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## Clinical and radiological outcome of intramedullary nailing in grade I and II (Gustilo-Anderson) compound diaphyseal fractures of tibia

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### Abstract

**Background:** The effectiveness of primary intramedullary nailing in open diaphyseal fractures in tibia is still controversial and the available literature is unclear. We conducted a study to evaluate the functional and radiological results of primary reamed intramedullary nailing in the management of open diaphyseal tibia fractures of Grade I & II (Gustilo-Anderson).

**Patients and Methods:** This is a prospective study, in which 30 Grade I & II open diaphyseal fractures of tibia who came to our hospital EMS fulfilling Inclusion & Exclusion criteria were included in this study. This study was done from the period of Jan 2017 to Sept 2018. They were evaluated on each follow up clinically by Klemm & Borner Score, radiologically by RUST score and the rate of infection was evaluated using Southampton Score.

**Results:** The average rate of union in this study was 28.5 weeks. 5 patients developed delayed union out of which 4 patients underwent dynamization. There was a significant improvement in all the scores compared to previously available method of fixation. Factors that influenced infections and delayed union in this study were Grade of injury, Diabetes and the habit of smoking.

**Conclusion:** Results of our study shared that, primary Intramedullary Nailing in Grade I & II open Diaphyseal fractures of tibia showed earlier fracture union when compared to the historical data on modalities of fixation with lesser infection and non-union rates.

**Keywords:** Primary nailing, tibia, open fractures

### Introduction

The tibial shaft is one of the most common sites of open fractures [1]. The incidence of tibial diaphyseal fractures are 26 per 1 lakh population, in which 23% of tibia fractures are open fractures [2].

Gustillo *et al*, has stated "The primary objective in the management of an open fracture is union with prevention or eradication of wound sepsis". As urbanization and industrialization are progressing with time, with rapid increase in traffic, incidence of high velocity trauma are also increasing [3]. As tibia is having 2/3<sup>rd</sup> of subcutaneous surface, they are more prone for open injuries. Further more the distal end of tibia has precarious blood supply than other long bones, because of inadequate muscle coverage [5].

There are five principle causes of tibial-diaphyseal fractures; direct blow, assaults, sports injuries, falls, motor vehicle accidents and gun shot injuries [3]. The important factors in prognosis are, Amount of displacement, Degree of comminution, Severity of soft tissue injury, Contamination of the wound, Duration of time lapsed for the initiation of treatment [6].

Five goals are aimed for the successful treatment of open fractures of tibia. Prevention of infection, maintaining limb length, achievement of bony union, prevention of deformity and restoration of function [3]. These goals are interdependent and usually are achieved in the chronologic order given. For instance, failure to prevent infection promotes delayed union or non-union, chronic osteomyelitis and ultimately delays functional recovery. Immobilization in a plaster cast has been used most commonly in the past but it does not always maintain the length of the tibia and it leaves the wound relatively inaccessible and rehabilitation will also be difficult due to stiffness, following prolonged immobilization.

Tibial shaft fractures occurring between 4 cm proximal to the ankle joint and 4 cm distal to the

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tibial tuberosity may be treated with interlocking techniques [7]. Excellent results were shown by treating these fractures with this technique [2, 8-11]. Gustilo *et al.* [12], and colleagues found the outcome differences in the subtypes with an infection rate of 4% in type III A, 52% in III B and 42% in III C. Court Brown *et al* [2, 8]. Reported that the time to union and infection rates were similar when open tibial fractures of type II, III A and III B were treated by reamed locked intramedullary nail or an external fixator. Bone *et al* [13]. Also showed good results with closed primary interlocking nailing in open tibial fractures. In a study by Keating *et al* [10]. On reamed vs unreamed nailing for open fractures of tibia Grade I, II, III a and B showed no significant differences in the results, however there was limitations in this technique with the prevalence of infection.

Studies had shown that reaming disturbs cortical blood flow to a greater extent than unreamed nails [14]. Possibly increasing susceptibility to infection. Few studies suggested that unreamed nails are superior to external fixator or reamed nail in management of open fractures of tibia [15, 16]. While in other studies there were no significant differences between reamed and unreamed nailing. Fixation, using reamed nailing for management of open tibia fractures is still debated in spite of its increased stability, because as theoretically there is an increased risk of nonunion as a consequence of disturbed endosteal blood supply [17].

Intramedullary nailing in open fractures of the tibia is a well-accepted treatment modality in the developing world. References are scanty regarding the incidence of infection/nonunion related to specific type of open injury with this background [13]. We conducted a prospective study at our institution to evaluate clinical, functional and radiological results of primary intramedullary nailing with adequate soft tissue cover in management of open fractures of tibia.

#### Statement of informed consent

Written informed consent was obtained from the patient and Ethics Committee for publication of this case series and any accompanying images.

#### Methodology

It is a prospective observational study. This study was done in a single center. The study population was 30, consecutive Sampling. Study was conducted from Jan 2017 to Sep 2018 (Including the last follow up case period of 9 months from Jan 2018). Patients who presented with grade I & II open diaphyseal tibia fracture in our EMS satisfying inclusion criteria were selected in this study. Patients included in our study were of age [18-60 years], had an open diaphyseal (Gustilo Anderson) Grade 1 and 2 fracture of Tibia, patient presenting within 72 hours of injury and patients who gave consent for treatment by Primary Nailing with a follow up period for 9 months. The exclusion criteria were, open fractures of Tibia type IIIA, B & C according to Gustilo Anderson classification, tibial fractures with intra-articular extensions, pathological fractures, any other fractures in Ipsilateral limb (Except leg component) and patients who were medically unfit to undergo a surgical procedure Study variables used in our series were Klemm and Borner scoring system for clinical assessment, RUST scoring system for radiological assessment and the prevalence of infection was assessed using Southampton scoring system.

Preoperatively after receiving the patients, they were resuscitated as per ATLS protocol in EMS. Other associated injuries were ruled out. Patients were stabilized

hemodynamically. All patients received Inj. Tetanus toxoid, Inj. Cefotaxime 1 gm, Inj. Metronidazole 500mg, Inj. Gentamycin 80mg. Injection Diclofenac was used for pain relief. After stabilization of patient's vitals, wound was inspected, debrided and preliminary grading according to Gustilo and Anderson was made. All patients were worked up with appropriate blood investigations and radiographs of leg of the involved limb with a proper antero-posterior and lateral view with one joint above and below. Other x-rays were taken to rule out other associated injuries.

The nail size was measure preoperatively from tibial tubercle to medial malleolus. This is obtained by measuring from the highest points on the tibial tubercle and medial malleolus.<sup>18</sup> We used later X-rays to measure the diameter of the nail. After anesthesia work up, patients were taken up for the planned procedure in Emergency operation room. 1gm of IV Cefotaxime was given to the patients before the time of induction.

#### Procedure

Patients were positioned supine on the fracture table with the knees hanging down by the end of the table under spinal anesthesia. Parts preparation was done, painted with povidone-iodine and draped sterile. A vertical incision was made from superior pole of tibial tuberosity to the lower pole of the patella. Patellar tendon was exposed and it was split in the middle. Entry point was made with an awl, just distal to the angle between tibial plateau and anterior tibial metaphysis and in line with the medullary canal on the antero-posterior view. Entry was made first perpendicular to the shaft, after it penetrates the first cortex, the awl is directed parallel to the shaft. Fracture reduction was done, after which the guide wire was inserted by manipulation under C-arm to hold the fracture. Then serial reaming was done in 0.5 mm increments. Then the exchange tube using flexible Teflon was passed over the ball tipped guide wire. Then the ball tipped guide wire was exchanged with a smooth tip wire for guiding nail insertion. Nail length was finalized by Fluoroscopy. Nail diameter was choosed 1 mm less than the last reamer used. The appropriate nail was mounted in the Jig and was inserted over the guide wire. The distal locking was done under C-arm guidance by free hand technique and a proximal locking was done with jig, after achieving compression at fracture site, whenever required.

Post operatively patients were continued on injection Cefotaxime, Metronidazole and Gentamycin. Post-operative antero-posterior X-rays were taken and analyzed for proper fixation. Wounds were inspected regularly to intervene in between, if required. Culture and sensitivity was done when there were any signs of infection and the patients were switched to appropriate antibiotics, if growth was positive for micro-organisms.

Post-operative physiotherapy by static quadriceps exercise and toe movements were started on the second post-operative day. Knee mobilization was started once the pain subsided. Progressive weight bearing was started once our patients tolerated pain and when the wounds were healing well.

Suture removal was done on 12th day and were followed up on 6<sup>th</sup> week, 3<sup>rd</sup> month, 6<sup>th</sup> month and on 9<sup>th</sup> month, with no wound related complications. We tried our level best to achieve 2 follow-ups in 6 months. Each follow-up patients were examined for, knee/ ankle pain, tenderness at the fracture side, signs of infection, joint motion, Radiological assessment of union. Union was defined as presence of 3 cortical continuities on two radiographic views with complete

absence of pain on full weight bearing walking. Delayed Union is a failure to see evidence of union on radiographs at various time-points ranging from twenty to twenty-six weeks [19]. Nonunion is defined as a fracture that occurred a minimum of nine months previously and has not shown radiographic signs of progression toward healing for three consecutive months [20]. Infection is defined as per CDC criteria. Malunion is defined as more than 5° of rotational or more than 1 cm of lengthening or shortening or angular deformity [19]. Data collected were entered in Data collection proforma sheet and Excel (MS Excel 2011). This sheet contained visual map and was divided into indications for both genders. Other social demography data were also

collected. Statistical analysis was made through SPSS version 20.0 (IBM SPSS, US) software with regression modules installed. Descriptive values were reported in Mean, Percentage and Standard Deviation of continuous variables.

## Results

A total number of 30 open Grade I & II Tibia presenting within 72hrs were selected on the basis of pre-defined inclusion and exclusion criteria after informed consent. All patients were recruited through the EMS department of MGMC&RI.

### Age distribution

**Table 1:** Age Distribution

S. No	Age group	No. Of patients	Percentage
1	18-24	8	26.66
2	25-34	5	16.66
3	35-44	12	40
4	45-54	3	10
5	>55	2	6.66

The table 1 above shows the distribution of patients according to their age. It shows that the majority of patients were between 35-44 years.

**Table 2:** Distribution of gender

Gender	Frequency	Percentage
Male	18	60
Female	12	40
Total	30	100

The above table 2 shows the distribution of gender where majority of the patients were male.

### Distribution by grade of injury

**Table 3:** Distribution of grade of injury

Grade	Frequency	Percentage
1	22	73.3
2	8	26.7

The above table 3 shows the incidence of grade of injury in this study. 73.3% of the patients had Grade I injury.

### Distribution by diabetes

**Table 4:** Distribution by diabetes

Diabetic	Frequency	Percentage
Yes	7	23.3
No	23	76.7

The above table 4 shows the incidence of Diabetics in this study. 7 patients were diabetic.

### Distribution by mode of injury

**Table 5:** Distribution by Mode of Injury

Mode of injury	Frequency	Percentage
Road traffic accident	23	76.7
Fall	3	10.0
Assault	2	6.7
Fall of heavy objects	2	6.7

The above table shows the distribution of mode of injury. Majority of the patients sustained RTA (Road Traffic Accident).

### Distribution by delayed unions

**Table 6:** Distribution by delayed unions

Delayed union	Frequency	Percentage
Yes	5	16.7
No	25	83.3

The above table shows the incidence of Delayed Union. 5 patients in this study had delayed union.

### Distribution by prevalence of infection

**Table 7:** Distribution by prevalence of infection

Infection	Frequency	Percentage
Yes	7	23.3
No	23	76.7

The above table shows the prevalence of infection in this study. 7 patients developed infection, which resolved in the due course of this study.

### Association of diabetes with fracture union

**Table 8:** Association of diabetes with delayed union

Diabetes	Union	Delayed union	P-value
Diabetic	4	3	0.0337
Non-diabetic	21	2	

The above table shows the association of delayed union with Diabetes with a significant p-value of 0.0337. 42.8% with Diabetes had delayed union and 8% of the non-diabetic patients had delayed union.

### Grade of injury influencing the infection rate

**Table 9:** Association of Grade of Injury with Infection

Grade	No signs of infection	Infection	P-value
Grade i	19	3	0.0373
Grade ii	4	4	

The above table shows the association of Grade of Injury on infection with significant p-value 0.0373. 50% of the patients with Grade II developed infection compared to Grade I with 13.6% in this study.

There were no non-union in our study. Patients on an average showed signs of union by 3<sup>rd</sup> month and union rates were achieved by 28.5 weeks. Delayed union were addressed by dynamization for 4 patients by removing the static screw in the proximal end of the nail. 7(23.3%) patients developed infection at the wound site, 6(20%) had superficial infections and 1(3.33%) patient had deep infection.

## CASE-1



Case 1



Pre OP X-Ray



Post OP X-Ray



6<sup>th</sup> Week



3<sup>rd</sup> Month



Dynamization



6<sup>th</sup> Month



9<sup>th</sup> Month



Clinical Picture

## CASE -2



Case 2



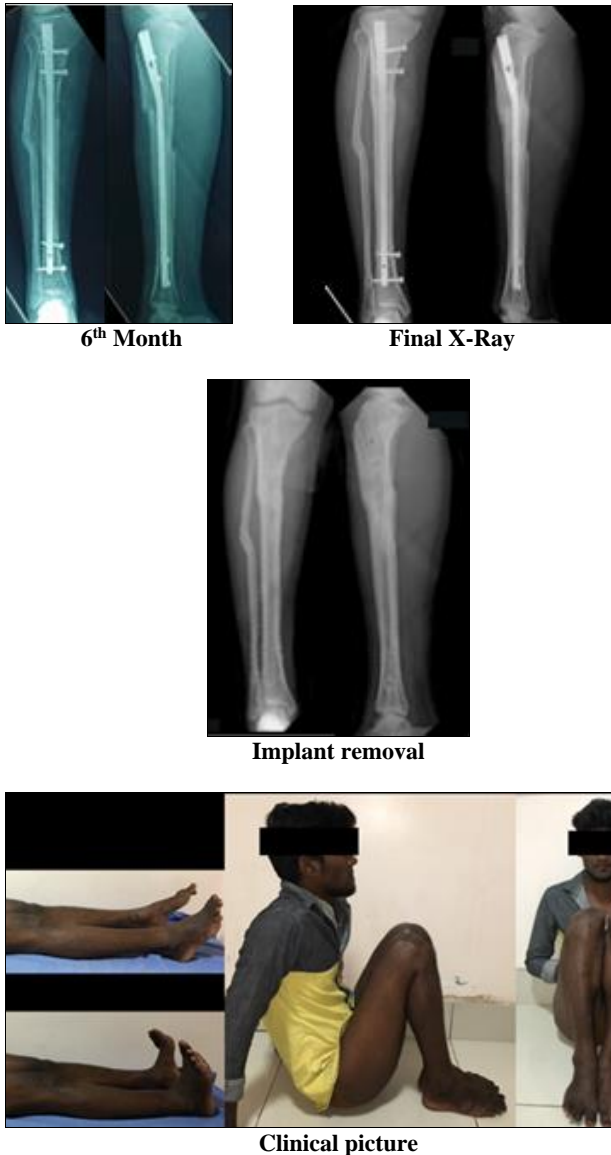
Pre OP



6<sup>th</sup> Week



3<sup>rd</sup> Month

6<sup>th</sup> Month

Final X-Ray

Implant removal

Clinical picture

## Discussion

Tibia fractures are one of the commonest fractures encountered in high velocity trauma. At present, early and repeated wound debridement, immediate rigid skeletal stabilization, and early wound coverage in combination with antibiotic therapy are the preferred treatment modality for open tibia fractures. The methods used for skeletal stabilization for these injuries still remains debated, with several options such as intramedullary rods, bone plates, external fixations, and intramedullary nailing [10, 21, 26].

## Social demography

The commonest age group involved in this study was between 35-45 years of age, with preponderance more towards male population. In a similar study done by Sao Paulo *et al.* [27]. The mean age was 31.76 with male preponderance of 78.14% and in Luciano Rodrigo *et al.* [28]. The mean age was 30.41 age, with male preponderance of 86.84%. The major cause of injury in this study was road traffic accident (76%). In a similar study by Casa de Saude Sante Marcelino *et al.* [29] had 74.18% cases, and in another study by Frederico Galves Malerba *et al.* [30] had 57.30% of cases with road traffic accident as the commonest mode of injury. Right side was affected in 63.3% of cases with distal 1/3<sup>rd</sup> as the commonest region 50%. In the study by Frederico Galves Malerba *et al.* [30]. Left side was common with 59.06%. 23.3% of patients were diabetic, 13.3% of patients were hypertensive in this

study. These factors influenced the time of union and incidence of infection in this study. 73.3% of the patients had grade I injury and 26.7% of the patients had grade II injury. The severity of the grade vastly influenced the delayed union and associated superficial and deep infection in this study. We were not able to carry out the 6-h rule of immediate wound care and stabilization in our study. Although we carried out operative debridement as a standard care for all open fractures as it was required for appropriate grading as well.

## Factors influencing infection

The infection rate in our series was 23.3%, 6 being superficial and 1 deep infection. Other literatures Donally *et al.* [31], showed 28.6% of incidence of infection in his study for primary nailing in open tibia fractures, 22 % in Henkelmann *et al.* [32], 25% in S Mudiganty *et al.* [33], and 30.3% in Desmond Tan Wei *et al.* [34]. Factors that were pre disposing to infection in this study was grade of injury which had a significant p-value 0.0373 with more chance of infection on severe the grade of injury. Smokers had a relatively increased risk of infection which accounted for 30% in our study. In other study 24.7% has been documented by Jonathan Tan Jiong Hao *et al.* [34]. Operative duration in this study > 60 mins showed 27% of infection compared to <60 mins population which was 16 % (p-value 0.4809). In a similar study by Sven Young *et al.* [35]. It was found that there was no significant difference in outcome from injury to surgery duration, as initial basic interventions play more of a role in limiting the risk of infection. In general, prolonged operative duration has an increased chance of surgical site infection of 13%, 17% and 37% for every 15 mins, 30 mins and 60 min of surgery Hang Cheng, *et al.* [36]. The time duration between the injury & operative intervention was from 10 hours to 72 hours. More than 72 hours were excluded from our study.

## Factors influencing Union

The average union time in our study was 28.5 weeks (6 months to 13 months). The union time was 36.7 weeks in the study by Court Brown *et al.* [2], Union occurred between 34.2 weeks in Karlstrom and Olerud [37], and 38.1 weeks in Chan *et al.* [38].

16.7% of the patients in this study had delayed union, which is comparable to Katie fong, *et al.* [39]. Who had 18.5% and Moin Mehmood *et al.* [40]. Had 18.95%. Factors which influenced delayed union in this study were diabetes melitus with a significant p-value of 0.0337. 42.8% of the diabetic patients developed delayed union in this study. In a study done by Hongli Jiao *et al.* [41]. T1DM & T2DM exhibit impaired bone formation under conditions of perturbation such as bacteria induced bone loss and bone fracture healing, hence chance for delayed union is much common in diabetic patients. 25% of Grade II injury had delayed union (p-value 0.4602). In a study by Joseph Westgeest *et al.* [42], with a study of 736 subjects concluded that higher gustilo grade fractures were associated with non-union and delayed union. 20% of smoking population developed delayed union in this study. In a recent study by Amrit Pal Singh *et al.* [43] 61.5 % of patients had delayed union in Grade IIIB injury. Another study done by Donald weber *et al.* [44] had 17% non union and 8% delayed union. Delayed union was equally encountered in operative duration of surgery > 60 mins and < 60 mins. Other studies also showed similar result with not much significant difference in the operative duration JYC Lua *et al.* [45]. In this study proximal 1/3<sup>rd</sup> fracture patients developed 50% of delayed union compared to patients with distal 1/3<sup>rd</sup> fracture.

In literature distal 1/3<sup>rd</sup> fractures were reported with delayed union because of the poor blood supply compared to proximal 1/3<sup>rd</sup> due to absence of muscle attachment at distal 1/3<sup>rd</sup> of tibia. Patients with intact fibula didn't develop delayed union in this study, compared to a study done by Teitz CC *et al.*,<sup>[46]</sup>. Who had 26% delayed union with intact fibula. This is due to the tibiofibular discrepancy that occurs and cause altered strain patterns in the tibia and fibula.

In our study we didn't have non-union. The average non-union rate, however, is about 8% Jensen *et al.*,<sup>[47]</sup> Digby *et al.*,<sup>[48]</sup>. Reported 2% and Austin *et al.*,<sup>[49]</sup>. Showed 1.6% bone grafting rates following functional bracing. Weller *et al.*,<sup>[50]</sup>. Donald and Seligson *et al.*,<sup>[51]</sup> and Hindley *et al.*,<sup>[52]</sup>. All report no requirement for bone grafting after using AO nails. There was no necessity, for bone grafting in our series, due to non-inclusion of Grade III open fractures. However, non-union requiring grafting is more common in other series.

A routine dynamization was not done in our study. Dynamization was done in 4 cases where no signs of union were present at 6 weeks to 12 weeks.

Knee pain is unquestionably the principal problem associated with nailing technique for tibia. This usually occurs after a few weeks and is associated with kneeling. The pain is usually abolished by removing the nail although relief take several months to occur.

### Conclusion

The present study was undertaken to investigate the clinical and radiological outcome of closed interlocking nailing in grade I and II open fractures of tibia. All the cases were followed up for a period of nine months. The fractures united on an average of about 28.5 weeks in our study. Primary closed interlocking nailing as a single staged procedure required less number of secondary procedures. This procedure allows early weight bearing leading to earlier fracture union with less morbidity. Though there is a risk of infection, with a high union rate, we can consider closed interlocking nailing as more ideal method of treatment for open diaphyseal tibia fractures of grade I and II.

### Limitations in this study

Small sample size.

No randomization was done.

Single centre study.

Multicentric large studies have to be carried out to improve the outcome of results.

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