Comparative study of functional outcome of primary closed intramedullary nailing in compound vs closed tibial diaphyseal fractures

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Abstract

Background: Open fractures of the tibia usually indicate a high-energy injury to soft tissue and bone with resultant difficulties of infection and poor bone healing.

Material & Methods: 20 cases of open and closed tibia diaphyseal fractures were followed for period of one year from July 2019 to June 2020 at Department of Orthopaedics, Rajah Muthiah Medical College, Annamalai University.

Result: The Mean time of union was 14 weeks 4 days for compound fractures overall, for grade I cases – 13 weeks 3 days, for grade II cases – 15 weeks, and for grade IIIA cases – 17 weeks 1 day, for closed cases – 12 weeks 2 days. Based on Johner-Wruhs criteria 90% and 20 % of grade I cases had excellent and good outcome. 80% and 20 % of grade II cases had excellent and good outcome. 75% and 25% of grade IIIA patient had excellent and good outcome respectively. Complications encountered was 2 patients in open fracture group had anterior knee pain, 1 patient (5%) had superficial infection, 1 patient went for non-union , and 1 patient had screw breakage.

Conclusion: This study demonstrates that grade 1, 2 and 3A open tibial shaft fractures can be treated with primary debridement and interlocking nail when compared with closed tibial diaphyseal fracture, There was no statistically significant difference (pvalue:0.492) in union rate, infection rate (5%) and functional outcome (p value 0.018) between the two groups.

Keywords: Nailing, tibia fractures

Introduction

As industrialization and urbanization are progressing year by year, with rapid increase in road traffic, the incidence of high energy trauma are increasing with the same speed exponentially. Tibial fractures are the most common long bone fractures encountered by most of the Orthopaedic surgeons and majority of them are compound fractures. The treatment of open tibial fractures is difficult and often controversial with no general consensus on their management [1]. The subcutaneous nature of the medial border as well as the delicate blood supply increases the vulnerability to open injuries, deep infection, mal-union and non-union [2]. The complication rate rises exponentially with high energy trauma, soft tissue disruption, wound contamination, altered vascularity and unstable fractures [3]. Several strategies have been developed to minimise these complications and include the use of prophylactic antibiotics, tetanus toxoid, immediate soft tissue debridement and reconstruction, skeletal stabilisation, and adjuvant treatment like dynamisation [4-7]. Both the extent of the soft-tissue injury and the amount of comminution are directly related to the level of energy which caused the fracture. Gustilo, Mendoza and Williams (1984) [5, 16, 10] first quantified the importance of soft-tissue damage as an important predictor of infection and poor outcome and this has since been confirmed (Rosenthal, MacPhail and Ortiz 1977; Waddell and Reardon 1983; Burgess et al., 1987; Caudle and Stern 1987; Edwards et al., 1988; Fischer, Gustilo and Varecka 1991) [3, 5, 16, 10]. In particular, grade-III A open tibial fractures are associated with high rates of infection, non-union and malunion (Gustilo, Gruniger and Davis 1987) [3, 5, 16, 10]. Infection rates in these fractures are reported to be much higher than those for grade-I and grade-II fractures: Gustilo, Merkow and Templeman (1990) [3, 5, 16, 10] had infection rates for grades I, II and IIIA of 0% to

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2%, 2% to 7%, and 10% respectively. The same authors also found a large difference between grade-II and grade-III A fractures, with infection rates of 4% and 10% respectively, but these cases were not treated by early debridement and skin closure (Gustilo Ct al 1987) [1, 5, 16, 10]. The increasing use of immediate antibiotics, aggressive and repeated irrigation and debridement, fracture stabilisation, early bony coverage has greatly reduced the rates of infection and nonunion (Edwards 1983; Patzakis, Wilkins and Moore 1983a; Burgess et al., 1987; Blick et al., 1989; Fischer et al., 1991) [5, 17, 18]. The ultimate goal is to achieve bony union, without infection, and a fully functional pain free limb [10]. The management of open fractures is regarded as an orthopaedic emergency [9]. The traditional method of treating open tibial fractures was with an external fixator preferably within six hours of injury [10, 13]. Monolateral external fixation has been employed to treat open tibial fractures with great success; however, not without significant complications [12, 13]. The efficacy of intramedullary nails in the acute management of open tibial fractures is contentious [14, 43]. The fear of osteomyelitis has previously precluded any form of internal fixation especially in the immune-compromised host and delays in operative management greater than six hours [44, 45]. Reamed nails offer a biological and mechanical advantage, however injurious to the endothelial vasculature with subsequent theoretical increase in infection and non-union [46, 47]. With the improvement in antibiotic use and surgical technique, the use of intramedullary nails has evolved from low energy open Gustilo grade I and grade 2 fractures to more severe Gustilo grade 3 injuries, with excellent long-term results [47, 48]. Both reamed and unreamed nails have become the accepted standard of care in many institutions ensuring axial alignment, early weight bearing, bony union and early return to pre-injury function with minimal complications. The use of locked intramedullary nails in the acute settings for open tibial fractures has been widely reported in the international literature [4, 52, 53]. However, there are no universally accepted guidelines. The primary objective of this study in the management of an open fracture is union with prevention or eradication of wound sepsis. Three goals must be met for the successful treatment of open tibial fractures: (a) Prevention of infection, (b) Achievement of fracture union (c) Restoration of function. These goals are interdependent and usually are achieved in the chronological order given.

Materials and methods
We performed a review of 20 patients each with open and closed tibial shaft fractures that were treated with primary intramedullary nailing between the period of one year from July 2019 to June 2020 at Department of Orthopaedics, Rajah Muthiah Medical College, Annamalai University. Functional result was compared as per Johner-Wruhs [17] criteria. Ethical approval was obtained from the institutional ethics committee prior to embarking on the study. A prospective database was created of all patients with tibial nails for the specified period. All 40 patients were managed according to a standard protocol.

Inclusion Criteria
1. Age >20 years of age
2. Acute fractures of diaphysis of tibia.
3. Closed fractures and Gustillo Anderson grade I, II, III A compound fracture
4. All fracture patterns except segmental fracture, intra and periarticular fractures.

Exclusion Criteria
1. Age <20 yrs.
2. Grade III b, IIIc Gustillo Anderson compound fractures.
3. Associated with head injury.
4. Pathological fractures, segmental fracture, intra and periarticular fractures, fracture non-union and delayed union.
5. Patients not willing and medically unfit for surgery

Wound management and antibiotic prophylaxis
In the emergency department patients were given a stat dose of tetanus toxoid and a third-generation cephalosporin, aminoglycosides, metrogyl (after test dose). Wounds were cleaned, irrigated and dressed, and the limb splinted prior to urgent surgical debridement. Debridement done and after observation for 24 to 36 hrs with varies of each patients, stabilisation with a locked intramedullary nail was performed based on wound status for open tibial fractures. The transpatellar tendon approach was used under guidance of an image intensifier. The injury was classified intra-operatively according to Gustilo and Anderson. The decision to ream the intramedullary canal was undertaken by the operating surgeon. Distal fragment reaming was not done for all grade IIIA cases during intra operatively Wounds were opened wash given edges trimmed, wound covered with opposite primary nailing done then after wound approximated with 2.0 ethylon interrupted sutures.

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Fig 1: (A and B-Patient received; C- Wound wash; D- Post wound wash)

Timing of débridement and irrigation
Débridement and irrigation are vitally important to the successful management of open tibia fractures. Most current guidelines recommend that débridement be performed within 6 hours of injury [59]. Although the details and methods of
irrigation are debated, the role of careful and complete débridement is clear. Gustilo stated that adequate débridement is the single most important factor in the attainment of a good result in the treatment of an open fracture. Systematic débridement, beginning with removal of gross contamination and debris, should be done as soon as possible in the casualty room. All necrotic tissue is excised, and muscle viability is determined by the four Cs: contractility, color, consistency, and capacity to bleed. Completely free, large cortical bone fragments may be preserved in a sterile fashion to aid in determining length and rotation at the time of fracture stabilization. However, these fragments should be removed before definitive fixation and closure. Significant articular fragments should be thoroughly cleansed and retained when possible. In high-energy injuries, it is often difficult to fully determine the viability of all tissues within the zone of injury at the time of initial débridement. Repeat débridement at 48- to 72-hour intervals should be done to eliminate devitalized tissue that subsequently develops. Irrigation is used to supplement systematic and thorough débridement in removing foreign material and decreasing bacterial load. Based on the widespread availability of 3-L bags of normal saline, Anglen recommended using 3 L of irrigation for type I fracture, 6 L for type II fracture, and 9 L for type III fracture.

Antibiotic prophylaxis
Antibiotic prophylaxis should be initiated as soon as possible after injury. The benefit of early antibiotic prophylaxis was demonstrated by Patzakis and Wilkins, who showed a significantly increased rate of infection in fractures managed with antibiotic prophylaxis >3 hours after injury compared with <3 hours after injury (7.4% versus 4.7%, respectively). However, the appropriate duration of antibiotic prophylaxis is less clear. Coagulase positive Staphylococcus aureus and β-hemolytic streptococci were the most common pathogens isolated. Open tibia fracture was the most common fracture associated with this pathogen. This study established strong evidence for the efficacy of third-generation cephalosporins in the management of open fractures. Quinolones have been used as an alternative to intravenous cephalosporins for infection prophylaxis. This class of drugs is attractive for several reasons. These drugs offer broad-spectrum bactericidal coverage, they can be administered orally also. They require less frequent administration, they achieve good bone penetration, and can provide prophylaxis for patients who are allergic to penicillin.

Pre-operative planning
A written, informed consent was taken from all the patients for their inclusion in this study. All the patients were explained in detail the available methods of treatment, with the final treatment decision left to the patient. A detailed history was taken, ascertaining the mode of injury, with particular emphasis placed on ruling out injuries to other areas. AP and lateral views of the involved leg with knee joint were taken. Routine blood and radiological investigations were done, as required for anaesthetic clearance.
Operative procedures
Operative Procedure positioning of the Patient All patients are operated under spinal/epidural anaesthesia. Under tourniquet control Patient is operated with his knee flexed to 70 degrees on a bolster for entry and by leg hanging reaming and nail insertion made. Assistant forearm is used to support the distal femur at a sufficient distance from the popliteal artery and vein, if it is not properly positioned, circulation is inhibited by the force used to insert the nail and damages the vascular wall. The injured leg is scrubbed, painted with betadine, spirit and draped. Longitudinal incision over the patellar ligament at the level of joint, 5 to 6 cm long is used, splitting the tendon longitudinally. Entry portal is made in sagittal plane in line with medial slope of lateral tibial eminence, in coronal plane just anterior to anterior tibial articular surface. A curved awl is used to open the medullary canal and is pushed as far as possible into the medullary canal, while the handle should be in line with the axis of the shaft. 3.2 mm guide wire is pushed into the canal, past the fracture site into the malleolar region (0.5 to 1 cm proximal to ankle joint) assisted by reduction manually. Next step is to ream the medullary canal. Reaming is done with the help of solid reamers. Normally we start from 8 mm and increase by increments of 0.5 mm. The medullary canal is reamed 1 mm more than the diameter of measured at isthmus an X-ray lateral view. Determination of the length of nail is done preoperatively and introperatively another nail of same size, which is used with C-arm assistance. The nail with the proximal insertion handle and jig is passed over the guide wire and is inserted as far as possible, measured hammering is done to drive the tip of nail to the distal metaphysis and proximal end should be flush with the surface of cortex at the point of insertion. The nail should be centralized as far as possible, the guide wire is removed. For distal locking done using jig and checked by C-arm. Drill bit is inserted through the skin incision down to the bone near the locking holes and drilled under C-arm with axis of drill centered on the locking hole with a 4.0 mm drill bit. Drilling hole is done through both cortices, across locking holes. The length is determined with a depth gauge and confirmed with the C-arm. The distal locking is done. Proximal locking is done with proximal jig and insertion handle. Stab-incision is done over appropriate locking hole. An 8 mm protection sleeve is inserted and trocar through it, till the cortex is contacted. Trocar is removed and 4.5mm diameter drill sleeve is inserted and drilled with 4 mm drill bit. The drill sleeve is removed, depth of hole is measured with a depth gauge and a screw/ bolt is inserted which is confirmed with the C-arm. The C-arm is used to confirm the locking and nail position and fracture alignment. The wound is closed and dressing is done, compression crepe bandage is applied to control postoperative swelling. Postoperatively the limb is elevated on a pillow.

Fig 4: (A- Skin incision; B- Deep fascia incision; C- Awl entry; D- Guide wire insertion; E- IM nail insertion after proximal segment reaming; F- Distal lock; G- Proximal lock; H- Wound closure; I and J- Intra operative C Arm picture showing proximal and distal lock.)
Post-operative care and follow up instruction

Post-operative antibiotics were individualised based on the severity of injury and continued for a period of 24 to 72 hours. Wounds were inspected at 48 hours in the ward and a redebridement was performed if necessary. Physiotherapy began on the first post-operative day. Weight bearing was allowed based on the degree of comminution and was continued on an outpatient basis. Wounds were cleaned and dressed appropriately. Outpatient follow-up was scheduled at monthly intervals until clinical and radiological union. Wounds were inspected for signs of infection and the erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) was taken if there was any clinical suspicion of infection. Infection was classified as superficial or deep. Superficial infection was defined as any infection of the wound or surgical site and cellulitis. Deep infection was defined as an infection involving any tissue deep to the skin and subcutaneous tissue, including bone, at any point in time. Resolution of infection was evaluated clinically and radiologically as well as by monitoring of inflammatory markers. Bony union was also assessed clinically and radiologically. The ability to fully weight bear in the absence of pain at the fracture site satisfied the clinical criteria. Radiological parameters encompassed the presence of bridging callus in a minimum of three cortices on orthogonal views. Nonunion was defined as no clinical or radiological evidence of healing after at least six months of treatment.

Statistical analysis

Was performed using IBM SPSS for Windows version 23 (Armonk, New York: IBM Corp). A p value of <0.05 was considered to be statistically significant. Categorical variables were compared by means of Pearson’s chi-square tests.

| Non-union, osteomyelitis, amputation | Excellent (left = right) | Good | Fair | Poor |
|-------------------------------------|------------------------|------|------|------|
| Non-union, osteomyelitis, amputation | None | None | None | Yes |
| Neurovascular disturbances | None | Minimal | Moderate | Severe |
| Deformity: Varus/valgus | None | 2-5° | 6-10° | >10° |
| Anteverision/recurvatum | 0-5° | 6-10° | 11-20° | >20° |
| Rotation | 0-5° | 6-10° | 11-20° | >20° |
| Shortening | 0-5 mm | 6-10 mm | 11-20 mm | >20 mm |
| Mobility | | | | |
| Knee | Normal | >80% | >75% | <75% |
| Ankle | Normal | >75% | >50% | <50% |
| Subtalar joint | Normal | >50% | Moderate | Severe |
| Pain | None | Occasional | Moderate | Severe |
| Gait | None | Normal | Insignificant limp | Significant limp |
| Strenuous activities | Possible | Limited | Severely limited | Impossible |

Fig 5: Statistical analysis

Case illustration 1

Wound Picture

Immediate Post-Operative X-Ray

Pre-Operative X-Ray

5 Months Follow up X-Ray
Standing

Knee flexion

Knee Extension

Dorsi Flexio

Healed wound

Plantar surface

Case illustration 2

Wound Picture

Antero-Posterior View

Lateral View

Pre Op X-ray

Antero – posterior view

Lateral View

Immediate post op X-ray

2nd Month Follow-up

Antero-Posterior View

Lateral View

4th Month Follow up
Case illustration 3

Pre operative X-Ray

Immediate post operative

1st month follow up

2 1/2 months follow up

6 Months follow up

Standing
Results
The mean age of patients was (table 14, 18) 40 years and 2 months and 34 yrs 7 months (range 21–67) for open and closed fracture groups. The Mean follow-up was 18 months (range 6 months–24 months). In total, (table 10) 7 fractures (35%) were classified as grade 1, 8 fractures (45%) as grade 2 and 5 fractures (20%) as Gustilo-Anderson grade 3A open fractures, 20 closed tibial fractures (table-2 & 3). The fracture morphology included comminuted 5 (25%), short oblique 10 (50%), transverse 3 (15%), wedge 2 (10%) in open fracture group and short oblique 5 (25%), transverse 6 (30%), wedge 5 (25%) spiral 4 (20%) in closed fractures group. The majority of the fractures were located in the middle third (54.7%) of the tibial diaphysis followed by distal third (34.7%) and proximal third (10.7%). The mechanism of injury was motor.
vehicle-related accidents in the majority of the patients. Medical comorbidities were identified in eight patients; these included diabetes, hypertension, and peptic ulcer disease. Twenty-five patients (34.7%) were smokers. The average time to surgery was (table12&17) 45 hours, 28 mints (range 32 hr–112hrs) and 37hrs and 10minnts for open and closed groups respectively. The mean operating time was 68 &75 minutes for closed and open groups. The average length of stay in hospital was nine days (range 4–30). The overall infection rate was 5% only one patient developed superficial infection, 2 (10%) patient developed anterior knee pain, and 1 (5%) patient went for non-union for which dynamisation done. And 1(5%) patient had screw breakage. (Table -3) There was a single patient who developed superficial wound infection that resolved following local wound care and oral antibiotics, (ESR 15, CRP <10). No patients with grade 1 and grade II injuries developed chronic osteomyelitis or deep infection. Pus swab showed no growth. The overall infection rate in Gustilo-Anderson grade 3 injuries was 5%. Staphylococcus aureus was cultured in infection. Pus swab showed no growth. The overall infection rate in Gustilo-Anderson grade 3 injuries was 5%. Staphylococcus aureus was cultured in infection. Pus swab showed no growth.

### Table 1: Demographic data on the patients and characteristics of the fracture

| Parameter                  | Closed tibia (n=20) | Compound tibia (n=20) | P value |
|----------------------------|---------------------|-----------------------|---------|
| Male                       | 16                  | 18                    | 0.376   |
| Female                     | 4                   | 2                     | 0.243   |
| Mean age (Years)           | 34                  | 40                    | 0.321   |
| Mean height (cm)           | 171                 | 173                   | 0.432   |
| Smokers                    | 13                  | 12                    | 0.421   |
| Mean fractures angulation (Deg) | 3°                  | 5°                    | 0.019   |
| Mean fracture shortening(mm) | 3mm                 | 4mm                   | 0.399   |
| Mean total fracture displacement(mm) | 12                  | 16                    | 0.213   |

### Table 2: Different fracture patterns of all grades of open tibia fracture

| Fracture pattern | Gustilo grade |
|------------------|---------------|
|                  | I   | II  | IIIA| Total |
| Transverse       | Nil | 1   | 2   | 3(15%)|
| Short oblique    | 4   | 3   | 3   | 10(50%)|
| Spiral           | Nil | Nil | Nil | Nil   |
| Wedge            | 1   | 1   | Nil | 2(10%)|
| Comminuted       | 2   | 3   | Nil | 5(25%)|

### Table 3: Fracture pattern of close tibia fracture

| Fracture pattern | Total no. | %  |
|------------------|-----------|----|
| Transverse       | 6         | 30 |
| Wedge            | 5         | 25 |
| Short oblique    | 5         | 25 |

### Table 4: Superficial and deep infection rates

| Sepsis                | Gustilo grade |
|-----------------------|---------------|
|                       | I  | II | IIIA| Total |
| Superficial           | Nil | nil| Nil | 1   |
| Deep/osteomyelitis    | Nil | Nil| Nil | nil |
| No sepsis             | 9  | 7  | 3   | 19  |

### Table 5: Time to union for all grades

| Time to union (weeks) | Gustilo grade |
|-----------------------|---------------|
|                       | I   | II  | IIIA| Total |
| Median                | 13 weeks 3 days| 15 weeks| 17 weeks 1 day| 14 weeks 4 days |
| 25th percentile       | 3 weeks 2 days| 3 weeks| 4 weeks| 3 weeks |
| 75th percentile       | 10 weeks 1 day| 12 weeks| 13 weeks| 11 weeks 2 days |
| Minimum               | 11 weeks 12 weeks| 16 weeks| 13 weeks |
| Maximum               | 16 weeks 17 weeks| 22 weeks| 18 weeks 3 days |

### Table 6: Appearance of leg

| Condition                 | Closed tibia (n=20) | Open tibia (n=20) |
|---------------------------|---------------------|-------------------|
| Foot drop                 | Nil                  | Nil               |
| Bump and/or asymmetry     | Nil                  | 1                 |
| Scar hypertrophy          | Nil                  | Nil               |
| Sensitive and /or painful fracture site | 1 | 1 |
| Harde ware irritation and /or prominence | 1 | 1 |
| Incisional numbness       | 1                   | 2                 |
| Satisfaction with appearance | 17             | 15                |

### Table 7: Complications closed vs open

| Complications             | Closed | Open |
|---------------------------|--------|------|
| Anterior knee pain        | 1      | 2    |
| Screw pull out            | Nil    | 1    |
| Infection                 | Nil    | 1    |
| Delayed union             | 1      | 1    |
| Non – union               | Nil    | 1    |

### Table 8: Time of Union

| Time of union       | No. of patients | Percentage |
|---------------------|-----------------|------------|
| 10-15 weeks         | 12              | 60         |
| 16-20 weeks         | 7               | 35         |
| 21-24 weeks         | 1               | 5          |

*Mean union time – 14 weeks 4 days

### Table 9: Union rate for Compound Fractures

| Compound fractures grades | Average union time | Percentage |
|---------------------------|--------------------|------------|
| Grade I compound          | 13 weeks 3 days    | 45         |
| Grade II compound         | 15 weeks           | 35         |
| Grade IIIA compound       | 17 weeks 1 days    | 20         |

### Graph 1: Time of Union

- Spinal 4 20%  
- Commindut  Nil Nil  

- Sepsis  
  - Superficial Nil Nil 1 1  
  - Deep/osteomyelitis Nil Nil Nil nil  
  - No sepsis 9 7 3 19  

- Time to union (weeks)  
  - Gustilo grade I 2 II 3 IIIA 4 Total  
    - Median 13 weeks 3 days 15 weeks 17 weeks 1 day 14 weeks 4 days  
    - 25th percentile 3 weeks 2 days 3 weeks 4 weeks 3 weeks  
    - 75th percentile 10 weeks 1 day 12 weeks 13 weeks 11 weeks 2 days  
    - Minimum 11 weeks 12 weeks 16 weeks 13 weeks  
    - Maximum 16 weeks 17 weeks 22 weeks 18 weeks 3 days  

- Complications closed vs open  
  - Closed 1 2  
  - Open 1 1  

- Time of union  
  - 10-15 weeks 12 60  
  - 16-20 weeks 7 35  
  - 21-24 weeks 1 5  

- Fracture pattern  
  - Total no. %  
    - Transverse 6 30  
    - Wedge 5 25  
    - Short oblique 5 25

- Percentage: 70 60 50 40 30 20 10 0  

- Graph 1: Time of Union  
  - 10-15 weeks 60  
  - 16-20 weeks 35  
  - 21-24 weeks 5  

- Table 9: Union rate for Compound Fractures  
  - Compound fractures grades  
    - Average union time  
      - Grade I compound 13 weeks 3 days 45  
      - Grade II compound 15 weeks 35  
      - Grade IIIA compound 17 weeks 1 days 20
Graph 2: Union rate for compound fractures

Table 10: Open fractures grades

| Grades          | No. of Patients | Percentage |
|-----------------|-----------------|------------|
| Grade I Compound| 7               | 35%        |
| Grade II Compound| 8              | 40%        |
| Grade IIIA Compound| 5          | 25%        |

Graph 3: Open fractures grades

Table 11: Open fracture group outcome

| Outcome | No. of patients | Percentage |
|---------|-----------------|------------|
| Excellent | 14           | 70%        |
| Good    | 6               | 30%        |
| Fair    | 0               | 0%         |
| Poor    | 0               | 0%         |

Graph 4: Outcome

Table 12: Duration time interval between injury and surgery

| Time interval | No. of patients | Percentage |
|---------------|-----------------|------------|
| <24 hours     | 0               | 0%         |
| 24-48 hours   | 17              | 85%        |
| 48-72 hours   | 1               | 5%         |
| >72 hrs       | 2               | 10%        |

*mean interval – 45 hours 28 mins

Graph 5: Fracture Pattern

Table 13: Outcome of compound injury

| Grade-compound injury | Excellent | Good |
|-----------------------|-----------|------|
| Grade I compound -8    | 7(90%)    | 1(10%) |
| Grade II compound -7   | 5(80%)    | 2(20%) |
| Grade III compound -5  | 3(75%)    | 2(25%) |
| Overall                | 15(75%)   | 5(25%) |
### Table 14: Mean age

| Mean age | No. of patient | Percentage |
|----------|----------------|------------|
| 21 - 30  | 8              | 40         |
| 30 - 40  | 1              | 5          |
| 41 - 50  | 6              | 30         |
| 51 - 60  | 4              | 20         |
| 61 - 70  | 1              | 5          |

Mean age - 40 years 2 months

![Graph 8: Mean age](image)

### Table 15: Time of union

| Time of union | No. of patients | Percentage |
|---------------|-----------------|------------|
| 10-15 weeks   | 19              | 95         |
| 16-20 weeks   | 1               | 5          |
| 21-24 weeks   | 0               | 0          |

Average union time – 12 weeks 2 days

![Graph 9: Time of union](image)

### Table 16: closed group Outcome

| Outcome | No. of patients | Percentage |
|---------|-----------------|------------|
| Excellent | 18              | 90         |
| Good     | 2               | 10         |
| Fair     | 0               | 0          |
| Poor     | 0               | 0          |

![Graph 10: Complication](image)

### Table 17: Duration time interval between injury and surgery

| Time interval | No. of patients | Percentage |
|---------------|-----------------|------------|
| <24 hours     | 9               | 45         |
| 24-48 hours   | 11              | 55         |
| 48-72 hours   | 0               | 0          |
| >72 hrs       | 0               | 0          |

Mean time interval – 37 hours 10mins

![Graph 11: Outcome](image)

### Table 18: Mean age

| Mean age | No. of patient | Percentage |
|----------|----------------|------------|
| 21-30    | 9              | 45         |
| 31-40    | 4              | 20         |
| 41-50    | 5              | 25         |
| 51-60    | 2              | 10         |
| 61-70    | 0              | 0          |

Mean age -34 years 7 months

![Graph 12: Fracture pattern](image)

### Graph 13: Duration time interval between injury and surgery

![Graph 14: Mean age](image)
Table 19: Comparison between closed and open group

| Complication                  | Closed fracture | Open fracture |
|-------------------------------|-----------------|---------------|
| Mean age group                | 34              | 38            |
| Mean time interval between day of injury and surgery | 32 hours and 16 mins | 37 hours 12 mins |
| Mean union rate               | 12 weeks 2 days | 14 weeks 4 days |
| Overall functional outcome    | 90% excellent 10% good | 75% excellent 25% good |

Table 20: Union time and infection comparison with other study

| Study                  | Treatment       | Union time (weeks) | Non-union (%) | Infection (%) |
|------------------------|-----------------|-------------------|---------------|---------------|
| Blick et al., (1990)   | Interlocking nailing | 14.4             | 5             | 5             |
| Court-brown (1990)     | External fixation | 45.2             | 38            | 9.5           |
| Court-brown (1991)     | Interlocking nailing | 36.7             | 36            | 17.6          |
| Megraw et al., (1988)  | Interlocking nailing | 38.2             | 32            | 11.1          |
| Maurer et al., (1998)  | Interlocking nailing | 27.3             | 54            | 44            |
|                       |                 | 24.3             | 35            | 25            |

Discussion

The treatment of open tibial fractures is complex and successful outcomes are dependent on multiple variables [14]. The long-term complications include non-union, mal-union chronic osteomyelitis and amputation. Despite multiple publications the optimal management of these injuries is still unclear, however, long term studies are required. The successful treatment of open tibial fractures with intramedullary nailing has been well documented but few studies have been published on this topic. This study reports the outcomes of our local experience of open tibial fractures. Infection rates are directly proportional to the severity of injury as defined by the Gustilo-Anderson classification as well as the host comorbidities [15-17]. Superficial infection usually resolves with minimal intervention; however, deep infection warrants multiple additional surgical procedures and often results in significant morbidity [18]. Multiple studies reported infection rates following intramedullary nailing of open tibial fractures. Court Brown reported infection rates ranging from 1.8% to 12.5% Yokoyama et al., Agrawal et al., and Joshi et al., [19], reported deep infection rates of 6.1%, 10% and 10.1% respectively [20-22]. The results in this study show a superficial infection rate of 10.8% and a deep infection of 6.8%, and are comparable to international literature.

The current management trend for Gustilo grade 1, 2, and 3A open fractures of the tibia is to perform a reamed or unreamed intramedullary nail ideally within six to eight hours of injury [23]. However, the traditional ‘six hour rule’ has been challenged in recent literature [24, 25]. Originally described by Friedrich in 1898, multiple studies have shown that this narrow time window should not be followed rigidly [26]. In our local hospitals, the demand for emergency theatre time does not permit surgery in the first six hours due to the high trauma burden and relative staff shortages. The mean time to surgery was 28 hours with 42 patients being operated after 24 hours. Although we still advocate surgical debridement and stabilisation as soon as possible, this delay was not associated with the development of infection. Emphasis has been placed on the soft tissue management in open tibial fractures in the recent literature [26-28]. Evidence suggests that nosocomial infections are the cause of osteomyelitis rather than the index traumatic event [29]. Open fractures were traditionally left open so as to allow for wound drainage and inspection, and primary wound closure was forbidden due to the fear of osteomyelitis [30]. This practice has been challenged due to the recent advances in systemic antibiotic use, local antibiotic beads, the so-called ‘fix and flap’ technique, more effective methods of fracture stabilization [22, 24]. In this study there is no association between type of closure and infection yet apposition with nylon interrupted sutures was associated with the highest deep infection rates. Rajasekaran et al., [29] closed wounds primarily in high energy open tibial fractures with 86.7% excellent results. Weitz-Marshall et al., [31] condone primary wound closure provided an adequate surgical debridement and stabilisation is performed. Hohmann et al., reported low infection rates with primary wound closure in low energy open tibial fractures in selected cases [28]. One of the primary goals in the management of open tibial fractures is to achieve bony union. This is dependent on multiple host, skin lesion, fracture pattern and surgical factors, and the presence or absence of infection. Drosos et al., [32] identified fracture gap, comminution, screw failure and dynamisation as potential risk factors for non-union in tibial fractures treated with intramedullary nails. Adams et al., reported an increase in soft tissue complications and non-union in patients who smoke with open tibial fractures Joshi et al., [33], Agrawal et al., [21, 22, 42] and Bali et al., [42], reported union times that ranged from 20.7 weeks to 32 weeks. Average time to union in our study was 17 weeks (range 12–50). Three patients had delayed union but required only full weight bearing to achieve union and two patients required dynamisation before union. Kakar et al., reported 32 patients with delayed union, of which 16 patients required additional surgical procedures to achieve union [32]. In this study one patient who sustained a grade 3A injury developed a delayed union and eventually united by 36 weeks after secondary procedures (dynamisation). Convincing biological and mechanical advantages exist for both reamed and unreamed intramedullary nails in the management of tibial fractures [21]. The benefits in open fractures is still uncertain [28]. Reaming strips the endosteal blood supply and affects the cortical perfusion which contributes to the vascular insult in open fractures [33]. There is concern that reaming open fractures may increase the risk of infection by spreading contamination in the medullary canal and osteocyte death by thermal necrosis [21]. However proponents of reaming suggests that seeding of bone graft throughout the medullary canal accelerates union rates by enhancing the biological milieu that is conducive to fracture healing [36]. Reamed nailing allows the use of larger diameter...
nail and increases the intimacy between the nail-cortex interface, therefore enhancing the biomechanical stability. Finkemeier et al., [47] and Ziran et al., compared reamed and unreamed nails in open tibial fractures and found no significant differences between the two with regard to union. The important factors in prognosis are (1) amount of initial displacement of fractures, (2) degree of comminution, (3) signs of infection (4) severity of soft tissue injury. When compared to other study groups our study showed better functional outcome, union rate with low infection and non-union rate.

In our study all patient treated with
1. Tetanus prophylaxis
2. Systemic triple antibiotic therapy,
3. Copious irrigation with normal saline
4. Prompt surgical debridement
5. Fracture stabilization
6. Timely wound closure,
7. Observation for next 24 -36 hrs(it varies depending upon wound status)
8. Followed by internal fixation thorough rehabilitation, and adequate follow-up.
With 95% of confidence interval union rate had p value (0.049) Functional outcome (p value 0.018) between the two groups and infection rate (5%), nonunion (5%).

Conclusion
This study demonstrates that grade 1, 2 and 3A open tibial shaft fractures can be treated with primary debridement and locked intramedullary interlocking nailing with excellent to good functional outcome, low infection rate and non-union rates. When compared with closed tibial diaphyseal fracture. There was no statistically significant difference (pvalue:0.492) in time to union (both clinically and radiologically,)and functional outcome between the two groups(open vs closed tibia diaphyseal fracture).we preper using primary intramedullary interlocking nailing for grade 1, 2 and 3A compound tibial shaft fractures.

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