RESEARCH PAPER

A prospective study of open tibial fractures treated with reamed interlocking intramedullary nail

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Introduction

Tibial diaphyseal fractures are one of the commonest long bone fractures seen today probably due to increased road traffic accidents and about 25% of them are open fractures. Tibial diaphysis open fractures are frequently linked with significant bone and soft-tissue damage complications are considerably increased when the fracture site is contaminated and the soft-tissue envelope is devitalized. These consequences lead to a great burden on healthcare costs and also affect the quality of patient's life.

High energy trauma is the primary mechanism of injury, with over 50% of cases being attributed to road traffic accidents or falls from a great height and are frequently contaminated[1,2] . Males are most commonly affected than females, with the male incidence being about 41 per lakh per year and the female incidence about 12 per lakh per year[3]

There are various treatment modalities available, such as conservative gentle manipulation and the use of a short leg or long leg cast, open reduction and internal fixation with plates and screws, intramedullary fixation (including Ender pins, intramedullary nails, and interlocking intramedullary nails with reaming or without reaming), and external fixation techniques such as the Ilizarov ring fixators or uniplanar fixators. The surgeon should be competent of using all these methods and must weigh advantages and disadvantages of each one and choose the best treatment.

Treatment objectives include correction and maintenance of alignment in sagittal and coronal planes, restoring the length of tibia, preventing infection, promoting bony union, and early rehabilitation.

The important factors in prognosis are

- Amount of initial displacement
- Degree of comminution
- Whether infection has developed and
- Severity of soft tissue injury excluding infection[4]

Immobilization in a plaster cast was used most commonly in the past but it does not always maintain the length of the tibia and it leaves the wound relatively inaccessible. Open reduction and internal fixation with plates and screws may be selected for fractures with mild or severe local injuries, associated with intra-articular fractures of knee and ankle but this has yielded unacceptably high rates of infection[6,7]. External fixation, considered the method of choice by many traumatologists, has the drawbacks of the bulky frames and frequent pin tract infections, nonunions, and malunions[6,8]. External fixation also increases the time of hospital stay, financial burdens as there is high incidence of re-surgeries. IM nails such as Lottes and Ender nails used without reaming have been used efficiently in the management of open tibial fractures and have been associated with low rates of post operative infection. They are however not indicated for comminuted fractures as there tends to be shortening or displacement of such fractures around these small nails[9,10]. This results in frequent malunions and nonunions with these types of implants.

With the advent of Intramedullary interlocking nails, the problem of loss of rotational stability and shortening after intramedullary fixation decreased due to firm proximal and distal fixation of nail to bone with screws. Interlocking intramedullary nail fixation can be done without reaming or after reaming. Earlier unreamed nail was thought best to be used in open fractures of tibia because it doesn't compromise the intramedullary blood supply. But it had its own demerits such as unstable fixation, breaking of screws leading to implant failure during weight bearing which was seen in studies conducted by Blachut et al[11] and Vishwanath et al[12].

This led us to design a trial to study the effects of primary reamed interlocking intramedullary nailing as a treatment method for open fractures of tibial diaphysis and know the clinical efficacy in terms of time duration required for weight bearing, duration required for radiological union, range of motion at knee and ankle joints and occurrence of complications such as nonunion, malunion, infection, compartment syndrome, fat embolism, and implant failure.

Material and Methods

This study was conducted at Sawai Man Singh medical college and hospitals from April 2020 to December 2021 after obtaining ethical clearance. 50 patients who presented to trauma centre emergency department with open fracture of tibia were included in the study. of them 9 were lost to follow up and 41 patients with open fractures of tibia who were managed with primary reamed interlocking intramedullary nailing were analysed.

Skeletally mature patients between the age of 18 to 70 years of both genders who sustained open tibial diaphyseal fractures of grade I to grade IIIa according to Gustilo Andersons classification were included in the study after informed consent. We excluded the patients with articular extension of fractures, fractures extending proximal to tibial tuberosity and patients having severe bone loss of tibia.

Patients with open tibial diaphyseal fractures on presentation were taken to minor OT and thorough wash with normal saline was given, and any contamination with foreign particles was removed and covered with sterile dressing and limb was splinted. This was followed by adequate analgesia and tetanus prophylaxis. Antibiotics given were inj. ceftriaxone 1gm i.v and amikacin 500mgi.v which was continued every 12 hourly.

On admission, the patient's general condition was examined for hypovolemia, related orthopaedic or other systemic injuries, and appropriate resuscitation methods were performed. A thorough clinical examination was carried out, which included a detailed history of the patient's age, gender, occupation, mechanism of injury, and previous and concomitant medical illnesses. All the patients had routine investigations performed. To rule out any further injuries, all patients were assessed clinically and radiographically. A-P and Lateral views were used for the radiographs. Patients were operated on as soon as possible after their general condition had stabilised and they were deemed fit for surgery. The nail length was measured from the highest point of the tibial tuberosity to the medial malleolus prior to surgery.

Preoperatively written informed consent was taken and patients were kept NPO for 8 hours before surgery. Adequate amount of compatible blood if needed was arranged. Preparation of whole extremity /private parts and back was done. I.V antibiotics were given 30 minutes before the procedure.

The surgery was performed under spinal anaesthesia. The patient is positioned supine on a C-Arm compliant surgical table. The afflicted leg is positioned freely on the operating table, with the knee flexed 90 degrees over the edge to relax the gastro soleus muscle and allow sufficient traction to be given. To ensure free movement of the image intensifier from the A.P to the lateral plane, the opposite leg is put in abduction, flexion, and external rotation. The injured leg is washed with betadine scrub solution from groin to foot and painted with betadine solution. The rest of the body and limbs are draped properly using sterile drapes. A thorough wound debridement of the open wound was done and washed with copious amounts of normal saline and the wound was given a sterile covering. The instruments used for debridement were replaced with fresh instruments.

A vertical patellar tendon splitting incision is made across the skin, reaching about 5 cm from the centre of the inferior pole of the patella to the tibial tuberosity. To reach the proximal part of the tibial tuberosity, split the patellar tendon vertically in the centre and retract it. The next step is to determine the insertion position; the accurate selection of the insertion point is critical to the procedure's success. The insertion position should be slightly distal to the tibial plateau, in between the medial and lateral lips of tibial spine, and perfectly aligned with the medullary canal as a general rule. There is a risk of fracturing the distal cortex of the major proximal fragment if the insertion point is too far away, especially in the case of proximal fractures. A curved bone awl is used to breach the proximal tibial cortex after determining the insertion position. Create an entry portal in the metaphyseal cancellous bone, aligning it with the medullary canal's centre. A proximal reamer is used to broaden the point of entry. After proximal widening of the medullary canal, a guide wire is inserted into the medullary canal of the proximal fragment, and the fracture fragments are reduced using an image intensifier while maintaining longitudinal traction in the tibia line. The tip of the guide wire is modified to pass into the distal fragment up to 0.5-1cm above the ankle joint under image intensifier once reduction is completed. confirm its containment within the tibia by anteroposterior and lateral views. Following which intramedullary reaming was conducted over the guide wire with use of cannulated power reamers. First, the surgeon reamed the intramedullary canal until the first detection of cortical chatter, forming the basis for the nail diameter. Following the appearance of cortical chatter, further reaming of 1mm larger than the chosen nail's diameter was done. Next an assemble nail of appropriate sixe was passed over the guide wire and its position and reduction confirmed under c-arm. Both proximal and distal locking was done. All incised wounds were washed and closed. After that the open wound was addressed and suitable closure was done. If it was not amenable to closure in primary setting then sterile dressing was done and patient was taken into surgery for closure within 5 days.

Postoperatively I.V antibiotics were given for 3 days. Whenever infection of the wound was suspected culture from the wound was sent. Switch over to oral antibiotics done on 4th postoperative day. Skin sutures, were removed between 10th to 15th postoperative days. Depending upon the culture report and wound condition antibiotics were stopped /continued.

The patient initially is placed in below knee slab, and early range of motion exercises are begun. Noncompliant patients or patients with unstable fracture fixation are placed in a patellar tendon-bearing cast until enough healing occurs to ensure stability. Unrestricted weight bearing is permitted in axial stable pattern (transverse fracture). Weight bearing is restricted until early callus (4 to 6 weeks) and then is progressed as tolerated in fractures without axial stability and those at the proximal or distal metaphyseal junction. Further follow up was done at 4 weekly intervals and each patient was individually assessed clinically and radiographically.

RESULTS

Open tibia fractures pose a significant challenge in orthopaedic care, requiring a nuanced understanding of their severity and appropriate treatment strategies. The Gustilo Anderson (GA) classification system serves as a crucial tool in categorizing these fractures. This article delves into the functional outcomes of open tibia fractures based on GA types, examining complications, range of motion (ROM) at the knee and ankle, duration of union, full weight bearing, and shedding light on the implications for patient recovery.

Complications Analysis: A comprehensive examination of complications associated with each GA type provides valuable insights into the challenges faced during the treatment of open tibia fractures.

- GA TYPE I: Notably, 9 cases showed no complications, indicating a favourable prognosis. One case experienced malunion, emphasizing the need for careful monitoring even in seemingly less severe fractures.
- GA TYPE II: Complications were more varied, with 21 cases reporting no issues, while 2 cases resulted in malunion. Additionally, 1 case each exhibited infective non-union and shortening with deep infection, highlighting the multifaceted nature of GA Type II fractures.
- GA TYPE III: Although this category tends to present more severe fractures, the data indicate varying complications. Five cases reported no issues, while one case each demonstrated infective non-union and superficial infection. The absence of malunion or shortening with deep infection in this group may indicate effective management strategies.

Range of Motion (ROM) at Knee following fracture union is as follows:

- In cases across all GA types, a significant number achieved full ROM at the knee, with 8, 20, and 6 cases in GA Type I, II, and III, respectively.
- Notably, 1 case in GA Type I achieved >90% ROM, emphasizing the potential for favourable outcomes even in seemingly less severe fractures.

Range of Motion (ROM) at Ankle following fracture union is as follows:

- In GA Type I, the majority achieved full ROM (8 cases), while 2 cases had >75% ROM.
- GA Type II presented a mix of outcomes, with 16 cases achieving full ROM and 7 cases having >75% ROM.
- GA Type III, despite the severity, displayed encouraging results, with 4 cases achieving full ROM and 2 cases having >75% ROM.

Duration of Union: The mean duration of union, a critical parameter in assessing the healing process, is as follows:

- GA TYPE I: 17.20 weeks (SD: 6.81)
- GA TYPE II: 16.35 weeks (SD: 5.77)
- GA TYPE IIIa: 20.00 weeks (SD: 4.00)

Full Weight Bearing: The mean time to achieve full weight-bearing is as follows:

- GA TYPE I: 8.00 weeks (SD: 5.96)
- GA TYPE II: 8.92 weeks (SD: 5.72)
- GA TYPE IIIa: 12.57 weeks (SD: 5.38)

Funvtional outcome calculated using Johner Wruh's criteria gave the following results:

- Poor - 1
- Fair – 3
- Good – 9
- Excellent – 28

DISCUSSION

Tibia is one of the most commonly fractured long bones of the body with around 25% of them being open fractures. Majority of open fractures result from high energy injuries such as road traffic accidents and fall from height. Open fractures of tibia are prone to complications mainly due to lack of soft tissue coverage and precarious blood supply. The most common and dreaded complication is infection which further leads to more complications.

The optimal management of open tibial shaft fractures continues to be a problem with several unanswered questions. The management of these fractures requires a multimodality approach in order to achieve a favourable healing, early ambulation and excellent outcome for the patient.

There are various ways by which an open fracture of tibia can be fixed. Recent improvements in wound coverage techniques and broad spectrum antibiotics have led to a decrease in complications of open tibial fractures.

Johner R *et al* [13] reported non-union was twice as common and infection five times more likely when open fractures were treated with plating, so use of a plate is an unattractive treatment option.

External fixation techniques maintain several advantages in the treatment of severely comminuted open tibial shaft fractures (grade IIIB and C), thus providing early stabilization in patients with polytrauma, improving the survival of injured tissues and permitting turning and mobility to prevent general complications in these patients. Currently, in grade I, II and IIIA open fractures, the use of external fixation has been reduced. Malunion and delayed union are common with this technique [4]. To avoid these complications, some authors have recommended the use of secondary intramedullary nailing after external fixation, but this procedure has an increased prevalence of deep infections after delayed conversion or previous pin tract infections.

Of the various intramedullary devices available, the unreamed unlocked nails have produced good results in open tibial fractures but the implant did not adequately stabilize the comminuted or segmental fractures. In a randomized prospective study comparing external fixation with Ender's nails, Holbrook *et al* [9] evaluated twenty eight open tibial fractures treated with external fixation and found a 14 percent rate of deep infection, a 21 percent rate of pin tract infection, and a 36 percent rate of malunions. For twenty nine comparable open fractures treated with Ender nails, they reported a 7 percent rate of infection and a 21 percent rate of malunion. The major limitation of ender's nail fixation is lack of axial control.

This limitation can be overcome with interlocking intramedullary devices, which includes unreamed and reamed intramedullary interlocking devices. In unreamed nailing, there is low risk of fat embolism and several studies suggest better preservation and more-rapid recovery of the intraosseous blood supply after insertion of a small-diameter nail without reaming [14]. In contrast, studies by Blachut et al.[11] and Court Brown et al.[15] seem to indicate that nonunion and malunion occurs more frequently with unreamed nailing. These studies also indicate increased incidence of screw breakage with unreamed nailing.

Therefore, reamed interlocking intramedullary nail combines the most desirable features of external fixators and of non locking intramedullary fixation. Length, alignment and rotation can be controlled, and soft tissues are easily accessible. These factors enable better post operative wound care and rehabilitation and lower the complication rate.

In current series 50 patients with open tibial diaphyseal fractures were treated with interlocking intramedullary nail. Among the 50 patients 9 patients were lost to follow up. 41 patients were followed up at regular intervals for a period of 6 to 10 months. The purpose of this study was to evaluate the functional outcome of treatment in these patients which is dependent on various factors like fracture union, range of motion at ankle and knee and complications.

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In this series there were three cases of infection (7.3%) which included one case of superficial infection which was treated with i.v antibiotics and one case of deep infection which required secondary debridement and i.v antibiotics and one case went to have infective non union. This is comparable to other series reporting infection rate ranging from 2.4% to 14.4% with interlocking intramedullary nailing in open tibia fractures. It is more favourable when compared other studies which report infections upto 30% with other modalities of management[16,17].

Malunion was defined as angulation in coronal plane >5º and sagittal plane >10º. In our series three cases of malunion have occurred. It is favourable compared to other modalities of management where malunion is as a high as 14.5% to 20%[17].

One patient in our study had nonunion. These results were comparable to those obtained by Blachut PA et al.[11] who noted non-union rate of 4.1% in the reamed interlocking intramedullary group. Keating JF et al[15] in his study of 94 patients observed that the non-union rate in the reamed interlocking intramedullary nail group was 8% which are comparable to our study.

In our study 34 patients (82.9%) had full knee ROM and 28 patients (68.3%) had full ankle ROM.

Our study shows that delayed weight bearing affects the range of motion at both ankle and knee joints. The mean duration of union was 17.2 weeks. Transverse and oblique fractures showed union within 15 weeks and comminuted fractures took an average of 21 weeks for union. Functional outcome in our study was measured using Johner Wruhs criteria which showed that 28 patients (68.3%) had excellent outcome, 9 patients (22%) had good outcome, 3 patients (7.3%) had fair outcome and 1 patient (2.4%) had poor outcome.

The average age of all cases in this series was 34.5 years. The fracture was more common in the age group of 20-40 years. The average age in a study of 50 open fractures of tibia conducted by the author Ellis H[18] showed that the average age was 34 years. In a study of 43 open fractures of tibia conducted by Singer RW et al[19] the average age was 36 years.

In this study Majority of the patients, 36 out of 41, were males. As the number of female patients was only 5, we conclude that gender difference did not play a role in final outcomes. The sex distribution in a study by the Leunig M et al[20] showed that there were52 men and 19 women. In a study by the Singer RW et al [19] there were 30 males and 11 females.

In our study none of the patients developed fat embolism, compartment syndrome, peroneal nerve palsy, or implant failure.

Our analysis from this study suggests that primary reamed intramedullary interlocked nailing with thorough debridement and good antibiotic coverage and soft tissue coverage is a safe way of treating open tibial diaphyseal fractures of typeI to typeIIIa.

CONCLUSION

Primary interlocking intramedullary nailing with help of image intensifier is a feasible method of treatment in open tibial diaphyseal fractures. Thorough debridement of the wound with good antibiotic coverage followed by soft tissue coverage is the key to minimize infections after these injuries. Ease of access for wounds lessens the burden during soft tissue coverage and post operative care. Early mobilisation of the patients helps in healing of the fracture and prevents joint stiffness. It also decreases the time period of hospital stay and facilitates early return to activities. Primary reamed intramedullary interlocking nailing has decreased complication rates when compared to other modalities of treatment.

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