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## 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 10 % 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, 90% and 10% of closed cases 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<sup>[1]</sup>. 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<sup>[2]</sup>. The complication rate rises exponentially with high energy trauma, soft tissue disruption, wound contamination, altered vascularity and unstable fractures<sup>[3]</sup>. 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<sup>[4-7]</sup>. 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)<sup>[3, 5, 16, 10]</sup> 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)<sup>[3, 5, 16, 10]</sup>. In particular, grade-IIIa open tibial fractures are associated with high rates of infection, non-union and malunion (Gustilo, Gruniger and Davis 1987)<sup>[3, 5, 16, 10]</sup>. 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)<sup>[3, 5, 16, 10]</sup> 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-IIIa 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) [3, 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 [8]. 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, 11]. 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 endosteal 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 1 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.<sup>49-51</sup> 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. >20years 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 oppsite primary nailing done then after wound appoximated with 2.0 ethylon interrupted sutures.



**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 [39]. 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 [40]. 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 [40]. 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 [41] 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, [38] 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 [20]. 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.



**Fig 2:** Instrumentation set

INDIVIDUAL EXAMINATION CARD																																																																																																									
<p><b>1. CASE NO:</b></p> <p><b>2. Patient Details</b></p> <p><b>NAME:</b> _____ <b>IP.No:</b> _____</p> <p><b>AGE:</b> _____ <b>Date of Injury:</b> _____</p> <p><b>SEX:</b> _____ <b>Date of Admission:</b> _____</p> <p><b>Diagnosis:</b> _____ <b>Date of Surgery:</b> _____</p> <p>_____ <b>Date of Discharge:</b> _____</p> <p><b>3. Nature of injury:</b></p> <p><b>4. Type of Fracture:</b> Closed / Open</p> <p><b>5. Associated injuries:</b></p> <p><b>6. Co morbidity:</b></p> <p><b>7. Personal habits:</b></p> <p><b>8. Radiological examinations:</b></p> <p>A. Level of fracture</p> <p>B. Type of fracture</p> <p>C. Fibular fracture level:</p> <p><b>9. A O Classification</b></p> <p><b>10. Pre Operative planning for Surgery</b></p> <ul style="list-style-type: none"> <li>◆ Type of Nail &amp; size</li> <li>◆ Consent</li> </ul> <p><b>11. Surgical Treatment</b></p> <ul style="list-style-type: none"> <li>◆ Date of operation</li> <li>◆ Type of Anesthesia</li> <li>◆ Plan</li> <li>◆ Approach</li> <li>◆ Nailing: reamed</li> <li>◆ Locking of Nail: (static / Dynamic)</li> <li>◆ Proximal</li> <li>◆ Distal</li> <li>◆ Procedure done:</li> </ul> <p><b>12. Intra operative complication:</b></p>	<p><b>13. Intermediate post operative complications</b></p> <p><b>B. Wound infection:</b></p> <p><b>14. Suture removal done:</b></p> <p><b>15. Weight bearing:</b> Non- weight bearing – till 2<sup>nd</sup> week                      Partial weight bearing – At _____                      Full weight bearing – _____                      Walking (with / without Aids)</p> <p><b>16. Follow up:</b></p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">CRITERIA</th> <th style="width: 5%;">4<sup>th</sup> week</th> <th style="width: 5%;">6<sup>th</sup> week</th> <th style="width: 5%;">10<sup>th</sup> week</th> <th style="width: 5%;">12<sup>th</sup> week</th> <th style="width: 5%;">14<sup>th</sup> week</th> <th style="width: 5%;">20<sup>th</sup> week</th> <th style="width: 5%;">6<sup>th</sup> month &amp; Above</th> </tr> </thead> <tbody> <tr> <td><b>Pain</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td><b>Range of motion</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Knee</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Ankle</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Subtalar</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td><b>Deformity:</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Valus /valgus</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Rotational deforming</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>LLD shortening / Lengthening</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td><b>Gait</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td><b>Strenuous activity</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td><b>Radiological union</b></td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> </tbody> </table> <p><b>17. Late / Delayed complications:</b></p> <p><b>18. Secondary procedures:</b></p> <p><b>19. Functional outcome:</b>                      (Excellent/Good/Fair/Poor)</p>	CRITERIA	4 <sup>th</sup> week	6 <sup>th</sup> week	10 <sup>th</sup> week	12 <sup>th</sup> week	14 <sup>th</sup> week	20 <sup>th</sup> week	6 <sup>th</sup> month & Above	<b>Pain</b>								<b>Range of motion</b>								Knee								Ankle								Subtalar								<b>Deformity:</b>								Valus /valgus								Rotational deforming								LLD shortening / Lengthening								<b>Gait</b>								<b>Strenuous activity</b>								<b>Radiological union</b>							
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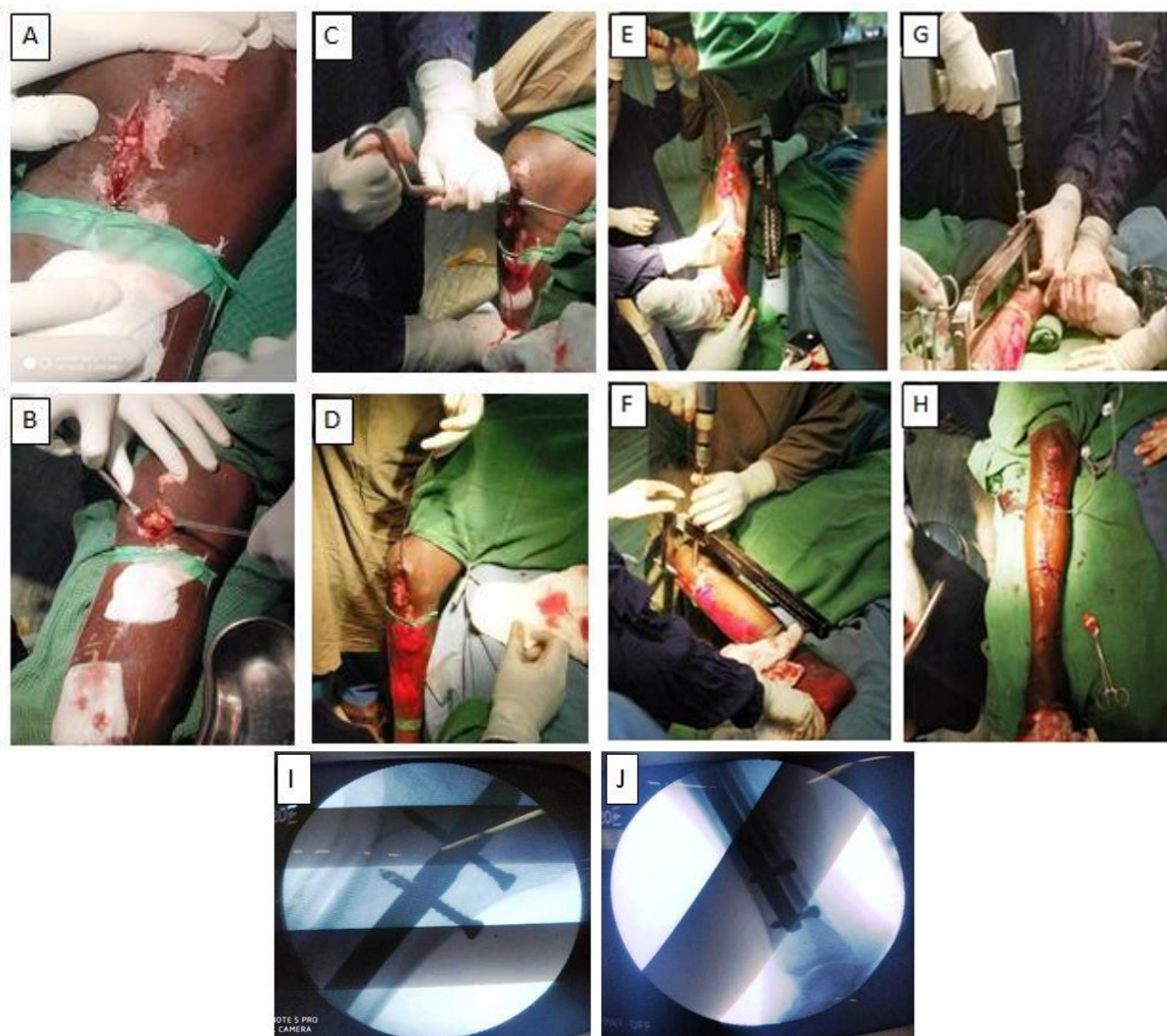
**Fig 3:** Pre and post-operative score card



### 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 saggital 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 intraoperatively 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 debridement 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. Sutures were removed at two weeks and 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.

	Excellent (left = right)	Good	Fair	Poor
Non-union, osteomyelitis, amputation	None	None	None	Yes
Neurovascular disturbances	None	Minimal	Moderate	Severe
<b>Deformity</b>				
Varus/valgus	None	2-5°	6-10°	>10°
Anteversion/recurvation	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
<b>Mobility</b>				
Knee	Normal	>80%	>75%	<75%
Ankle	Normal	>75%	>50%	<50%
Subtalar joint	>75%	>50%	<50%	
<b>Pain</b>	None	Occasional	Moderate	Severe
<b>Gait</b>	None	Normal	Insignificant limp	Significant limp
<b>Strenuous activities</b>	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



2<sup>nd</sup> Month Follow-up



Antero-Posterior View



Lateral View

4<sup>th</sup> Month Follow up



Standing

Knee Flexion

Knee Extension



Dorsi Flexion

Plantor Flexion



AP View



Lateral view

2 1/2 months follow up

**Case illustration 3**

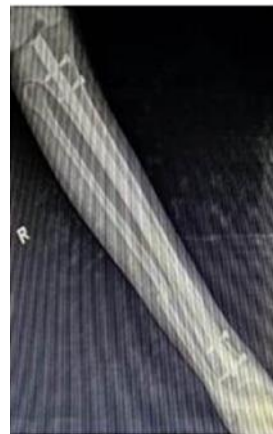


AP View



Lateral view

Pre operative X-Ray



AP View



Lateral view

6 Months follow up



AP View



Lateral view

Immediate post operative



Standing



AP View



Lateral view

1<sup>st</sup> month follow up







6 Months follow up

**Knee flexion**



Ankle plantar flexion



Ankle Dorsi flexion

**Case illustration: 4**



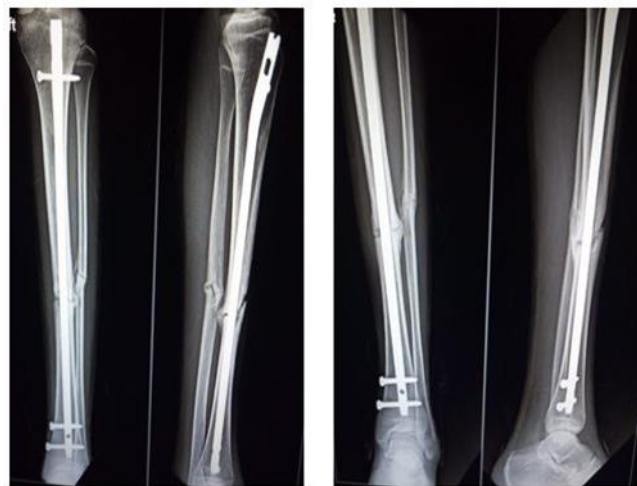
Pre operative x ray



Immediate

1<sup>st</sup> month post op

Post operative x ray



3<sup>rd</sup> month follow up

6<sup>th</sup> month follow up



Standing

Knee extension



Ankle plantar flexion

Ankle Dorsi flexion



Foot Inversion

Foot eversion

**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 and10mints 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 that case..The average time to union was 13 weeks 3 days in the grade 1, 15 weeks in the grade 2 (Figure 3), and 17 weeks 1 day in grade 3A fractures (Figure 4). The mean time to union for all grades was 14 weeks 4 days (range 12–50) (Table 5). Three patients had delayed union but united with full weight bearing. One patient required dynamisation before union could be achieved. – In that 90 % of grade I fractures had excellent outcome, 10% of patient had good functional outcome. 80% of grade II fractures had excellent outcome,20% of patient had good outcome.75% of grade IIIA patient had excellent outcome and 25% of patient had good outcome. For closed tibia cases 90% of patient had excellent outcome and 10%of patient had good outcome. 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, 1 patient had screw breakage.

**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%

Spiral	4	20%
Comminuted	Nil	Nil

**Table 4:** Superficial and deep infection rates

Sepsis	Gustilo grade			
	I	II	IIIA	Total
Superficial	Nil	Nil	1	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 days	14 weeks 4 days
25 <sup>th</sup> percentile	3weeks 2 days	3 weeks 6 days	4 weeks 4 days	3 weeks 5 days
75 <sup>th</sup> percentile	10 weeks 1 day	12 weeks 1 day	13 weeks 1 day	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

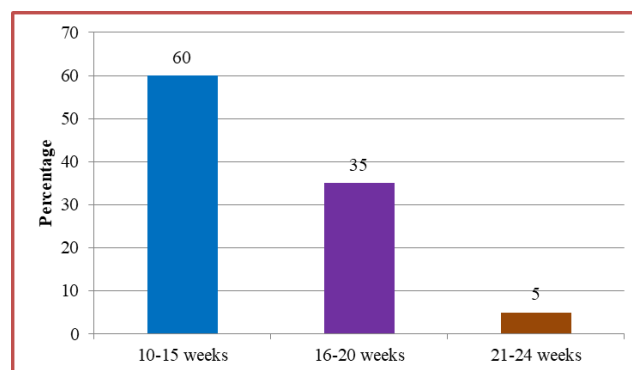
**Table 7:** Complications closed vs open

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

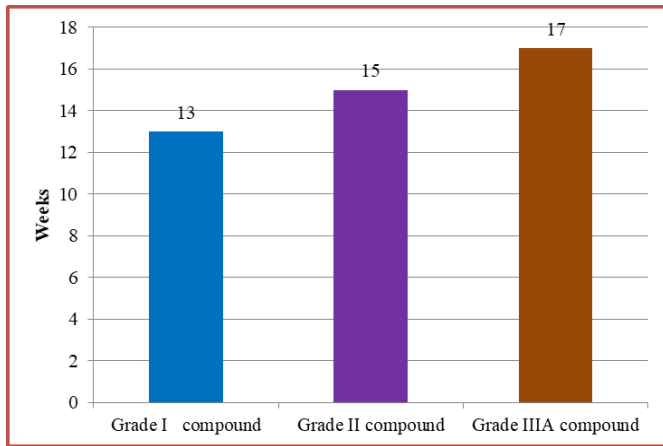
\*Mean union time – 14 weeks 4 days



**Graph 1:** Time of Union

**Table 9:** Union rate for Compound Fractures

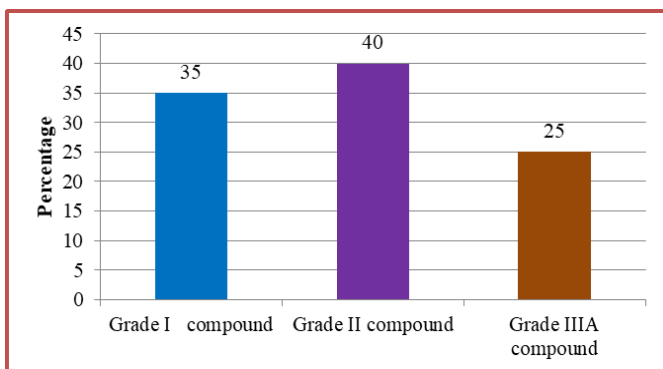
Compound fractures grades	Average union time	Percentage
Grade I compound	13 weeks 3 days	45
Grade II compound	15 weeks	35
Grade IIIA compound	17 weeks 1 days	20



**Graph 2:** Union rate for compound fractures

**Table 10:** Open fractures grades

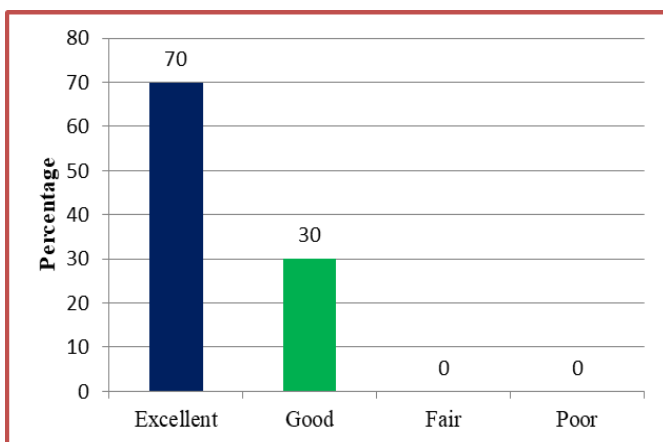
Grades	No. of Patients	Percentage
Grade I Compound	7	35
Grade II Compound	8	40
Grade IIIA Compound	5	25



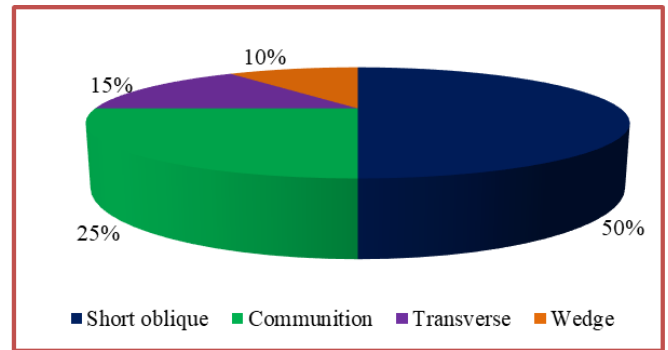
**Graph 3:** Open fractures grades

**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

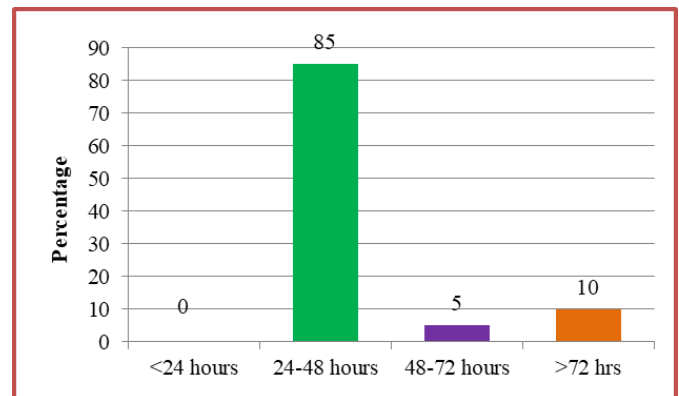


**Graph 5:** Fracture Pattern

**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

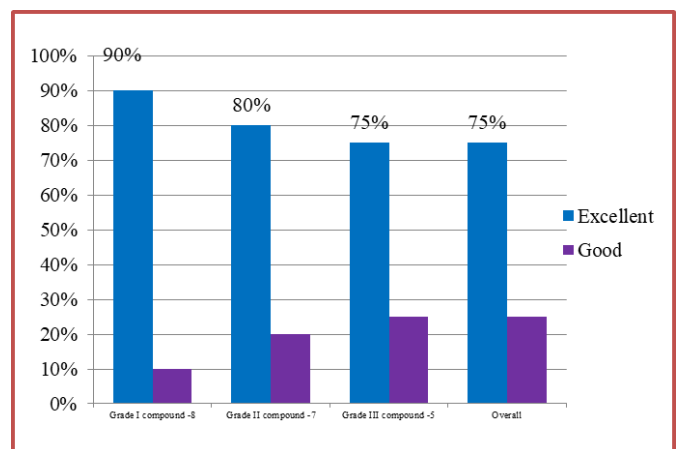
\*mean interval – 45 hours 28 mins



**Graph 6:** 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%)



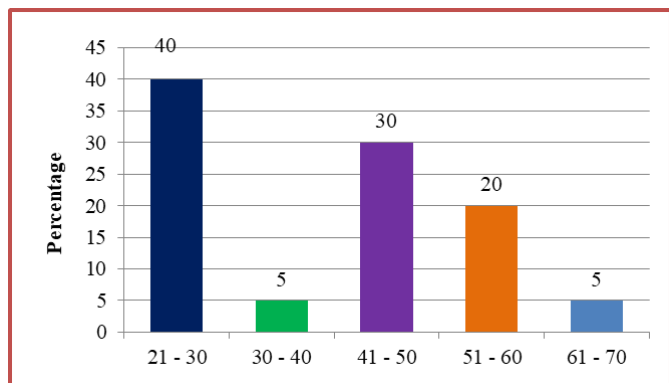
**Graph 7:** Outcome of compound injury



**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

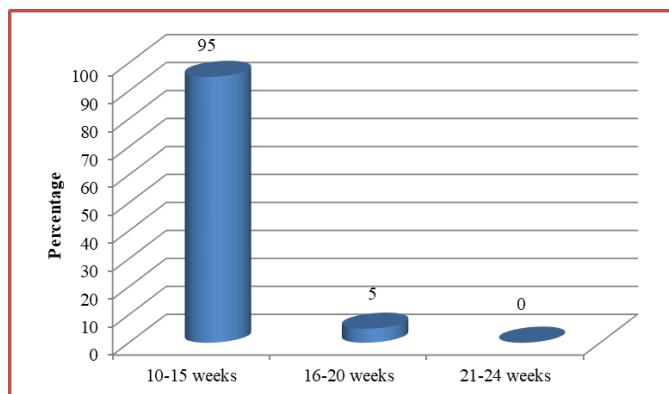


**Graph 8:** Mean age

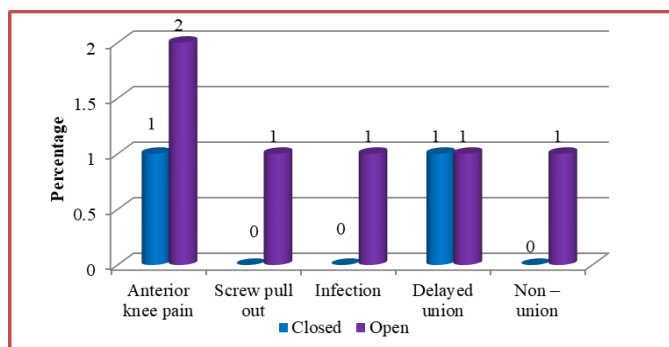
**Table 15:** Time of union

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



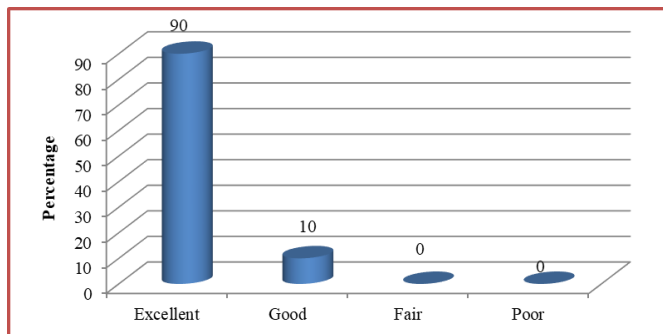
**Graph 9:** Time of union



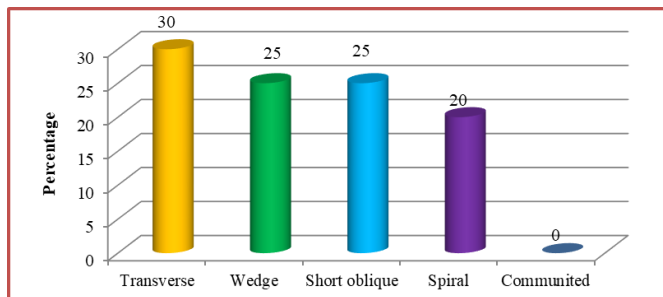
**Graph 10:** Complication

**Table 16:** closed group Outcome

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



**Graph 11:** Outcome

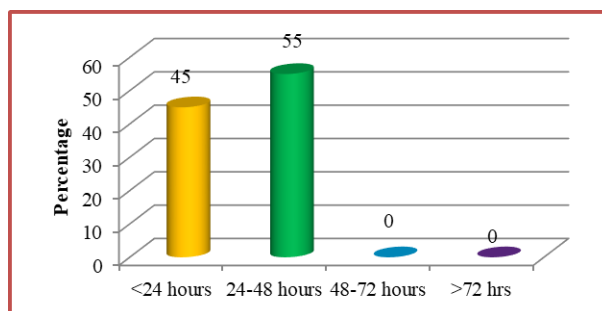


**Graph 12:** Fracture pattern

**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

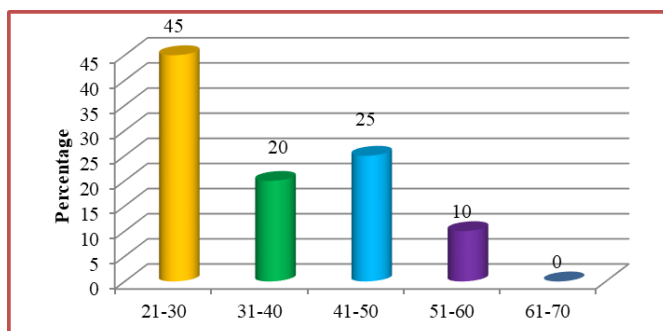


**Graph 13:** Duration time interval between injury and surgery

**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 14:** Mean age

**Table 19:** Comparison between closed and open group

	Closed fracture	Open fracture
Mean age group	34	38
Mean time interval between day of injury and surgery	32 hours and 16mins	37 hours 12mins
Mean union rate	12 weeks 2 days	14 weeks 4 days
Overall functional outcome	90% excellent 10% good	75% excellent 25% good
Complication	Anterior knee pain -1 Delayed union -1	Anterior knee pain -2 Delayed union-1 Non-union-1 Screw breakage -1

**Table 20:** Union time and infection comparison with other study

Study	Treatment	Union time (weeks)	Non-union (%)	Infection (%)
<b>Our study</b>	<b>Interlocking nailing</b>	<b>14.4</b>	<b>5</b>	<b>5</b>
Blick <i>et al.</i> , (1990)	External fixation	45.2	38	9.5
Court-brown (1990)	External fixation	36.7	36	17.6
Court-brown (1991)	Interlocking nailing	38.2	32	11.1
Megraw <i>et al.</i> , (1988)	Interlocking nailing	27.3	54	44
Maurer <i>et al.</i> , (1998)	Interlocking nailing	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.*, [45]. 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 [42]. 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 [23, 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.*, [26] closed wounds primarily in high energy open tibial fractures with 86.7% excellent results. Weitz-Marshall *et al.*, [27] 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.*, [31] 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.*, [32]. 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 non-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 [35]. 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.*,<sup>[47]</sup> 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 débridement
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 prefer using primary intramedullary interlocking nailing for grade 1, 2 and 3A compound tibial shaft fractures.

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