

**TIBIAL DIAPHYSEAL FRACTURES: AETIOLOGY,  
MORPHOLOGY AND TREATMENT APPROACH IN  
ADULT PATIENTS AT MOI TEACHING AND  
REFERRAL HOSPITAL, ELDORET KENYA**

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the requirements for the award of the degree of Masters of Medicine (Orthopedics  
Surgery) at Moi University**

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## **DECLARATION**

### **Declaration by Candidate**

This research is my original work and to the best of my knowledge, has not been submitted for an award of academic credit in any other university or research institution.

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### **DEDICATION**

This work is dedicated to all those persons and organizations who have endeavored to commit their effort, time and resources in provision and improvement of orthopedic healthcare services.

**DISCLOSURE**

The investigator did not receive any outside funding or grants in support for this study.

Neither he nor a member of his immediate family received payments or other benefits thereof or commitment or agreement to provide such benefits from a commercial entity.

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## ABSTRACT

**Background:** Tibial diaphyseal fractures (TDF) arise from various forms of trauma and assume various morphology or patterns. They are responsible for high morbidity and mortality despite the various treatment approaches. There is paucity of published research information regarding the tibial diaphyseal fractures in terms of the etiology, morphology and treatment approaches at MTRH, Eldoret.

**Objective:** To analyze and establish the mechanism of injury, the resulting morphology and treatment methods of tibial diaphyseal fractures in adult patients seeking treatment at MTRH.

**Methods:** This was a hospital based descriptive prospective study involving adult patients with tibial shaft fractures carried out at MTRH orthopedics wards and outpatient fracture clinic. Informed consent was obtained before enrollment. Consecutive sampling was used. Data collection was via interviews of patients, summary of file notes and patients x-ray interpretation entered into a standardized questionnaire and analysed using standard software for statistical analysis and computation (R Core Team, 2015). Association between categorical variables was assessed using Pearson's Chi Square test.

**Results:** A total of 89 patients with 93 TDF were recruited into the study. Median age was 28.0 (IQR: 24.0, 40.0) years with a minimum and maximum of 18 and 75 years respectively. Male participants were more than three quarters of the population with male to female ratio of 3.2:1. Most of the TDF (67.4%) were due to Road Traffic Accidents (RTAs); fall 16 (18.0%) and the least, gunshot 3 (3.4%). Up to 40.9% of the fractures were open type while (59.1%) were closed. Middle 1/3 tibia shaft was the commonest site of fracture at 52.7%. Fibula fracture was the most associated injury at 62.9%. Most fractures (61.6%) were managed operatively.

**Conclusion:** Most participants were male. RTAs were the major cause of TDF with motorcycles injuries leading. Most TDF were closed type; mainly type A and at mid third level. Fibular fractures were the most associated injuries. Treatment to TDF was mainly surgical with locked intramedullary nail (SIGN).

**Recommendations:** Education to the young males in the population on road safety. Maintain and strengthen the SIGN programme at MTRH as an implant of choice in the treatment of these fractures.

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**ABBREVIATIONS AND ACRONYMS**

<b>IMN</b>	Intramedullary Nail
<b>IQR</b>	Inter Quartile Range
<b>IREC</b>	Institutional Research and Ethics Committee
<b>MTRH</b>	Moi Teaching and Referral Hospital
<b>MVAs</b>	Motor Vehicle Accidents
<b>NTSA</b>	National Transport and safety authority
<b>ORIF</b>	Open Reduction and Internal Fixation
<b>OTA</b>	Orthopaedic Trauma Association
<b>RTAs</b>	Road traffic Accidents
<b>SIGN</b>	Surgical Implant Generation Network
<b>TDF</b>	Tibial Diaphyseal Fractures

## **OPERATIONAL DEFINITIONS OF VARIABLES AND KEY CONCEPTS**

**Adult:** A person who is 18 years and above

**Fracture:** Is a medical condition in which there is a break in the continuity of the bone.

**Fracture pattern/morphology:** Physical and radiological characteristic of a fracture that may define its management approaches.

**Tibia:** Also known as shinbone or shankbone, is the larger and stronger of the two bones in the leg below the knee (the other being the fibula), and connects the knee joint with the ankle joint.

**Tibial diaphysis:** The shaft of the tibia bone between the epiphyses.

**Treatment approaches:** Medical intervention put in place to address the arising fracture

## **CHAPTER 1:INTRODUCTION**

### **1.1 Background Information**

Tibial diaphysial fractures (TDF) are among the most common long bone fracture encountered by most orthopaedics surgeons (Barnes, Brown, Garden & Nicoll, 1964). The TDF are often difficult to manage especially in resource constrained settings (Klok, 2011). In developing world, non-operative treatment of tibial fractures has been, and in some centers, is still the mainstay mode of treatment. The tibia bone has a subcutaneously located anteromedial surface with very little soft tissue coverage. As such, this makes it susceptible to severe bone and soft tissue injury as may be the case in high energy trauma. Moreover, the tibia bone records high levels of open fractures compared with other long bones and this are particularly extremely challenging to treat. These injuries are different and vary in their presentation, and their outcomes are unpredictable (Johner et al., 2000). The optimal treatment of a tibia fracture is derived from an analysis of the natural history of the fracture. An assessment of the fracture type and morphology and then correlating it with the natural history of a similar fracture type allows achievement of the best functional outcome for each respective patient. Often, other fractures and or injuries to other body systems are usually associated with severe TDF. Commonly associated is the fibula fracture.

The mechanism of injury in TDF can be direct or indirect (Klok, 2011). Direct mechanisms of injury are often high-energy fractures (road traffic accidents), penetrating injuries, and 3-point bending injuries. High-energy mechanisms produce transverse or comminuted displaced diaphyseal injuries. These have higher incidence of bone exposure

and soft-tissue injury. Descriptive indices used to classify tibial fractures show differences between the types of people involved in motor vehicle accidents. Motorcyclists are often younger and present with a higher incidence of open tibial fractures than pedestrians or vehicle occupants. In Kenya, injuries to motorcyclists are increasing at an annual rate of approximately 29 percent (Bachani *et al.*, 2012). Indirect mechanisms are mainly torsional, low-energy injuries. The resulting fracture morphology is mainly spiral, nondisplaced, minimally comminuted fractures with little or no soft-tissue damage.

Presenting symptoms include pain and inability to walk after an accident. Bleeding at the site of injury is reported in the event the fracture is open. Examination reveals deformity and or soft tissue swelling at the fracture site. In open fractures, wound and exposed bone fragment(s) are often evident. Anteroposterior and lateral radiographs are the main investigative modalities for TDF. They are imperative in diagnosing and characterizing the fracture.

## **1.2 Problem statement**

Fractures of the tibia diaphysis are among the most common long bone fractures with reported annual incidence of two TDF per 1000 individuals (Alho, Benterud & Høgevoll, 1992). Major causes of TDF are preventable. TDF imparts a heavy economic burden on an individual, family and the health systems of a country. Injury dynamics are changing in our country due to changing technology and economic standards that has seen rise in the trauma burden. Kenya has recently seen a sharp rise in number of registered motor vehicles and motorcycles. TDF burden on the rise at MTRH despite preventive strategies (2010-105 cases 2011- 128 cases, 2012-140 cases). The available on data TDF locally and

regionally is more than five years old. TDF have a myriad of etiological mechanisms and varying morphology whose data has not been clearly analysed at MTRH.

### **1.3 Justification**

Clinico-epidemiological data as regards to mechanism of injuries, fracture morphology and treatment modalities of TDF is lacking in our setup. Injuries resulting in fractures often arise in the process of man's quest to meet his biological, social, cultural and economic needs. This occurs in an environment that is diverse and may have a variable impact on the injury mechanisms, fracture morphology, the riding socio-demographic patterns and treatment methods of TDF. This informs the need to quantify this injury burden at MTRH. TDF are of public health concern due to their far reaching social economic impact at an individual level, family and as a nation in terms of their management. Severe injuries and complex fracture patterns are often associated with high morbidity and mortality. Major causes of TDF such as RTAs are preventable (Baral, Khan & Singh, 2013). In Kenya over 12,000 crashes occur annually. Approximately 26,000 vehicle crashes are reported causing over 3,000 fatalities and 9,000 serious injuries such as TDF (WHO, 2013). Well elucidated etiological mechanisms of injury will help highlight probable areas of primary intervention and need for strengthening the pre-existing preventive measures for TDF in our set up such as review of the national road safety strategy. Clinical and epidemiological knowledge will also be established and avail local literature on TDF in our set up. The data realized will be instrumental to healthcare planners in adopting evidence based healthcare planning thus enhanced clinical management. The data will also be compared with that from documented studies. Future studies on TDF can also be based on the data realized from this study.

#### **1.4 Research Question**

1. What are the aetiological mechanisms, the resulting fracture morphology and treatment methods in adult patients presenting with TDF at MTRH?

#### **1.5 Research Objectives**

##### **1.5.1 Broad objective**

To determine the mechanisms of injury, the resulting morphology and treatment methods of TDF in adult patients seeking treatment at MTRH

##### **1.5.2 Specific objectives**

1. To describe the socio-demographic profile of adult patients presenting with TDF at MTRH
2. To describe the aetiology and fractures pattern in adult patients presenting with TDF at MTRH
3. To determine presence and nature of associated injuries arising from these injuries
4. To describe the treatment methods of TDF in adult patients at MTRH



## CHAPTER 2 : LITERATURE REVIEW

### 2.1 Introduction

In an accident or incident leading to trauma, one is more likely to injure the long bones among other body injuries. Tibia diaphyseal fractures occur more than other long bone fractures and approximately 24% of these fractures are open with Gustilo grade III being the most frequent (Court-Brown, Rimmer, Prakash & McQueen, 1998 Sept). These fractures are not only common, but they are challenging to treat. The subcutaneous location of the anteromedial surface of the tibia, with little soft tissue cover, means that severe bone and soft tissue injury and loss are common.

### 2.2 Social demographic profile

About 26 TDF per 100,000 of the population per year are reported in an average population. There's a male preponderance with an incidence which is about 41 per 100,000 per year as compared to female incidence of about 12 per 100,000 per year (Klok, 2011; Grütter *et al*, 2000). A study in Pakistan at Gurski Trust Teaching Hospital, Lahore Medical and Dental College reported a male to female ratio of 7.3: 1. The youngest patient was 17 years of age and oldest 60 years (Irfanullah, Shahzad, Gauhar & Amer, 2013). The average age of a tibial fracture population is about 37 years. Males have an average age of about 31 years and females 54 years. These indicative of a bimodal distribution with young males more affected (Court-Brown & McBirnie, 1995). The second peak, often after the age of 80 years, often affects the female and is largely attributed to osteoporosis. Age is strongly predictive of outcome, defining time to weight bearing, union time, and the delay in returning to ambulatory activities (Gaston, Will & Elton, 1999). A study in Pakistan

showed that 72% of the patients were less than 40 years of age while 28% were more than 41 years of age (Irfanullah *et al.*, 2013).

In a local study conducted at MTRH involving 196 patients with post- traumatic open fractures, males were more affected (M:F= 5.76:1) and the mean age was 32.51years (SD=13.26). All Patients had exposed bones due to open fractures (97%) and degloving injuries (3%) in association with polytrauma (36.8%). The tibia was the most affected bone. Road traffic accidents were responsible in 49.5% of the patients. (Ayumba, Lelei, Emarah & Langat, 2012).

### **2.3 Aetiological Mechanisms of injury**

Tibia diaphyseal fractures have various aetiological mechanisms of injury. This can be broadly grouped into direct or indirect. Direct mechanisms include high-energy fractures (RTAs), penetrating injuries, and 3-point bending injuries. High-energy mechanisms produce transverse or comminuted displaced diaphyseal fractures, with higher rates of open fractures and soft-tissue injury (French & Tornetta, Jan 2002; Norris & Kellam, 1997 Jan). Indirect mechanisms are largely torsional, low-energy injuries. They tend to result in spiral, nondisplaced, minimally comminuted fractures with minimal soft-tissue injuries.

Main causes of TDF can be grouped into five categories: Road traffic accidents, falls, sports injuries, direct blows or assaults, and gunshot injuries.

#### **2.3.1 Road Traffic Accidents**

Road traffic injuries (RTIs) are a major cause of global mortality and morbidity, killing approximately 1.3 million people and injuring 20 to 50 million each year (Puvanachandra, Hoe, El-Sayed, Saad, Al-Gasseer, Bakr & Hyder, 2012). These contribute the highest

incidence of TDFs. In the Edinburgh series (Court-Brown & McBirnie, 1995), 37.5% of tibial fractures followed road traffic accidents. The average age of those involved was reported as 39.8 years with majority (35%) sustaining OTA type C fractures. Of the total fractures due to RTAs, 59.3% were closed fractures. Pedestrians recorded the highest incidence of tibial shaft fractures among RTAs accounting for 59.2% while motorcyclist the least at 22.4%. However, motorcyclist largely sustained open fractures at 63.6% with most of them being young (average age of 28.4 years). A study in India reported the incidence RTAs (motorcycle, automobiles, bicycle and overruns) as the most common cause of TDFs at 65% (Baral et al. , 2013). A study in Uganda looking at patterns of injuries after road traffic crashes involving motorcycles found out that motorcycles contributed 73% of the trauma patients with majority of the fractures being in the lower limb and the leg being more involved (Kigera & Naddumba, 2010). In Nigeria, a study looking at Epidemiology of open tibial fractures in a teaching hospital reported that road traffic accidents constituted most of the injuries (91.4%), of which 51.5% were motorcycle related (Ibeanusi & Ekere, 2007).

Tibia bone is the most frequently injured bone in motorcycle accidents accounting for 19.2% of all motorcycle-related fractures (Zettas, Zettas & Thanosophon, 1979). This is particularly due to the exposed location of the tibia in motorcyclists. In a study highlighting the severity of tibial fractures in pedestrians, 93% of cases showed a high-energy fracture pattern and 30% of the tibial fractures were bilateral or segmental. There was also a reported 65% incidence of Gustilo type III open fracture and 33% associated multisystem injuries with 43% (Burgess, Poka & Brumback, 1987). A study in western

Kenya reported that tibia fibular fractures predominated at 29.3% of the all motorcycle injuries (Khanbhai & Lutomia, 2012).

### **2.3.2 Falls**

Falls may be categorized into simple falls, falls down the slope or stairs and fall from heights. Simple falls are those in which the patient falls the distance of his or her height. They are commonly seen in the elderly and flailing persons. As per the Edinburgh series, these accounted for the highest incidence of TDF at 17.8% with an average age of 57.4 years. Most of them (91.2%) were closed with a relatively simple fracture configuration. Falls down slope or stairs accounted for 2.5% of TDF and 92.3% were closed with a simple fracture pattern. Fall from heights were the least at 6.2% but with most of them (53.1%) being open fractures 47.1% of which were Gustillo III (Court-Brown *et al.*, 1998). A study in India reported falls as comprising 16.7% of TDF (Baral *et al.*, 2013).

### **2.3.3 Sports injuries**

Sports-related tibial fractures incidence and severity varies from country/region depending on the popularity of a particular sport. In Europe and America, two sports are particularly associated with TDF; soccer and skiing. In the Edinburgh series they accounted for 30.9% of all TDF with an average age of 23.5 years. Soccer accounted for 80.1% of all sports-related fractures and 24.7% of all tibial fractures while skiing caused 7.5% of TDF (Court-Brown & McBirnie, 1995). It is worth noting that the incidence of skiing is region dependent and may be extremely minimal or absent in most countries in the tropics. The study in India reported an incidence of 5.5% in sports/football related injuries in TDF (Baral *et al.*, 2013). Most sports related fractures are low velocity injuries (OTA type A) hence majority (95.6%) are usually closed.

### **2.3.4 Direct blows or assaults**

These accounted for only 4.5% of all TDF. They tend to occur in younger patients and are associated with less-severe fracture morphology, 69.6% being classified in OTA type A (Court-Brown & McBirnie, 1995).

However, in a study involving baseball assault patients, 69% of the fractures were OTA type B or C, and were associated with significant soft tissue damage that they similar to injuries sustained in RTAs, gunshot wounds, and crushing injuries (Levy, Bromberg & Jasper, 1994) . Notable in these injuries is that compartment syndrome was nine times that of their overall tibial fracture population. Repeated soft tissue damage causing significant muscle damage but not of much severity to tear the fascia may explain this finding. The India study reported incidence of 1.7% in stone related injuries (Baral *et al.*, 2013).

### **2.3.5 Gun-shot injuries**

Gunshot injuries are considered high energy trauma and are vary depending on the type of gun that is used to inflict the injury. The muzzle velocity of the weapon used determines the fracture morphology and the nature of soft tissue damage (Hollermann, Fackler, Coldwell, & Menchem, 1990). Gunshot injury is increasing worldwide due to the increase civilian unrest and violence (Mauffrey, 2006).

Data about the incidence of gunshot TDF in the population is scanty. In the United States where gunshot injuries are relatively common in major cities, most of the patients who sustain TDF are usually young, homeless or about to be imprisoned for crimes. This complicates follow up of such patients thus paucity of information on these fractures. Tibia fractures constituted 16.1% of lower limb fractures involving gunshot injuries. The average

age of the patients was 32.5 years (Olasinde, Ogunlusi & Ikem, 2012). Most of the fractures are OTA type C (54.3%) (Leffers & Chandler, 1985). The India study reported an incidence of 1.7% from bomb blast injuries in TDF (Baral *et al.*, 2013)

## **2.4 Fracture patterns/morphology**

TDF can simply be classified as either open or closed and whether it involves the upper, middle or lower third of the bone. A study in United Kingdom estimated that 77% of TDF treated by most orthopaedic surgeons are closed, and the remaining 23% are open (Court-Brown *et al.*, 1995). Some schools of thought suggest that integrity of the fibula bone and amount of fracture displacement are key in the prognosis of the fracture hence their consideration in the fracture classification (Teitz, Carter & Frankel, 1980).

Numerous fracture classifications have been proposed over the past decades. Most tend to be descriptive in nature and are based on the following criteria: (i) open versus closed injury; (ii) involvement of the proximal, middle, or distal thirds; (iii) the number and position of fragments, such as comminution or butterfly fragments; (iv) transverse, spiral, or oblique fractures; (v) varus, valgus, anterior, or posterior angulation; (vi) displacement or the percentage of cortical contact; (vii) rotation; and (viii) associated injuries. The most comprehensive classification of TDF is the Orthopaedic Trauma Association (OTA) classification initially described by the AO group (Muller, Nazarian & Koch, 1990). This is a morphologic classification based on the initial anteroposterior and lateral radiographs. (See appendix 4). Type A fractures constitute the majority at 54% of all tibial shaft fractures, while type C fractures account for 18.3% (Court-Brown & McBirnie, 1995).

Open fractures are classified with the system that Gustilo and Anderson proposed in 1976 and modified in 1984 (Gustilo, Mendoza & Williams, Aug 1984). The classification depends on increasing soft tissue injury. (See appendix 4). About 60% are usually type III fractures 19% are type II (Court-Brown & McBirnie, 1995).

Tscherne classification (See appendix 4) has been proposed for closed TDF (Oestern & Tscherne, 1984). This is usually pegged on the extent of soft tissue abrasions and contusions, the radiologic features of the fracture, the presence of closed degloving, the rupture of major blood vessels, and the presence of a compartment syndrome. Tscherne C1 fractures comprise 53%, while 6% of closed TDF are C3 fractures (Court-Brown, Keating & McQueen, 1992).

A study by in India reported incidence of closed fractures at 65% and open type at 35%. Lower 1/3 level was the most affected at 49.2% and the transverse subtype was the most common (Baral *et al.*, 2013). In a study that was exclusively looking at motorcycle injury patterns at a county referral hospital in Kenya reported 75% closed tibia fractures patients (Khanbhai & Lutomia, 2012)

Categorizing of fractures and soft tissue injuries assists in transfer of information and the storage of data. It may also assist in defining fracture management and predict simple outcome measures (Jackson & MacNab, 1959). OTA classification is predictive of time to weight bearing and time to return to activities of daily living. Gustillo classification is predictive of time to union and incidences of non-union, malunion and infections but not predictive of functional outcome. On the other hand the Tscherne classification is

predictive of time to union and time to return to activities of daily living (Court-Brown *et al.*, 1992).

## **2.5 Associated injuries**

It is imperative for the examining clinician to note that there may be other injuries associated with TDF especially in high energy injury. Fracture of the fibula is the most common associated injury. In the Edinburgh study, the fibula was fractured in 77.7% of tibia shaft fractures (Court-Brown & McBirnie, 1995). Isolated tibial fractures with an intact fibula commonly occur in a younger age group and have a higher incidence of OTA type A fractures and lower. Debate still rages as to whether an intact fibula is associated with improved or worse prognosis (Whittle, Russell & Taylor, 1992; Teitz *et al.*, 1980).

Incidence of associated knee ligament injuries in tibial shaft injuries is high (Templeman & Marder, 1989). In all tibia fractures, 5% are usually bifocal where there are two separate fractures in the tibia bone (Keating, Kuo & Court-Brown, 1994). Weber was the first to describe the combination of tibial shaft fractures and additional ankle joint injuries (Weber, 1972). This is usually a result from torque forces of the lower leg making the ankle joint susceptible to injury especially the distal tibiofibular syndesmosis. One study recorded a 20.1% associated ankle injuries in patients with tibia shaft fractures with 88.4% of those with ankle injuries having a ruptured distal tibiofibular syndesmosis (Ewa & Klaus, 2008).

Data on proportion of other regions injured in association with tibia shaft injuries is not available or quite scanty. Thus this study will endeavor to highlight these associated injuries including but not limited to head injuries, chest trauma, other long bones injuries and pelvic injuries.



## 2.6 Treatment methods

Generally two modes of management for an acute tibial fracture are in use. These are non-operative and operative approaches. Non operative methods include; i) Casting with a long leg cast, followed by a patellar tendon-bearing cast or a cast braces ii) Functional bracing. The Indian study recorded rates of 51.7% of the patients managed operatively (Baral *et al.*, 2013). Operative methods involve plating, intramedullary nailing, external fixation and amputation for severely mangled limbs (Alho *et al.*, Apr 1992).

Choice of the treatment method is dependent on fracture pattern or morphology. Closed fractures with minimal displacement or stable reduction may be treated nonoperatively with a long leg cast. Cast application should be delayed for 3-5 days to allow early swelling to diminish. A study has reported that 53% of patients reported a fair or poor result using long leg casts to treat tibial shaft fractures (Kyro, Tunturi & Soukka, 1991). Functional brace was popularised by Sarmiento. The device allows more movement of the knee and ankle while still protecting the tibial fracture thus preventing joint stiffness. A study has reported 40% nonunion rate with functional brace (Karaharju, Alho & Nieminen, 1975).

For open fractures, surgical debridement is done as an emergency before definitive fixation is done. This is very important to prepare the fracture for reduction and to combat infection (Edwards, 1983). Plating remains a viable surgical option for tibial shaft fractures and was once the main treatment of choice. Large surgical incision may be required in the insertion of the conventional plates. Their use in open fractures is highly discouraged due to high rates of infections (Behrens & Searls, 1986). External fixation is a common method of treating some types of tibial shaft fractures. It is especially useful for proximal tibial

fractures that may be difficult to align properly with intramedullary nailing as well as severely comminuted fracture pattern that is hard to align for reaming and nailing. External fixation may also be applied in tibias whose intramedullary canal is too narrow to ream. External fixators come in different designs and configurations. Higher rates of nonunion and malunion have been associated with external fixation as compared to intramedullary nailing (Clifford, Lyons, & Webb, 1987).

Intramedullary nailing with locking screws has become the treatment of choice for most tibial shaft fractures since rates of nonunion and malunion is greatly decreased as compared to the other methods of fixation. Patients are also able to resume to low demand activities much sooner than they can with the other methods (Busse, Morton, Lacchetti, Guyatt & Bhandari, 2008; Duan, Al-Qwbani, Zeng, Zhang & Xiang, 2012).

While uncommon, amputation is sometimes indicated for severe tibial fractures, especially those with extensive soft-tissue injury or those with vascular compromise. Rates of amputation are increased for grade III fractures. A study has reported that fractures requiring revascularization (type IIIC fractures) have a corresponding amputation rate of greater than 20% (Lange, Bach, Hansen Jr & Johansen, 1985). Mangled Extremity Severity Score is a tool that has been developed to help the surgeon decide whether or not amputation is indicated. However, this should not be used in exclusion as surgical expertise and patient communication are pivotal in making the decision.

## CHAPTER 3: METHODOLOGY

### 3.1 Study site:

The study site was at the Moi Teaching and Referral Hospital, Eldoret. This is a national teaching and referral hospital in western region of Kenya attending to both rural and urban populace. Eldoret town is located North-West and approximately 311km from the capital city Nairobi. It lies on the geographical latitude of  $0^{\circ} 31' \text{ N}$  and longitudinal  $35^{\circ} 17' \text{ E}$ . It is the administrative centre of Uasin Gishu County. Eldoret is now among the fastest growing town in Kenya being the 5<sup>th</sup> largest city in Kenya today. It lies south of the Cherangani Hills and has a local elevation varying from about 2100 to 2700 metres above sea level (7000–9000 feet). With the high altitude, it is dotted with a milliard of training camps for many middle and long distance athletes who contribute largely in the town's economic prowess. Eldoret is also one of Kenya's bread baskets as it is endowed with rich agricultural soils and favourable climatic pattern. As a leading training hub of the country, the town also hosts numerous learning institutions.

Moi Teaching and Referral Hospital offers a wide range of health services in its Out-Patient and In-Patient sections. The hospital has a bed capacity of 1000. The facility boasts of highly trained and specialised medical staff from both the hospital and its associated training institution, College of Health Sciences, Moi University. The hospital's catchment regions include North Rift Region, Western Kenya, parts of Eastern Uganda and Southern Sudan with a population of at least 20 million people. The hospital also hosts students from Moi University, Kenya Medical Training Centre (KMTC), University of East Africa, Baraton, and the ECN (enrolled community nurse) upgrading programme as well as international students on exchange programmes courtesy of Moi University.

The hospital has a very busy department of surgery which is serviced by other key departments of the hospital e.g. laboratory, physiotherapy, occupational therapy, nutrition, social work, and operating theatres. The department experiences high bed occupancy of between 100%-150%. The hospital is also the home to AMPATH, the fruit from the collaboration involving the Indiana and Moi Universities. The Riley Mother and Baby Hospital is a modern facility for the care of expectant mothers and their babies. There are recent developments- including construction and now operational Shoe for Africa Children Hospital and Chronic Diseases and Cancer Center.

### **3.2 Study design:**

A prospective hospital based descriptive study that began in 1<sup>st</sup> October 2013 and ended in 30<sup>th</sup> September 2014.

### **3.3 Study population:**

All the adult patients with TDF referred or seeking treatment at MTRH and who met the inclusion criteria and consented for the study.

#### **3.3.1 Inclusion criteria**

Adult patients with TDF treated at MTRH clinically diagnosed and radiologically confirmed. The patients who were 18 years and above, had the cognitive ability to understand questions and were willing to take part in the study

#### **3.3.2 Exclusion criteria**

- Patients with tibia shaft fracture treated elsewhere but followed up at MTRH
- Patient who did not complete treatment at MTRH for whatever reason.

### **3.4 Sample size determination:**

The sample size required in order to be 95% sure that the proportion of the patients who suffer a closed tibia fractures is within plus or minus 10% of the population proportion of 67% was estimated using the following formula (Cochran WG. , 1963).

$$\begin{aligned}
n &= \left( \frac{Z_{1-\alpha/2}}{\delta} \right)^2 P(1-P) \\
&= \left( \frac{1.96}{0.1} \right)^2 0.67(1-0.67) \\
&= 85
\end{aligned}$$

Where P, equal to 67%, is the population proportion of those who develop the closed tibia fracture,  $\delta$  is the margin of error equal to the 10% used in this study, and  $Z_{1-\alpha/2}$  is the  $(1-\alpha/2) \times 100\%$  quantile of the standard normal distribution.

This gave us a total of 85 patients.

The population proportion of 67% was obtained using the preliminary data from the Moi Teaching and Referral Hospital (MTRH) where in the year 2012 a total of 95 patients had closed tibial diaphyseal fractures out of the total of 142 patients with all types of tibial diaphyseal fractures. Other studies have also shown prevalence values of the closed tibia fractures of around 75%. (Edinburgh Orthopaedic Trauma Unit tibial diaphyseal fractures epidemiological series study). However since the latter is a far of location from the study area, the preliminary data from MTRH was opted for.

Given that non-probability consecutive sampling was used provided there was satisfaction of eligibility criteria there was no need to adjust this sample size for finite population. Thus the final minimum sample size that was needed in this study was 85.

**3.5 Sampling method:**

Non-probability consecutive sampling was used on all adult patients meeting the eligibility criteria with fracture tibia diaphysis seeking care as either outpatient or as inpatients.

**3.6 Data collection tools :**

The study tool was an interviewer administered questionnaire which was done by the researcher. The questionnaire had questions on patient's socio-demographic factors, occupation, detailed mechanism of injury, age of the injury, and whether the patient was primarily seeking treatment or referred from other facility. Morphological classification of the fracture was also documented as discerned from the radiological investigation and clinical evaluation. Type and nature of any associated injury(s) was also documented.

**3.7 Quality Control:**

Development of questionnaire and pre-testing of the questionnaire was carried out. Review of data after collection to check for missing data and unclear parts, cleaning of data and counter checks on data entry was done.

**3.8 Data analysis and presentation:**

Data analysis was done using standard software for statistical analysis and computation known as R (R Core Team, 2015). Categorical variables were summarized as frequencies and the corresponding percentages while continuous variables that assumed Gaussian distribution were summarized as mean and the corresponding standard deviation (SD). Continuous variables that violated the Gaussian assumptions were summarized as median and the corresponding inter quartile range (IQR). Normality assumptions were assessed empirically using Shapiro Wilk test for normality. Association between categorical

variables was assessed using Pearson's Chi Square test and Fisher's exact test. Results were presented using tables, graphs and pie charts.

### **3.9 Ethical considerations:**

To carry out the study, permission was sought and granted from the Institutional Research and Ethics Committee (IREC) as per the attached approval letter in the appendix. Informed consent was sought from all eligible patients in a language that they fully understood and his/her written consent sought. Any risks or benefits accrued to the research were explained to each participant. This was voluntary participation and no patient was denied treatment whether she/he gave consent or not. Utmost confidentiality with regards to the participants was assured. The participants had the leeway to withdraw from the study at any stage even after consenting and this did not affect their medical care. The research was compiled into a thesis which has been submitted in partial fulfilment of the MMed Orthopedics Program.

### **3.11 Study limitation:**

Inadequate xrays in terms of views and extent of regions captured was sometimes experienced. This was overcome by requesting repeat xrays that were view and region specific.

## CHAPTER 4: RESULTS

A total of 89 participants with 93 TDF were recruited into the study. Over half of the participants were attended to first at MTRH after injury while 41 (46.1%) were referrals.

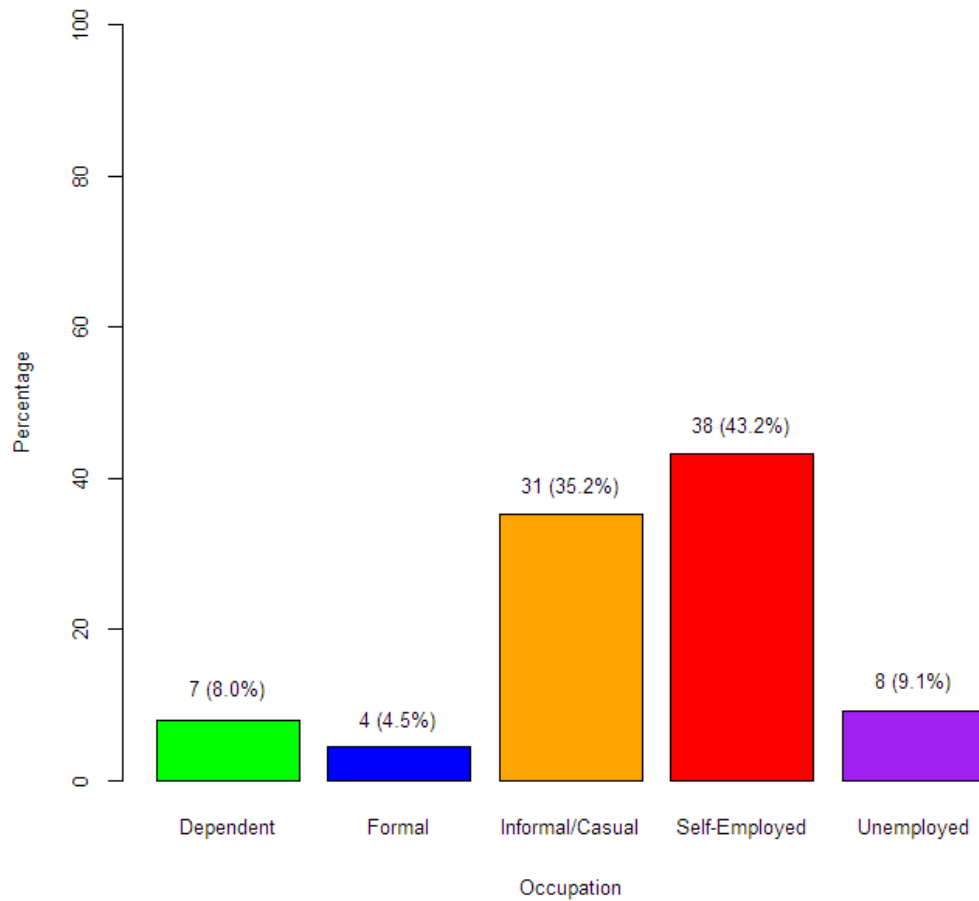
In terms of the affected limb, 4(4.5%) participants had bilateral injury, 33 (37.1%) participants left leg while 52 (58.4%) had the right leg affected.

**Table1: Socio-Demographic characteristics**

Variable		Sample size	n (%) or Median (IQR)
Age (years)		89	28.0 (24.0, 40.0)
Male		89	68 (76.4%)
Female			21 (23.6%)
Religion	Christians	89	81 (91.0%)
	Muslims		1 (1.1%)
	No Religion		7 (7.9%)

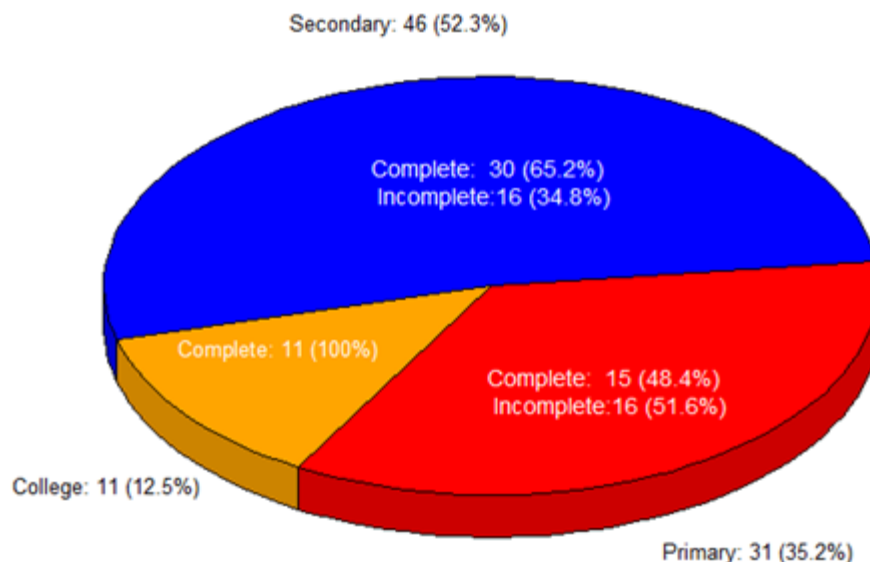
Table 1 shows the social demographic characteristics of the patients studied. Median age was 28.0 (IQR: 24.0, 40.0) years with a minimum and maximum of 18 and 75 years respectively. Over three quarters of the patients (75.3%) were 40years and below in age. Male participants comprised more than three quarters of those recruited with a male to female ratio of 3.2:1.





**Figure 1: Distribution of participants by type of occupation**

A greater proportion of the participants as seen in Figure 1, 38 (43.2%), were self-employed and slightly more than one third, 31 (35.2%), were working as casual laborers. Formally employed participants account for less than 5%. Dependent and unemployed participants constituted 7 (8.0%) and 8 (9.1%) respectively.



**Figure 2: Distribution by highest education level**

More than half of the participants reached high school level of education. However, less than two thirds completed secondary school level of education giving an overall rate of 34.1% of those who completed secondary school level of education. Overall 17.0% completed primary school level of education and 12.5% completed tertiary level education. Results show that over half, 53.4% had either incomplete secondary education, complete or incomplete primary education.

**Table 2: Aetiological mechanisms of injury**

Variable	Sample size	n (%)
Degree of injury		
High energy	89	69 (77.5%)
Low energy		20 (22.5%)
Mechanism		
RTAs	89	60 (67.4%)
Fall		16 (18.0%)
Direct blows/assault		6 (6.7%)
Sports		4 (4.5%)
Gunshot		3 (3.4%)

Over three quarters of the participants, 69 (77.5%) sustained high energy injury. The specific injuries show that two thirds of the participants 60 (67.4%) sustained injuries due to RTAs. Those who sustained injuries due to falls comprised 16 (18.0%). Three (3.4%) had gunshot injuries, 4 (4.5%) had sports related injuries and 6 (6.7%) were injured as a result of assault or direct blows.

**Table 3: Association between the degree of injury and the mechanism of injury**

	Degree of injury		
Mechanism	High Energy	Low Energy	P
Direct blows/assault	5 (7.2%)	1 (5.0%)	1.000 <sup>f</sup>
Fall	3 (4.3%)	13 (65.0%)	<0.0001 <sup>f</sup>
Gunshot	3 (4.3%)	0 (0.0%)	1.000 <sup>f</sup>
RTAs	57 (82.6%)	3 (15.0%)	<0.0001
Sports	1 (1.4%)	3 (15.0%)	0.034 <sup>f</sup>
<b>Overall</b>	<b>69 (100%)</b>	<b>20 (100%)</b>	

<sup>f</sup> – Fisher's exact P value was reported because the expected cell frequency of at least one cell in the created 2x2 table was <5, a violation of Chi Square assumptions.

A significantly higher proportion of those who had low energy injuries were due to fall injuries, 13 (65.0%) vs. (3 (4.3%),  $p < 0.0001$ ). A significantly higher proportion of those who had high energy injuries were due to RTAs, 57 (82.6%) vs. 3 (15.0%),  $p < 0.0001$ .

Sport injuries were also associated with low energy degree of injury,  $p = 0.034$ .

There was no sufficient evidence from the data to link the degree of injury with direct blows and assault as well as gunshots.

**Table 4: RTA related mechanisms of injury**

RTA		n	n (%)
RTA mechanism of injury	Motorcycle	60	39 (65%)
	Car		20 (33.3%)
	Bicycle		1 (1.7%)
Car	Driver with Seat belt on	20	1 (5.0%)
	Driver with no seatbelt on		2 (10.0%)
	Passenger with no seatbelt on		9 (45.0%)
	Passenger with seatbelt on		2 (10.0%)
	Pedestrians		6 (30.0%)
Motorcycle	Cyclists	39	19 (48.7%)
	Pedestrians		8 (20.5%)
	Pillion		12 (30.7%)
Bicycle	Cyclist	1	1 (100%)

One third of the RTA related fracture injuries involved cars. A higher proportion of RTA related injuries, 39 (65%), involved motorcycle. Of those that involved cars, drivers comprised 3 (15.0%); two without seat belts and one with the seat belt on. Passengers comprised 11 (55.0%), and pedestrians comprised 6 (30.0%). Of the eleven passengers, 9 had no seatbelt on.

Of the fracture injuries involving motorcycles, cyclists comprised 19 (50.0%). Pedestrians were 8 (20.5%) while pillions were 12 (30.7%). There was only one bicycle cyclist.

**Table 5: TDF due to gunshots, sports, fall and direct blows or assaults**

Variable			N	n (%)
Gunshot	Cattle rustling		3	3 (100%)
Sports	Type of sport	Rugby	4	1 (25.0%)
		Soccer		3 (75.0%)
	Nature of sport	Contact	4	4 (100%)
Fall	Nature of fall	Down a gradient	16	4 (25.0%)
		From height		6 (37.5%)
		Simple		6 (37.5%)
Direct blow	Incidence	Domestic violence	6	1 (16.7%)
		Hit by heavy falling object		1 (16.7%)
		Farm accident		2 (33.3%)
		Mob justice		1 (16.7%)
		Occupational injury		1 (16.7%)
	Nature	Accidental	6	4 (66.7%)
		Intentional		2 (33.3%)
	Object	Blunt	6	3 (50.0%)
		Sharp		2 (33.3%)
		Blunt and sharp		1 (16.7%)

**Table 6: Fracture morphology**

Variable		Open	Closed	n(%)
Levels	Mid 1/3	16	33	49(52.7%)
	lower 1/3	14	13	27 (29.0%)
	Upper 1/3	8	9	17 (18.3%)
Totals		38(40.9%)	55(59.1%)	93(100%)

Up to 40.9% of the analyzed fractures were open type while 59.1% were closed type.

Slightly more than half of fractures were in the mid 1/3 level while 29% of them were in the lower 1/3 and 18.3% had an upper 1/3 fracture level respectively.

**Table 7: Correlation between age and level of the fracture**

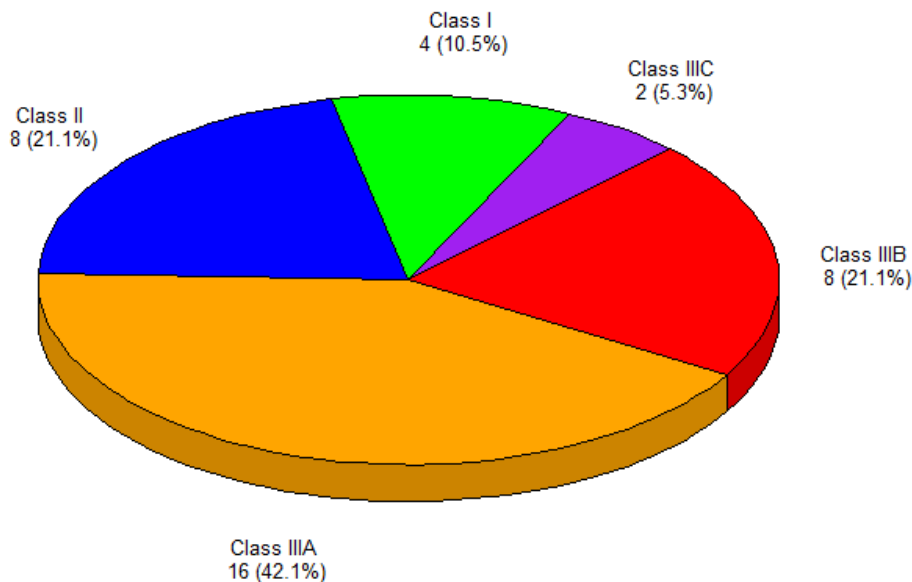
		Age (Years)		Fisher's Exact test P –value
		<=40	>40	
Level of fracture	Lower 1/3	22 (31.0%)	5 (22.7%)	0.720
	Mid 1/3	37 (52.1%)	12 (54.5%)	
	Upper 1/3	12 (16.9%)	5 (22.7%)	

There was no association between the age of the participants and the level of fracture, P = 0.720.

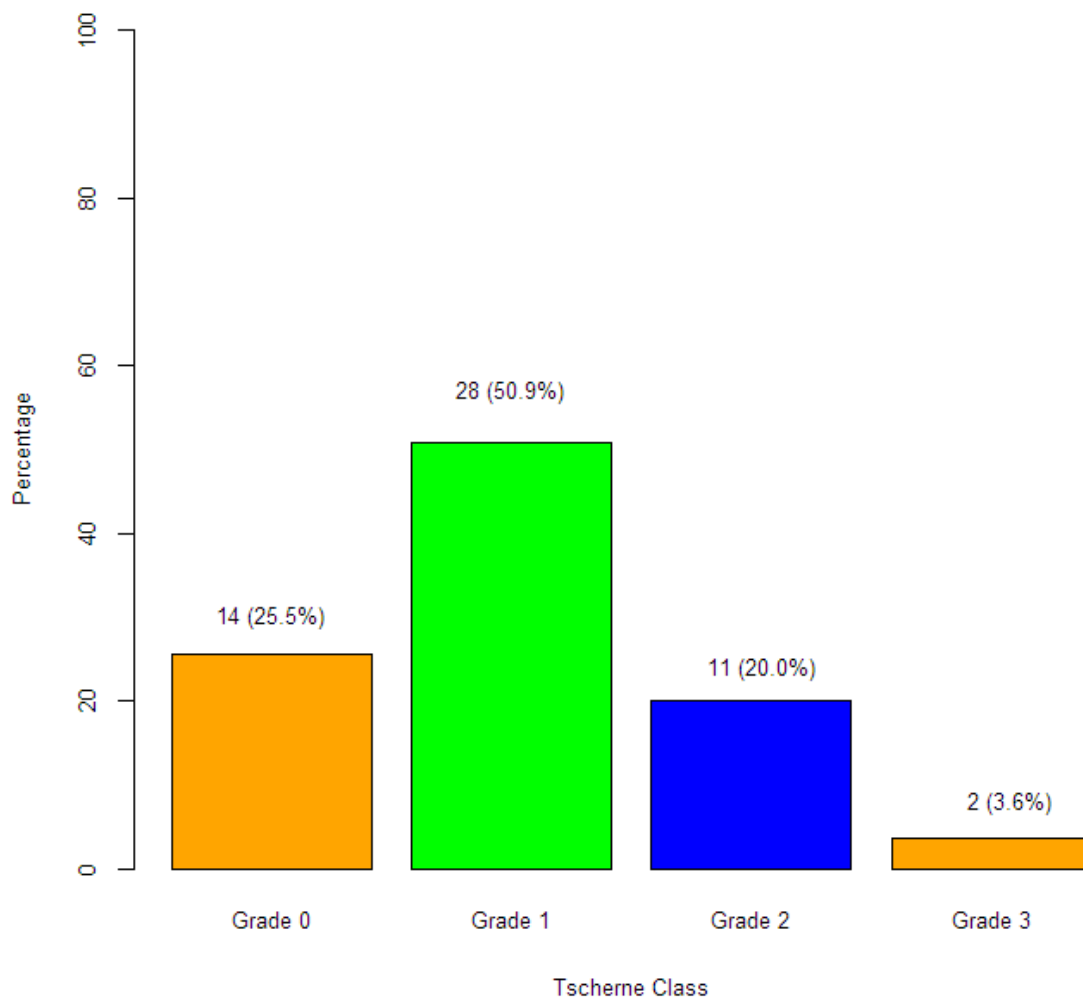
**Table 8: Orthopedic Trauma Association fracture classification**

OTA classification	Subgroups	Open	Closed	n (%)
Unifocal-A Type	Spiral	3	7	10(10.7%)
	Oblique	4	17	21(22.6%)
	Transverse	4	9	13(14.0%)
Wedge-B Type	Intact spiral wedge	2	2	4(4.3%)
	Intact bending wedge	6	4	10(10.7%)
	Comminuted wedge	2	8	10(10.7%)
Complex-C Type	Spiral wedge	4	4	8(8.6%)
	Segmental	6	3	9(9.7%)
	Comminuted	7	1	8(8.6%)

Overall, type A fractures were the most common comprising 47.3% while type B and C recorded almost similar numbers. However, among open fractures, type C patterns were the most common at 44.7% of open fractures. Notable among type C open fractures, comminuted ones recorded the highest number. In closed fractures, Type A were the most common at 60% with the oblique subtype recording the highest number.

**Figure 3: Gustilo classes among open fractures types**

Majority of the open fractures were in Gustilo class IIIA at 42.1% followed by class II and IIIB at 21.1%. The least were in class IIIC.



**Figure 4: Tscherne Class among the closed fractures with soft Tissue Injury**

Tscherne classification among those with closed fractures showed that half, 28 (50.9%), of those who had closed fracture with soft tissue injury were in Grade I. A quarter of the fractures were in Grade 0, one fifth in grade 2 and 3.6% in Grade 3.



**Table 9: Associated injuries**

<b>Injury (n=89)</b>	<b>n (%)</b>
Fibula	56 (62.9%)
Upper limb	15 (16.9%)
Femur	14 (15.7%)
Head	12 (13.5%)
Ankle	11 (12.4%)
Chest	5 (5.6%)
Knee	4 (4.5%)
Pelvis	3 (3.4%)
Foot	2 (2.2%)
Abdomen	2 (2.2%)

Assessment of the associated injuries revealed that there were 56 (62.9%) participants with an associated fibula injury closely followed by upper limb at 15 (16.9%), and femur at 14 (15.7%). The least associated injuries involved both the foot and abdomen at 2(2.2%).

**Table 10: Treatment methods**

<b>Variable (N=89)</b>		<b>n (%)</b>
Patient category		
	Inpatient	58 (65.2%)
	Outpatient	31 (34.8%)
Non-operative		
	Casting	34(38.4%)
Operative- <b>Unilateral leg Fractures</b>		
	Amputation	4 (4.5%)
	Debridement + Casting	4(4.5%)
	Debridement + IM Nailing	18(20.2%)
	IM Nailing	18(20.2%)
	Debridement+ External Fixator	5(5.6%)
	IM Nailing + Plating	1(1.1%)
	Plating	1(1.1%)
Operative- <b>Bilateral legs Fractures</b>		
	Debridement + IM Nailing, Debridement+ External Fixator	2(2.2%)
	IM Nailing, Debridement+ External Fixator	1(1.1%)
	Debridement + IM Nailing, Amputation	1(1.1%)

Over half of the participants were admitted into the wards.

Casting was done to all the participants treated as outpatients. Of those who underwent operative treatment approach, majority 43% were treated using IM nailing method with more than half undergoing debridement before nailing. Plating was the least used modality of treatment at 1.1%.

## **CHAPTER 5: DISCUSSION**

### **5.1 Socio-Demographic Characteristics**

In this study majority of the participants were young. Male participants were dominant with a male to female ratio of 3.2:1. This concurs with a study in Edinburg which reported a closely similar ration of 3.42:1 (Court-Brown & McBirnie, 1995). However, in a study by Irfanullah *et al.*, 2013 in Lahore Pakistan, a male to female ratio of 7.3:1 was reported with age range of 17-60 years. The same study reported many participants at 40 years and below at 72%. Male domination may be reflective of a society where the male is largely the provider to the family thus takes more risks in his economic quest. Younger age domination may be explained by the fact that this is the most productive age group in the population and with huge risk appetite thus likely to encounter situations leading to injuries such as TDF.

Concerning economic undertaking, this study revealed a low percentage of those in formal employment at less than 5%. This may be explained by their possibility of having an elaborate medical insurance cover thus able to seek treatment in private facilities.

### **5.2 Aetiological mechanisms of injury**

The right leg was the most affected in the study. This study did not identify the dominant limb. The finding compares closely to a study in India that reported involvement of the right leg at 66.6% (Baral *et al* 2013). There was however, no explanation in his study and there was no control for the dominant limb.

Over three quarters of the participants had high energy degree of injury. This may be explained by the fact that RTAs were overall major contributors to TDF in the study. Also explaining this is that major energy transmission is involved during impact in a RTA hence likely to result to high energy degree of injury.

The specific injuries showed that majority of the injuries were due to RTAs. Those who were injured due to falls comprised close to one fifth while gunshot injuries reported the least cause of TDF. The study in India reported similar findings with MVAs (motorcycle, automobiles, bicycle and overruns) as the most frequent cause of TDFs at 65% and falls at 16.7% (Baral *et al.*, 2013). A study in Edinburg on the other hand reported RTA contribution to TDF at 37.5% (Court-Brown & McBirnie, 1995). The high contribution by RTA in our setup may be explained by recklessness by motorists and inconsistencies in the enforcement of traffic laws. Considerable numbers of unroadworthy vehicles and unqualified drivers may also partly explain the situation. Another possibility is that many passengers may fail to raise their voices in the face of carelessly driven public service vehicles only doing so when an RTA has occurred.

A higher proportion of RTA related injuries involved motorcycles. This compares well with a study in Uganda where motorcycles contributed 73% of the trauma patients (Kigera & Naddumba, 2010). A study in Nigeria, a study looking at Epidemiology of open tibial fractures in a teaching hospital reported that road accident constituted most of the injuries (91.4%), of which 51.5% were motorcycle related (Ibeanusi & Ekere, 2007). In contrast, the Edinburg study reported 22.4% contribution by motorcycles in TDFs (Court-Brown & McBirnie, 1995). High contribution by motorcycles to these injuries may be explained by increased number of motorcycles on our roads for commercial use without provision of cycle lanes. Also partly may be due to their affordability, quick and ease of accessibility as a means of transport and poor regulation of their use. Moreover, most of the cyclists may be poorly trained with some not licensed as riders. In addition, there's a likelihood that many cyclists inconsistently put on reflective jackets especially at night hence may easily

be knocked down by other road users. The high cost of living may drive the cyclist to try and make more money hence are likely to flaunt traffic rules and regulations in the process and this may expose them and their clients to risk of injuries. Complacency on the part of the pillion leaves them at the mercy of the cyclists who may be careless or unqualified hence exposing them to dangers of trauma.

A study in Uganda found out that majority of the fractures were in the lower limb with the leg being more involved (Kigera & Naddumba 2010). Another study in western Kenya reported that tibia fibular fractures predominated at 29.3% of the all motorcycle injuries (Khanbhai & Lutomia, 2012). This may be explained by the fact that the lower limbs are relatively exposed with the leg dangling dangerously as the motorcycle weaves through traffic.

The study realized that close to two thirds of RTA injuries involved pedestrians knocked by cars, cyclists and pillions. Toro et al 2005 reported that likelihood of sustaining lower limb fractures is higher in cyclists and pedestrians due to the impact on the lower limbs by car bumpers (Toro, Hubay, So'tonyi & Keller, 2005).

### **5.3 Fracture morphology**

The study found out that closed fractures were slightly more than open fractures with more than half of fractures being in the mid 1/3 level. A study by in India reported similar findings with closed fractures at 65% and open type at 35%. However lower 1/3 level was the most affected at 49.2% (Baral *et al* 2013). However, a study that was exclusively looking at motorcycle injury patterns at a county referral hospital in Kenya reported 75% tibia fractures were closed (Khanbhai & Lutomia, 2012). Similarly in the Edinburg series reported 77% of tibial diaphyseal fractures being closed, while 60% of open fractures were

type III. Tscherne Grade I fractures comprised 53% in closed fractures (Court-Brown *et al.*, 1992). The relatively higher proportion of open fractures in this study may be attributed to RTAs especially motorcycles being the major cause of injuries which in essence are high energy mechanism. Also the relatively superficial anteromedial border of the tibia bone leaves it poorly cushioned by soft tissues hence likely to lead to open fractures. The middle third of tibia shaft has the weakest stress tolerance hence likely to give on impact. Ongoing road network improvement in the country is likely to encourage speeding on the road hence leading to severe form of fractures. Rising number of registered public service vehicles and motorcycles in the country has led to high competition among operators leading to speeding that is likely to lead into fatal or severe injuries in the event of an accident.

#### **5.4 Associated injuries**

This study found out that majority of the participants had an associated fibula injury. This is similar to the study in India which reported 55% associated fibula injury (Baral *et al.*, 2013). However the Edinburgh study reported associated fibula fracture in 77.7% of tibia diaphyseal fractures which was slightly higher than reported in this study (Court-Brown & McBirnie, 1995). Depending on the level of the fibula fracture, this may have an implication on the outcome of treatment of TDFs based on whether the fibula fracture is fixed or not. The level of fibula fracture also helps determine the energy magnitude of the fracture. The high proportion of associated fibula fracture in this study may be due to majority fractures arose from high energy injury mechanisms. The fibular bone is anatomically located in juxtaposition with the tibia and absorbs the same forces deforming the tibia during injury hence the association. Presence of other associated injuries may

have been influence by factors such as cause of the injury, magnitude of energy transmitted and incase of RTA, use of protective gears such as helmets and seat belts.

### **5.5 Treatment methods**

Majority of the patients in the study were managed as inpatients despite many of the fractures being closed. This is explained by severe associated injuries some of which warranted inpatient observation and or treatment. Partly contributing may be the severe and displaced fractures needing inpatient operative treatment.

Operative management was the most common approach used for TDFs in this study accounting for 61.6% with locked intramedullary nailing being popularly used. This compared will with the study in India which reported 51.7% of the patients being managed operatively (Baral *et al.*, 2013). Studies have reported that locked intramedullary have shown lower rates of nonunion and malunion as compared to the other methods of fixation (Busse *et al.*, 2008 Oct; Duan *et al.*, 2012). The use of locked intramedullary nail as the implant of choice for fixation may be explained by its ease of use affordability and availability at MTRH since they were donated by a philanthropist. Moreover, a lot of research surrounding SIGN nail, a locked intramedullary nail, is ongoing at the study site.

## **CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS**

### **6.1 Conclusions**

1. Majority of the participants were relatively young with the males were more affected.
2. Road Traffic Accidents especially motorcycle injuries were the major cause of TDF.
3. Most of the TDF were closed type; mainly type A with mid third the most affected level.
4. Fibular fracture was the most common associated injury.
5. Treatment to TDF was mainly surgical with locked intramedullary nail (SIGN) mostly used.

### **6.2 Recommendations**

1. Education to the young males in the population on road safety.
2. Maintain and strengthen the SIGN programme at MTRH as an implant of choice in the treatment of these fractures



## REFERENCES

- Alho A, Benterud JG, Hogevoid HE. (Apr 1992). Comparison of functional bracing and locked intramedullary nailing in the treatment of displaced tibial shaft fractures. *Clinical Orthopaedics*, 277:243-50.
- Ayumba, BR; LK, Lelei; Emarah, AM, Lagat, D. (2015). The management of post-traumatic exposed bones at MTRH, Eldoret. *East Africa Orthopaedics Journal*, 7:21-25.
- Bachani AM, Koradia P, Herbert HK, Mogere S, Akungah D, Nyamari J...Stevens KA. (2012). Road Traffic Injuries in Kenya: The health burden and risk factors in two districts. *Traffic Injuries Prevention*, 13(1):24-30.
- Baral R., Khan JA, Singh GP. (2013). pattern of tibial shaft fractures in universal college of medical sciences, bhairahawa: a review of sixty cases. *Journal of Universal College of Medical Sciences*, 1 (03).
- Barnes R, Brown JT, Garden RS, Nicoll EA. (1964). fracture of tibial shaft. A survey of 705 cases. *Journal of Bone & Joint Surgery*, 46:373-87.
- Behrens F, Searls K. (1986 Mar). External fixation of the tibia. Basic concepts and prospective evaluation. *Journal of Bone & Joint Surgery*, 68(2):246-54.
- Burgess AR, Poka A, Brumback RJ. (1987). Pedestrian tibial injuries. *Journal of Trauma*, 27:596-601.
- Busse JW, Morton E, Lacchetti C, Guyatt GH, Bhandari M. ( 2008 Oct). Current management of tibial shaft fractures: a survey of 450 Canadian orthopedic trauma surgeons. *Acta Orthopaedica*, 79(5):689-94.
- Clifford RP, Lyons TJ, Webb JK. (1987 May). Complications of external fixation of open fractures of the tibia. *Injury*, 18(3):174-6.
- Cochran WG. . (1963). *Sampling Techniques* (2<sup>nd</sup> ed). New York, USA: John Wiley and Sons, Inc.
- Court-Brown CM, Keating JF, McQueen MM. (1992). Infection after intramedullary nailing of the tibia. Incidence and protocol for management. *Journal of Bone & Joint Surgery*, 74B:770-774.
- Court-Brown CM, McBirnie J. (1995). The epidemiology of tibial fractures. *Journal of Bone & Joint Surgery*, 77B:417-421.



- Court-Brown CM, Rimmer S, Prakash U, McQueen MM. (Sep 1998). The epidemiology of open long bone fractures. *Injury*, 29(7):529-34.
- Duan X, Al-Qwbani M, Zeng Y, Zhang W, Xiang Z. (2012, Jan 18). Intramedullary nailing for tibial shaft fractures in adults. *Cochrane Database Syst Rev*, p. 1:CD008241.
- Edwards,CC. (1983 Sep). Staged reconstruction of complex open tibial fractures using Hoffmann external fixation. Clinical decisions and dilemmas. *Clinical Orthopaedics*, (178):130-61.
- Ewa K S, Klaus M S. (2008). Tibial Shaft Fracture and Ankle Joint Injury. *Journal of Orthopaedics Trauma*, 22:107–112.
- French B, Tornetta P. (Jan 2002). High-energy tibial shaft fractures. *Orthopaedics Clinical North America*, 33(1):211-30.
- Gaston P, Will E, Elton RA, et al. (1999; ). Tibial fractures. Can their prognosis be predicted? *Journal of Bone & Joint Surgery*, 81B:71-76.
- Grütter R. et al. (2000). The epidemiology of diaphyseal fractures of the tibia. *Injury*, 31:64.
- Gustilo RB, Mendoza RM, Williams DN. . (Aug 1984). Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. *Journal of Trauma*, 24(8):742-6.
- Hollermann JJ, Fackler ML, Coldwell DM, Menchem Y. (1990). Gunshot wounds: Bullets, ballistics and mechanism of injury. *American Journal of Roentgenol*, 155(4):685-90.
- Ibeanusi S.E.B, Ekere A.U. (2007). Epidemiology of Open Tibial Fractures In a Teaching Hospital. *Port Harcourt Medical Journal*, 1(3):156-160.
- Irfanullah K, Shahzad J, Gauhar N. K. and Amer A. (2013). Outcome of Intramedullary Interlocking SIGN Nailing in Tibial Diaphyseal Fracture. *Journal of the College of Physicians and Surgeons Pakistan*, 23(3): 203-207.
- Jackson RW, MacNab I. (1959). Fractures of the shaft of the tibia. A clinical and experimental study. *Annals of Surgery*, 97:543-547.
- Johner R. (2000). The point of view of the clinician: a prospective study of the mechanism of accidents and the morphology of tibial and fibular shaft fractures. *Injury*, 31 (3) 45-93.

- Karaharju EO, Alho A, Nieminen J. (1975 Aug). The results of operative and non-operative management of tibial fractures. *Injury*, 7(1):47-52.
- Keating JF, Kuo RS, Court-Brown CM. (1994). Bifocal fractures of the tibia and fibula. *Journal of Bone & Joint Surgery*, 76B:395-400.
- Khanbhai M, Lutomia M. (2012). Motorcycle Accident injuries seen at Kakamega Provincial Hospital in Kenya. *East and Central African Journal of Surgery*, 17 (1): 43-46.
- Kigera J, Naddumba E. (2010). Patterns of Injuries after Road Traffic Crashes Involving Bodabodas. *Annals of African Surgery*, 5:12-15.
- Klok, J. (2011). *Tibial Shaft, in Evidence-Based Orthopedics*. New Jersey,USA:Wiley-Blackwell.
- Kyro A, Tunturi T, Soukka A. (1991). Conservative treatment of tibial fractures. Results in a series of 163 patients. *Annales Chirurgiae et Gynaecologiae*, 80(3):294-300.
- Lange RH, Bach AW, Hansen ST Jr, Johansen KH. (1985 Mar). Open tibial fractures with associated vascular injuries: prognosis for limb salvage. *Journal of Trauma*, 25(3):203-8.
- Leffers D, Chandler RW. (1985). Tibial fractures associated with civilian gunshot injuries. *Journal of Trauma*, 25:1059-1064.
- Levy AS, Bromberg J, Jasper D. ( 1994). Tibial fractures produced from the impact of a baseball bat. *Journal of Orthopaedics Trauma*, 8:154-158.
- Mauffrey. (2006). Management of gunshot wound to the limbs.A review. *The Internet Journal of Orthopaedic Surgery*, 3(1).
- Muller ME, Nazarian S, Koch P. ( 1990). *The comprehensive classification of fractures of long bones*. Berlin, Germany: Springer-Verlag.
- Norris BL, Kellam JF. (Jan 1997). Soft-tissue injuries associated with high-energy extremity trauma: principles of management. *Journal of American Academy of Orthopaedic Surgeons*, 5(1):37-46.
- Oestern H, Tscherne H. (1984). *Pathophysiology and classification of soft tissue injuries associated with fractures*. Berlin, Germany: Springer-Verlag.

- Olasinde A, Ogunlusi J, Ikem I. (2012). Gunshot fractures of tibia and femur - excellent results with reamed bone marrow graft and interlocking nailing. *South Africa Orthopaedic Journal Summer* , 11(4): 48-51.
- Puvanachandra P, Hoe C, El-Sayed H, Saad R, Al-Gasseer N, Bakr M, Hyder AA. (2012). Road Traffic Injuries and Data Systems in Egypt: Addressing the Challenges. *Traffic Injury Prevention*, 13 (1):44-56.
- Teitz CC, Carter DR, Frankel VH. (1980). Problems associated with tibial fractures and intact fibulae. *Journal of Bone & Joint Surgery*, 62A:770-776.
- Templeman DC, Marder RA. (1989). Injuries of the knee associated with fractures of the tibial shaft. *Journal of Bone & Joint Surgery*, 71A:1392-1395.
- Toro K, Hubay M, So'tonyi P, Keller E. ( 2005). Fatal Traffic Injuries among Pedestrians, Bicyclists and motor vehicle occupants. *Forensic Science International*, 151:151–6.
- Weber BG. (1972). *Injury of the ankle joint. In Huber*. Berlin, Germany: Bern Stuttgart Wien.
- Whittle AP, Russell TA, Taylor JC. (1992). Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. *Journal of Bone & Joint Surgery*, 74A:1162-1171.
- WHO. (2013). *Road Safety in African region, The Fact*. Geneva, Switzerland: WHO
- Zettas JP, Zettas P, Thanosophon B. (1979). Injury patterns in motor cycle accidents. *Journal of Trauma*, 19:833-836.

## APPENDICES

### Appendix 1: IREC Approval

	<b>INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)</b>	
MOL TEACHING AND REFERRAL HOSPITAL P.O. BOX 3 ELDORET Tel: 334711/2/3		MOI UNIVERSITY SCHOOL OF MEDICINE P.O. BOX 4806 ELDORET
Reference: IREC/2013/122 Approval Number: 0001073		30 <sup>th</sup> September, 2013

Dr. Gachathi S. Wanjema,  
 Moi University,  
 School of Medicine,  
 P.O. Box 4608-30100,  
ELDORET-KENYA.

Dear Dr. Wanjema,

**RE: FORMAL APPROVAL**

The Institutional Research and Ethics Committee have reviewed your research proposal titled:-

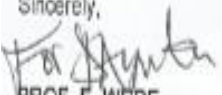
***"Tibial Diaphyseal Fractures: Aetiology, Morphology and Treatment Approaches in Adults Patients at Moi Teaching and Referral Hospital".***


Your proposal has been granted a Formal Approval Number: **FAN: IREC 1073** on 30<sup>th</sup> September, 2013. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 29<sup>th</sup> September, 2014. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

  
**PROF. E. WERE**  
**CHAIRMAN**  
**INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE**



cc	Director - MTRH	Dean - SOM
	Principal - CHS	Dean - SPH
		Dean - SON
		Dean - SOD

## Appendix 2: Approval from Moi Teaching and Referral Hospital



### MOI TEACHING AND REFERRAL HOSPITAL

Telephone: 2033471/2/3/4

Fax: 61749

Email: director@mtrh.or.ke

Ref: ELD/MTRH/R.6/VOL.II/2008

P. O. Box 3

ELDORET

30<sup>th</sup> September, 2013

Dr. Gachathi S. Wanjema,  
Moi University,  
School of Medicine,  
P.O. Box 4606-30100,  
ELDORET-KENYA.

#### **RE: APPROVAL TO CONDUCT RESEARCH AT MTRH**

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

*"Tibial Diaphyseal Fractures Aetiology, Morphology and Treatment Approaches in Adults Patients at Moi Teaching and Referral Hospital".*

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

**DR. J. KIBOSIA**  
**DIRECTOR**  
**MOI TEACHING AND REFERRAL HOSPITAL**

- CC - Deputy Director (CS)  
- Chief Nurse  
- HOD, HRISM



### Appendix 3: Consent Form

TIBIAL DIAPHYSEAL FRACTURES: AETIOLOGY, MORPHOLOGY AND TREATMENT APPROACHES IN ADULTS PATIENTS AT MOI TEACHING & REFERRAL HOSPITAL

INVESTIGATOR – DR. GACHATHI S. WANJEMA OF P.O BOX 4606, ELDORET, KENYA

I.....of P.O Box.....

Tel.....hereby give informed consent to participate in this study in MTRH. The study has been explained to me clearly by Dr. GACHATHI S. WANJEMA (or his appointed assistants) of P.O. Box 4606 Eldoret.

I have understood that to participate in this study, I shall volunteer information regarding nature and cause of my injury and undergo medical examination. I am aware that I can withdraw from this study at any time without prejudice to my right of treatment at MT&RH now or in the future. I have been assured that no injury shall be inflicted on me from my participation in this study. I have also been assured that all information shall be treated and managed in confidence. I have not been induced or coerced by the investigator (or his appointed assistant) to append my signature in this form and by extension participate in this study.

Initials of participant.....

Signature.....

Date.....

Name of Witness.....Signature.....

Date.....

## Appendix 4: Questionnaire

### Demographic Data

Case identity.....

Age.....

Gender ☐ Male ☐ Female

Occupation- Dependent ☐ Self-employed ☐ Informal/Casual ☐ Formal ☐

Unemployed ☐ Others ☐

Level of education- Complete-C Incomplete-IC

No formal education ☐ Primary: C ☐ Secondary: C ☐ College: C ☐ Others

☐ .....

IC ☐

IC ☐

IC ☐

Religion- Christian ☐ Muslim ☐ Hindu ☐ Others ☐ .....

Date of injury: Date.....Month.....Year.....

Primary Attendance ☐ Referral ☐

If referral, support treatment at referring facility: immobilization ☐ debridement ☐

Antibiotics ☐ Analgesics ☐ None ☐

Estimated time from injury to contact with health care provider in hours.....

Laterality of the fracture: Left leg ☐ Right leg ☐ Bilateral ☐

Resuscitation done: iv fluids ☐ Blood & blood products ☐ Oxygen ☐ Emergency drugs

☐ None ☐

### Mechanism of injury:

Low energy ☐ High energy ☐

MVAs ☐ Gunshot ☐ Falls ☐ Sports ☐ Direct blows/Assault ☐ Others

☐ .....

### MVAs

Motor vehicle occupants:

Driver ☐ Passenger ☐ Pedestrian ☐

Seat Belt ☐ No Seat Belt ☐

On Tarmac ☐ off Tarmac ☐

### Motorcycle:

Cyclist ☐ Pillion ☐ Pedestrian ☐

On Tarmac ☐ off Tarmac ☐

### Bicycle

Cyclist ☐ Pillion ☐ Pedestrian ☐

On Tarmac ☐ off Tarmac ☐

### Gunshot injuries

Incidence: .....

Type of gun: Shotgun ☐ Rifle ☐ Pistol ☐ indeterminate ☐

### Sports



Type of Sport .....

Nature of sport:    Contact ☐            Non-contact ☐

Falls

    Nature: Simple ☐      Down a Gradient ☐      From Height ☐

v) Direct blows/Assaults

    Incidence: .....

    Nature:      Accidental ☐                      Intentional ☐

    Object:      Blunt ☐                      Sharp ☐

Relevant Comorbidities:

Epilepsy ☐    Incidental Fits ☐    Fainting attacks ☐    Leg malformations ☐

Osteoporosis ☐    visual impairment ☐    Others ☐ .....

Social habits

Smoking: Yes ☐                      No ☐

If yes, No. of pack years.....

Alcohol consumption: Yes ☐      No ☐

If yes, Sobriety status at the time injury: Sober ☐    Not sober ☐

Fracture Morphology

Open ☐    Closed ☐

Levels:    Upper 1/3 ☐            Mid 1/3 ☐            Lower 1/3 ☐

If open- Gustillo Class: I ☐    II ☐    IIIA ☐    III B ☐    IIIC ☐

    -OTA Class.....

If closed- OTA Class: .....

If closed with soft Tissue Injury- Tscherne Class

Grade 0 ☐    Grade 1 ☐      Grade 2 ☐      Grade 3 ☐

Associated injuries:

<u>Injury</u>	<u>description</u>
<input type="checkbox"/> Fibula	.....
<input type="checkbox"/> Femur	.....
<input type="checkbox"/> Pelvis	.....
<input type="checkbox"/> Ankle	.....
<input type="checkbox"/> Knee	.....
<input type="checkbox"/> Hip	.....
<input type="checkbox"/> Foot	.....
<input type="checkbox"/> Upper limb	.....
<input type="checkbox"/> Chest	.....
<input type="checkbox"/> Head	.....
<input type="checkbox"/> Abdomen	.....
<input type="checkbox"/> Spine	.....

Treatment modality

Outpatient      ☐                      Inpatient      ☐

Non-Operative: External Casting ☐

Functional Bracing ☐

Operative: Amputation ☐ Debridement ☐

External Fixator ☐

Plating ☐

IM

Nail ☐

STSG ☐ Muscle flaps ☐

## Appendix 4: Fracture Classifications

### 1. Orthopedic Trauma Association (OTA) classification (Tibia assigned bone number 4, diaphyseal region number 2)

#### Type A: Unifocal fractures

<b>Group A1</b>	<b>Spiral fractures</b>
Subgroups	42A1.1 Intact fibula
	42A1.2 Tibia and fibula fractures at different level
	42A1.3 Tibia and fibula fractures at same level
<b>Group A2</b>	<b>Oblique fractures (fracture line &gt;30 degrees)</b>
Subgroups	42A2.1 Intact fibula
	42A2.2 Tibia and fibula fractures at different level
	42A2.3 Tibia and fibula fractures at same level
<b>Group A3</b>	<b>Transverse fractures (fracture line &lt;30 degrees)</b>
Subgroups	42A3.1 Intact fibula
	42A3.2 Tibia and fibula fractures at different level
	42A3.3 Tibia and fibula fractures at same level

#### Type B: Wedge fractures

<b>Group B1</b>	<b>Intact spiral wedge fractures</b>
Subgroups	42B1.1 Intact fibula
	42B1.2 Tibia and fibula fractures at different level
	42B1.3 Tibia and fibula fractures at same level
<b>Group B2</b>	<b>Intact bending wedge fractures</b>
Subgroups	42B2.1 Intact fibula
	42B2.2 Tibia and fibula fractures at different level
	42B2.3 Tibia and fibula fractures at same level
<b>Group B3</b>	<b>Comminuted wedge fractures</b>
Subgroups	42B3.1 Intact fibula

42B3.2 Tibia and fibula fractures at different level

42B3.3 Tibia and fibula fractures at same level

### **Type C: Complex fractures (multifragmentary, segmental, or comminuted fractures)**

#### **Group C1                      Spiral wedge fractures**

- Subgroups    42C1.1 Two intermediate fragments
- 42C1.2 Three intermediate fragments
- 42C1.3 More than three intermediate fragments

#### **Group C2                      Segmental fractures**

- Subgroups    42C2.1 One segmental fragment
- 42C2.2 Segmental fragment and additional wedge fragment
- 42C2.3 Two segmental fragments

#### **Group C3                      Comminuted fractures**

- Subgroups    42C3.1 Two or three intermediate fragments
- 42C3.2 Limited comminution (<4 cm)
- 42C3.3 Extensive comminution (>4 cm)

## **2. Gustilo Classification of Open Fractures**

### **Grade 1**

- The skin opening is 1 cm or less.
- This injury is most likely due to an inside-out mechanism.
- Muscle contusion is minimal.
- The fracture pattern is transverse or short oblique.

### **Grade 2**

- The skin laceration is greater than 1 cm, with extensive soft-tissue damage, flaps, or avulsion.
- A minimal to moderate crushing component may be noted.

- The fracture pattern is simple transverse or short oblique, with minimal comminution.

### **Grade 3**

- Extensive soft-tissue damage includes the muscle, skin, and neurovascular structures.
- This is a high-velocity injury with a severe crushing component.
  - **Grade 3A:** Involves extensive soft-tissue laceration (10 cm) but adequate bone coverage and includes segmental fractures and gunshot wounds.
  - **Grade 3B:** Consists of extensive soft-tissue injury with periosteal stripping and bone exposure. This grade is typically associated with massive contamination and inadequate bone coverage. The treatment requires flap advancement or a free flap.
  - **Grade 3C:** Is a vascular injury requiring repair.

### **3. Tscherne and Oestern Classification of closed soft-tissue injuries associated with fractures**

#### **Grade 0**

- Soft-tissue damage is absent or negligible. The fracture is a result of indirect forces with a simple fracture pattern.

#### **Grade 1**

- Superficial abrasion or contusion is caused by fragment pressure from within. The fracture configuration is more severe than that of grade 0.

#### **Grade 2**

- Deep, contaminated abrasion is associated with localized skin or muscle contusion from direct trauma. Impending compartment syndrome is part of this grade of injury, which is usually the result of direct violence.

#### **Grade 3**

- This injury is characterized by extensively crushed, contused skin and severe muscle damage. Other criteria are subcutaneous avulsions, decompensated compartment syndrome, and rupture of a major blood vessel. Usually, patients have a severe, complex fracture pattern.