to be 0.4 months/cm, and mean bone loss was 8.6 cm.

Using bifocal compression-distraction with an Ilizarov-type circular external fixator, Sen *et al* [15] described the results of acute shortening and relengthening in the acute treatment of Grade III open tibial fractures with osteocutaneous loss in 24 patients. The bone results in their series were excellent in 21 (88%) and good in three (12%). The functional results were excellent in 19 (79%), good in four (17%), and fair in one (4%) patient. However, external fixation time was 7.1 months, EFI was 1.4 months/cm, and bone healing time was 7.5 months, which were longer than in the present study. This was probably because they did not combine circular external fixator with intramedullary nailing; they did not use primary grafting of the docking site. In our study the CI and EFI was in the average of 0.6 and1.4 months/cm respectively.

Our combined technique has the potential to decrease the EFI and external fixation time by reducing problems originating from the circular external fixator [10, 16, 17]. The use of intramedullary nailing together with an external fixator reduced the number of Schanz screws and Kirschner wires needed with the fixator. In this combined technique, a circular

external fixator was preferred over a unilateral external fixator to avoid valgus malalignment deformity [10, 16]. Angulations and translations were recorded as a bone transport complication. We did not observe any valgus deformity resulting from the Ilizarov external fixator. Based on our results, we conclude that using an intramedullary nail with an external fixator will help minimize angulation and malalignment of the regenerated bone segment.

None of the patients exhibited knee ROM loss, anterior knee pain, or skin wounds associated with the nail. (Figure 4) One patient had knee stiffness and was subjected to manipulation under anaesthesia following which he recovered functional range of movements of the knee.

Equinus deformity is a frequently encountered complication during bone transport and lengthening [10, 14]. Eldridge and Bell [10] proposed that the foot must be included in the frame if the desired distraction is more than 10% of the total tibial length. In the current study, we had no such complications.

## 5. Conclusion

Our technique combining primary tibia nailing and bone transport over nail using Ilizarov technique successfully treated tibial fractures with bone loss in a small group of patients. This technique had favourable bone union time, external fixator time, EFI, and clinical results compared with reported parameters in studies of other approaches mentioned. However, future studies directly comparing available approaches to this surgical challenge is warranted.

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