# PATTERNS OF FOREARM FRACTURES AND THEIR TREATMENT OUTCOMES IN ADULT PATIENTS AT MOI TEACHING AND REFERRAL HOSPITAL, ELDORET, KENYA

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**A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF MEDICINE IN ORTHOPAEDIC SURGERY OF MOI UNIVERSITY.**

# DECLARATION

## DECLARATION BY CANDIDATE:

This thesis is the candidate's personal original work done in partial fulfilment leading to the award of degree of Master of Medicine, Orthopaedic Surgery. This work has not been presented for a degree in any other university. No part of this thesis may be reproduced without prior written permission of the author and/or Moi University.

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SM/PGORT/06/2013

## DECLARATION BY THE SUPERVISORS:

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# DISCLOSURE

The candidate did not receive any outside funding or grants in support of this study. Neither the candidate nor a member of the immediate family received payment or other benefits or commitment or agreement to provide such benefits from a commercial entity.

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## DEDICATION

The candidate dedicates this work to the patients with forearm fractures who made this piece of work possible.

## ABSTRACT

**Background:** The forearm is a complex anatomic structure serving an integral role in upper extremity function. The dexterity of the upper limb depends on a combination of hand and wrist function and forearm rotation. Thus, fractures of the radius and/or ulna alter the congruency and range of motion of the forearm. The outcomes of treatment methods of forearm fractures in adult patients at MTRH have not been published. This study sought to identify the causes, treatment modalities and functional outcomes of forearm fractures. The information in this study will help improve care to the patients with forearm fractures. **Objective:** To describe the patterns of forearm fractures, treatment methods and the functional outcomes in adult patients at MTRH.

**Methods:** A prospective descriptive study conducted from January 2015 to December 2015 at MTRH. Patients with forearm fractures who met the inclusion criteria were recruited consecutively and followed on their treatment modality for six months to determine the outcomes. An interviewer administered questionnaire was used to collect data on the demographics, cause of fracture, and pattern of fracture, treatment modality and outcomes. DASH questionnaire was used for functional outcomes. Data was entered into MS Excel then exported to STATA V.13 for analysis. Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean (SD) and median (IQR). Mann-Whitney U test was used for comparison of median DASH Scores among different variables. Results were presented in prose, tables and figures.

**Results:** A total of 98 patients were recruited into the study, with an age range of 18-85 years and a mean of 41.9 years (SD 16.6). There were 55 males and 43 females (male: female ratio of 1.3:1). The causes of fractures were falls in 46 patients (47%), Road Traffic Accident in 28 patients (29%), assault in 18 patients (18%) and other causes were found in 6 patients (6%). Closed fractures were found in 82 patients (84%) while open fractures were found in 16 patients (16%). There were 51 radius fractures (52%), 21 ulna fractures (21.4%) while both radius and ulna fractures were found in 26 patients (26.5% of the cases). Non-operative treatment in the form of cast immobilisation was done in 74 patients (76% of the cases). Twenty four patients (24%) received operative treatment by open reduction and internal fixation (ORIF), out of which 21 patients were treated by plating. The median DASH score at 6 months for non-operative patients was 11.2 (IQR 7.5, 20), while for the operative patients was 18.4 (IQR 5.8, 25).

**Conclusion:** Falls were the leading causes of forearm fractures and the radius was the most commonly fractured bone with distal radius metaphyseal fractures being the commonest. Majority of the fractures were treated non-operatively and had good functional outcome by DASH score. Operative treatment was done for open fractures, both bones and complex fractures. ORIF by plating was the main method of operative treatment and yielded good functional outcome by DASH score at six months follow up.

**Recommendations:** Patterns of forearm fractures should be a guide to the surgeons on the treatment methods. Though short term outcomes were good, studies on long term functional outcomes are recommended.

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## ACKNOWLEDGEMENT

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| **A/E** | Accidents and Emergency |
| **AO/ASIF** | Association for Osteosynthesis/ Association for the Study of Internal Fixation |
| **DASH** | Disabilities of the Arm, Shoulder and Hand |
| **DCP** | Dynamic Compression Plate |
| **DRUJ** | Distal Radioulnar Joint |
| **HIV** | Human Immunodeficiency Virus |
| **HRIS** | Health Records and Information Service |
| **IMN** | Intramedullary Nailing |
| **LC-DCP** | Limited Contact Dynamic Compression Plate |
| **MTRH** | Moi Teaching and Referral Hospital |
| **ORIF** | Open Reduction and Internal Fixation |
| **PRUJ** | Proximal Radioulnar Joint |
| **RTA** | Road Traffic Accident |
| **TFC** | Triangular Fibrocartilage |
| **TFCC** | Triangular fibrocartilage Complex |

## OPERATIONAL DEFINITION OF TERMS

**Adult-** Anyone above the age of 18 years.

**Forearm-** The forearm is the structure and distal region of the upper limb, between the elbow and the wrist. The forearm contains two long bones, the radius and the ulna.

**Forearm fracture-** is a break in one or both bones of the forearm.

**Functional outcomes-** this describes the result of treatment of forearm fractures in concrete, observable terms.

**Outcome-** is the end results of treatment of the forearm fractures.

**Patterns of fractures (Classification system)** - The set of fracture categories and its structure that defines the important fracture diagnoses to be made. The AO Classification system and the type of fracture whether open or closed are the patterns of fractures in the context of this study.

**Treatment-** is the management of forearm fractures by conservative, surgical or other methods.

# CHAPTER ONE: INTRODUCTION

## Introduction

This chapter introduces the background information on the study topic, the problem statement, justification of the study, the research question and the objectives of the study.

## 1.1 Background of the study

The forearm is a complex anatomical and functional unit with unique osseous, soft tissue and articular relationships (Jayakumar & Jupiter, 2014). It is made up of radius and ulna bones which articulate with each other at the proximal and distal radioulnar joints. There are also pronating and supinating muscles of the forearm enabling forearm rotation. The forearm therefore serves an integral role in upper extremity function including positioning the hand into the space. The dexterity of the upper limb depends on a combination of hand and wrist function and forearm rotation (Arnander & Newman, 2006).

Thus, fractures of one or both bones of the forearm alter the congruency and range of motion of the forearm. These fractures when they occur should be reduced anatomically to restore normal function of the forearm and avoid mal-union and non union complications (Boussakri et al., 2016; Prakash & Basanthi, 2013).

### 1.1.1 Relevant Anatomy

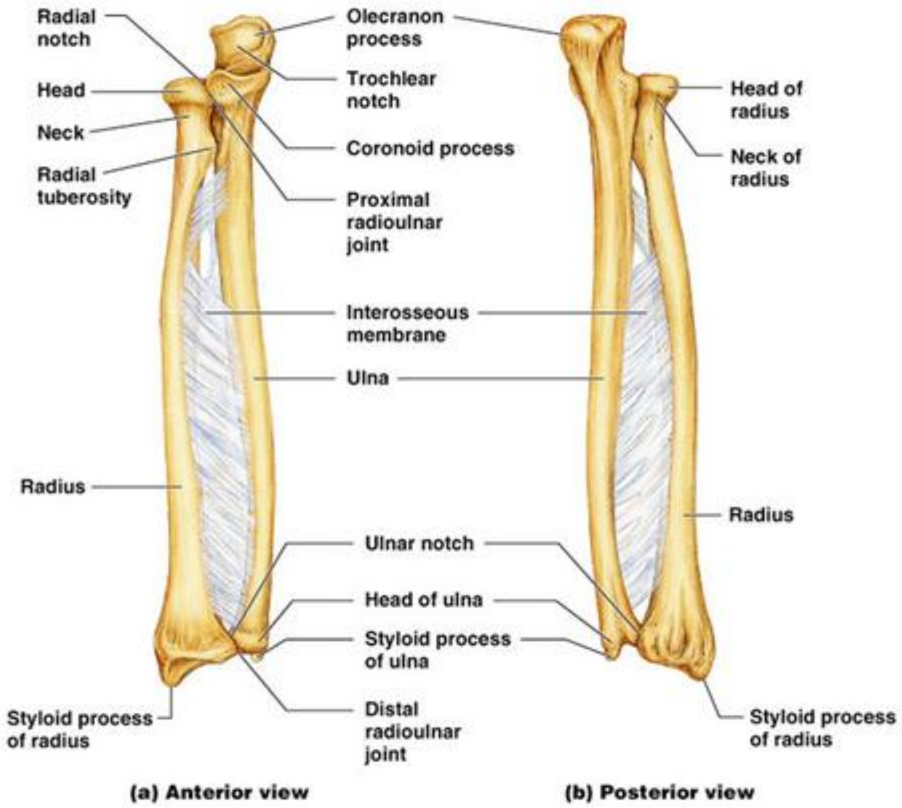


**Fig 1.1.1 Anterior and posterior views of the forearm**

Anterior and posterior views of the forearm demonstrating the interosseous membrane. Image courtesy of http://idijournal.com/radius-bone-markings-diagram.html.

**Radius Anatomy**

Radius is the lateral bone of the forearm; it is a curved bone with an apex lateral bow. It is cylindrical in the proximal third, triangular in the middle third, and flat distally. Proximally, the radial head articulates with the capitellum of the humerus forming the radiocapitellar joint. The radial head also forms proximal radioulnar joint (PRUJ) with the radial notch of the ulnar through the annular ligament. This PRUJ allows pronation and supination of the forearm (Crenshaw, 2008).

Wheeless, (2013) demonstrated that radius and ulna bones lie parallel to each other when forearm is supinated; during pronation radius crosses ulna, rotating on axis that passes from capitelum through the distal end of ulna. Jayakumar and Jupiter, (2014) stated that the radius has a physiological bow and it rotates around a stationary ulna during pronation and supination. The radial bow should therefore be restored anatomically after a fracture.

**Interosseous membrane**

Sauerbier and Unglaub, (2015) stated that radius and ulna are joined by proximal and distal radioulnar joints and by interosseous membrane, which is directed obliquely downward from radius to ulna. Since ulna does not articulate with carpi, direction of interosseous membrane is important in transmission of longitudinal forces from radius to ulna and it contributes to the longitudinal stability of the forearm. Kotwal and Singla, (2016) documented that the supinator, pronator teres and pronator quadratus muscles exert deforming forces upon fracture fragments leading to narrowing of the interosseous space and altered rotation. Therefore the integrity of the interosseous space should be maintained during fracture treatment.

**Ulna Anatomy**

Wheeless, (2013) described the ulna as having a triangular shape throughout, with an apex posterior bow in the proximal third. The ulnar side of wrist is supported by Triangular Fibrocartilage Complex (TFCC), which articulates with both lunate and triquetrum. The ulnar attachment of Triangular Fibrocartilage (TFC) is to the base of ulnar styloid and distally to triquetrum with volar ulnocarpal ligaments.

**Functional Anatomy**

Wheeless, (2013) documented the average range of pronation/supination of the forearm is 90/90 degrees with 50/50 degrees being necessary for activities of daily living. Middle third forearm deformity has a greater effect on supination, while the distal third deformity affects pronation to a greater degree.

Sauerbier and Unglaub, (2015) stated that the forearm supination and pronation movements are made possible by the intact proximal radioulnar joint (PRUJ) and distal radioulnar joint (DRUJ). Therefore, the axes of the two radioulnar joints must be aligned coaxially during fracture treatment, if not, forearm rotation is blocked. Rotation of the forearm allows the palm of the hand to be directed facing upward, medially and downward while the elbow is flexed and anteriorly, medially and posteriorly with an extended elbow. The total arc of rotation is close to 180 degrees. These ranges of motion are important when assessing the functional outcome of various treatment methods of forearm fractures.

The state of the elbow joint also has an impact on the position of the radius. Quigley et al., (2014) stated that the angle of elbow flexion has a secondary effect on the longitudinal position of the radius causing changes of less than 0.8mm. Therefore, fractures involving elbow joint or elbow stiffness have effects on the forearm rotation.

**1.1.2 Causes of forearm fractures**

The mechanisms of injury causing forearm fractures are variable. They can be caused by low energy injuries as well as high energy injuries. Arnander and Newman, (2006) documented the causes of these fractures which includes: direct blow to the forearm, producing a single (nightstick) fracture of the ulna, radius, or both; a fall on an outstretched hand with the forearm pronated. Other mechanisms of injury include road traffic accidents and athletic injuries. Most forearm shaft fractures resulting from falls occur in athletes or in persons who fall from heights.

High energy injuries such as gunshot injuries can result in fracture of both bones of the forearm. These injuries are commonly associated with nerve or soft-tissue deficits and frequently have significant bone loss. Severely debilitating and mutilating injuries are caused by accidents involving farmyard machines and industrial machinery (Arnander & Newman, 2006).

In osteoporosis, there is increased risk of a fragility fracture – defined as a fracture that is sustained with minimal trauma or a fall from a standing height or lower. Dave, (2013) stated that the classical osteoporotic fractures in older individuals involves the spine, hip and wrist, and may also involve the ribs, shoulder and pelvis.

### 1.1.3 Classification of forearm fractures

Jupiter and Kellam, (2009), stated that a classification system must document a number of factors, including location, fracture pattern, soft tissue involvement, and proximal and distal radioulnar joint involvement. For descriptive purposes, as well as for operative considerations, forearm fractures are classified by location, being categorized as proximal, middle, or distal third fractures. The middle third of the radius stretches from the radial bow to the beginning of diaphyseal straightening. The ulna is relatively straight and can be divided using longitudinal dimensions alone (Ertl, 2012).

Fracture of proximal ulna and dislocation of the proximal radio-ulna joint in the same arm is called Monteggia fracture- dislocation (Musa, 2006). The Galeazzi fracture-dislocation is an injury pattern involving a radial shaft fracture with associated dislocation of the distal radioulnar joint (DRUJ); the injury disrupts the forearm axis joint (Ertl, 2014).

Fractures are classified as open or closed. Closed fracture is when the skin at the fracture site is intact while open fracture is when there is a wound at or near the fracture site such that the fracture is in communication with the external environment.

Open fracture classification system (The Gustillo classification system) has significant interuser variability; the extent of the wound is often indeterminable until intraoperative exploration (Jegede, 2012).

Type I - Puncture wound less than 1 cm, minimal contamination

Type II - Laceration greater than 1 cm; moderate soft tissue damage; adequate bone coverage

Type IIIA - Extensive soft tissue damage, often high energy with massive contamination and adequate bone coverage

Type IIIB - Extensive soft tissue damage with bone exposure, flap coverage usually required

Subtype IIIC - Arterial injury requiring repair

Numerous fracture classification systems have been proposed in orthopaedics, but only a small number of them have become widely accepted in practice, one such being the Müller AO Classification of fractures of long bones (Müller, 1987). This is an alphanumeric morphological classification that helps in determining the kind of treatment to be used.

### 1.1.4 Treatment of forearm fractures

Treatment of forearm fractures can be done either non-operatively or operatively depending on the patterns of the fractures. The main aim is to preserve the longitudinal axis of the forearm and to ensure a stable anatomic reduction of radius and ulna. Manjappa et al., (2011) emphasized that to ensure maximal functional outcome, the goals of treatment of forearm fractures should be anatomic reduction of skeleton, restoring bone length, rotation and the interosseous space. There should also be secure fixation of the skeleton to enable early soft tissue rehabilitation.

The initial management of these fractures should be pain relief by all possible appropriate means in a timely, efficient and effective manner. Haonga et al., (2011) stated that pain should be assessed, reassessed and recorded as a fifth vital sign and appropriate management should be instituted as indicated by standard guidelines.

**Non-operative treatment**

Non-operative treatment is in the form of closed reduction and plaster cast immobilization. In the adult forearm fracture, Jupiter and Kellam, (2009), stated that the primary indication for non-operative treatment is the isolated ulnar shaft fracture that has resulted from a direct blow (nightstick fracture).

Jupiter and Kellam, (2009) also stated that with non displaced radial shaft fracture, non-operative treatment may prove successful provided that the anatomic bow of the radius is maintained. However, the time to healing may be prolonged because the intact ulna prevents coaptation of the radius fracture. Non-operative treatment is also effective in extraarticular metaphyseal distal radius fractures (Ogunlade et al., (2002).

**Operative treatment**

Operative treatment of forearm fractures is achieved through Open Reduction and Internal Fixation (ORIF). Arnander and Newman, (2006) stated that all displaced adult forearm fractures should be stabilized because no other means of management is available that provides a comparable result. The following are specific indications for operative treatment: Fracture of both bones of forearm; fracture dislocations, Monteggia fracture dislocations, and Galeazzi fracture dislocations; isolated radius fractures; displaced ulnar shaft fractures; delayed union or non-union; open fractures; fractures associated with a compartment syndrome, irrespective of the extent of displacement; multiple fractures in the same extremity, segmental fractures, and floating elbow; pathologic fractures.

ORIF can be done either by plating or intramedullary nailing. The 3.5 mm Dynamic Compression Plate (DCP) has been used satisfactorily for internal fixation of forearm fractures. The theory of DCP is that compression is applied by eccentric insertion of screws. Slot for compression has a sloping surface at one end; when the spherical head of the screw impinges on this surface, plate moves away from the fracture, thereby compressing fracture plane (Wheeless, 2013).


**Fig 1.1.4.1: Dynamic compression plate and screws**

A picture of a six hole DCP and cortical screws. Source: candidate’s photography.

Intramedullary nailing is the use of a device which is inserted into the medullary canal of the bone to fix the fracture fragments. It is recommended due to its shorter operating time, reduced blood loss and reduced soft tissue stripping (Moerman et al., 1996). Akpinar et al., (2011), documented that intramedullary nails are not routinely used in the surgical treatment of forearm fractures due to insufficient rotational and linear stability in this region. However currently there are newer designed interlocking intramedullary nails, which provide the control of malalignment at the fracture site.

**Fig 1.1.4.2: Rush Rod intramedullary nail**

An example of unlocked intramedullary nail (Rush Rod). Source: Candidate's photography.

### 1.1.5 Functional outcome

Various functional rating systems can be used to assess the functional outcome, such as the Disability of the Arm Shoulder and Hand (DASH) questionnaire (Institute for Work and Health, 2006). There are also the Andersons scoring system, Grace and Eversmann rating system and Short Form-36 scores.

The DASH questionnaire, which is recommended by the Upper Extremity Collaborative Group, allocates scores as percentages (Hudak et al., 1996). The DASH is a 30-item questionnaire intended to assess the function and symptoms of persons with disorders of the upper limb. Patients rate their ability to perform 21 physical activities such as opening jars, turning doorknobs and similar activities. The remaining nine items relate to symptoms (six items) and self-image and social life (three items). Each is scored on a five-point Likert scale. The raw score is converted to a global score ranging from 0 to 100. A score of 0 indicates ‘no disability’, and 100 indicate ‘severe disability’ (McClure & Michener, 2003). According to Lee Y. H et al., (2008), a score of 0 points indicates a perfectly functioning upper extremity, whereas a score of 100 points indicates complete impairment.

The health records and information system database at Moi Teaching and Referral Hospital (MTRH) provides the number of forearm fractures in adults seen in the years preceding 2015 as approximately 120 patients per year (HRIS MTRH, 2015). These fractures are managed by both non-operative and operative methods of treatment at MTRH. The management of forearm fractures at MTRH is done by various cadres of health care personnel including clinical officers, plaster technicians, registrars and consultants. Operative management of these fractures is mainly done by the registrars and consultants.

## 1.2 Problem Statement

Forearm fractures are common injuries seen at the MTRH Casualty, Orthopaedic Wards and Orthopaedic Outpatient Clinics. The causes of these fractures in adults are varied and they determine the patterns of the fractures. The patterns of the fractures have an impact on the choice of the treatment method. Both non-operative and operative methods of treatment are offered to these patients at MTRH. Review of records at MTRH reveals that majority of these fractures in adults are treated non-operatively. The treatment methods offered to these patients have an impact on the functional outcome and disability of the forearm. The clinical and functional outcomes after treatment of these fractures at MTRH have not been published. This study set out to assess the functional outcomes of the treatment methods of these fractures.

### 1.3 Justification of the Study

There is need to know the causes of forearm fractures in this setup to help in determining the patterns of the fractures.

The patterns of forearm fractures are important in the management of the patients especially in choosing the kind of treatment method to provide. There is therefore a need for the health care workers to evaluate these fractures according to their patterns.

There is need to know the proportions of adult patients with forearm fractures treated either non-operatively or operatively and the eventual functional outcomes of those treatment methods. The disability, if any, after treatment of these fractures needs to be documented.

There are no published data on this topic at this study site. Therefore this study will provide a background for future research.

### 1.4 Research Question

What are the causes, patterns and treatment outcomes of forearm fractures in adult patients at Moi Teaching and Referral Hospital, Eldoret, Kenya?

### 1.5 Objectives

#### 1.5.1 Broad Objective

To identify the causes, patterns and treatment outcomes of forearm fractures in adult patients at Moi Teaching and Referral Hospital, Eldoret, Kenya.

### 1.5.2 Specific Objectives

1. To identify the causes of forearm fractures in adult patients at Moi Teaching and Referral Hospital.
2. To describe the patterns of forearm fractures in adult patients at Moi Teaching and Referral Hospital.
3. To evaluate the proportion of adult patients with forearm fractures treated non-operatively and operatively at Moi Teaching and Referral Hospital.
4. To assess the functional outcomes of the treatment of forearm fractures in adult patients at Moi Teaching and Referral Hospital using DASH score.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Forearm fractures

The forearm has a complex architecture consisting of two mobile relatively parallel bones that provide a stable link between the elbow and the wrist and serve as the origin of several muscles inserting into the hand. Therefore after fractures of one or both bones of the forearm, there is need for restoration of forearm rotation, elbow and wrist motion and grip strength (Droll et al., 2007).

## 2.2 Magnitude of forearm fractures

According to the AO documentation centre, forearm fractures accounted for 10-14% of all fractures between 1980 and 1996 (Ertl, 2012).

Data from the National Hospital Ambulatory Medical Care Survey show that radius and/or ulna fractures account for 44% of all forearm and hand fractures in the United States of America (Chung & Spilson, 2001).

Mirdad, (2000) studied the pattern of trauma cases of the extremities associated with neurovascular injury seen at Assir Central Hospital, Saudi Arabia, between 1990 and 1999 and found that the ulna and radius fractures constituted 18.3% of fractures of the extremities. This was however only among those who had neurovascular injuries.

A study done in Nigeria at the Federal Medical Centre Owerri between January 2000 and December 2003 to determine the anatomic pattern of fractures and dislocations by Okoro and Ohadugha, (2006) found that among the upper limb bones the radius is the most affected bone accounting for 8.1% of the fractures followed by the ulna. Radius and ulna fractures constituted 5.9% of all the fractures.

Haonga et al., (2011) found in their study done at Muhimbili Orthopaedic Institute in Dar es Salaam, Tanzania, that the radius and ulna fractures were 17 % of all long bone fractures. In Kenya, Khanbhai and Lutomia, (2012) did a study aimed at determining the pattern of injuries caused by motorcycle crash among patients seen at Kakamega Provincial General Hospital, and found that among the 116 patients, fractures of the forearm bones constituted 3% of all the fractures.

### 2.3 Patient demographics

Matejëiê et al., (2000) conducted a ten year study on the fixation of forearm fractures at a university hospital in Croatia and found that males were 55% and females were 45% (M: F 1.2:1). The mean age was 43 years.

Goldfarb et al., (2005) assessed 23 patients with both radius and ulna fractures and found the mean age of 40 years (19-84), there were 14 males and 9 females (M: F 1.5:1). In their study there were 9 fractures of the dominant and 15 fractures of the non dominant limb. In terms of occupation, 14 patients were employed outside of the home, 4 were unemployed, 3 were full time students and 2 were housewives.

Wang et al., (2005) did a study on the treatment of open diaphyseal fractures of the radius and ulna and found the mean age of the patients to be 41 years (19-81). There were 17 males and 8 females (M: F 2.1: 1). There were a total of 15 right sided and 10 left sided fractures.

Ogunlade et al., (2002) studied 35 patients who presented in the Accidents and Emergency Department of University College Hospital, Ibadan, Nigeria with displaced distal radial fractures. The patients age was 15 years and above with a mean age of 43.49 years.

## 2.4 Causes of forearm fractures

Goldfarb et al., (2005) assessed 23 patients with fractures of both bones of the forearm and found that the mechanism of injury was a motor-vehicle accident in 13 patients (56.5%), a fall from a height in five (21.7%), a work-related injury in four (17.4%) and a pedestrian *vs.* train accident in one (4.3%).

Ogunlade et al., (2002) studied 35 patients in Nigeria who presented with displaced distal radial fractures and found that in the mechanism of injury, fall was 51.4%, RTA 37.1%, others 11.4%. The study did not specify what 'others' was.

Wang et al., (2005) studied 25 patients with forearm fractures and found the causes to be motor vehicle accident in 11 (44%), simple fall in 6 (24%), crushing injury in 5 (20%), fall from a height in 2 (8%) and sports injury in 1 (4%).Lee Y.H et al., (2008) studied 38 forearm fractures in 27 patients and found the causes to be motor vehicle accidents in 10 (37%), industrial accidents in 8 (30%), sports injury in 5 ( 18%) and falls in 4 (15%).

Gakuu, (2011) reviewed 60 patient files with osteoporosis treated in three private hospitals in Nairobi between 1998 and 2007, and found out that 5 of them (8.3%) had distal radius fractures.

Goodier and Rubin, (2010) reported in South African Journal of Radiology of a 30 year old woman who presented with an echinococcal cyst of the right radius complicated by a pathological fracture.

## 2.5 Patterns of Forearm Fractures

Goldfarb et al., (2005) used the AO classification in their study on the fractures of both radius and ulna diaphyses and found that most of the fractures, 18 (78%), were 22-A3 (simple fracture of both bones of the forearm.

Ng et al., (2017) also used the AO Classification in their study and found that the least fracture pattern was 22-B2 (wedge fracture of the radius diaphysis) at 5.9%.

Lee Y.H et al., (2008) studied 38 fractures in 27 patients, used AO Classification system and found the A- type fractures were 32%, B- type fractures were 50% and C-type fractures were 18%. They also found that closed fractures were 31 (82%) while open fractures were 7 (18%). Among the open fractures, Gustillo I were 2, Gustillo II were 4 and Gustillo III was 1.

Matejëiê et al., (2000) found in their study that among the 354 cases of forearm fractures, bilateral diaphyseal fractures were 34%, radial fractures were 29% and ulnar fractures were 37%. In this study closed fractures were 81% and open fractures were 19%. Both Monteggia and Galleazi fractures were 30% each.

Wang et al., (2005) studied 25 open fractures of the forearm and found the Gustillo and Anderson classification as follows; Gustillo I, 16(64%), Gustillo II, 6(24%), Gustillo IIIA, 2(8%), Gustillo IIIB, 1(4%). There was no Gustillo IIIC.

**Presentation**

The symptoms include pain, deformity, and loss of function of the forearm. Clinical examination should include a careful neurologic evaluation of the motor and sensory functions of the radial, median, and ulnar nerves. Compartment syndrome should be ruled out especially in polytrauma patients or in comatose or obtunded patients (Arnander & Newman, 2006).

## 2.6 Treatment of forearm fractures

Ogunlade et al., (2002) recommended the use of hematoma block for closed reduction of displaced distal radial fractures and application of plaster cast. Their patients also regained good range of movement following wrist physiotherapy within 6 weeks after removal of the plaster of Paris. However, Jakhar and Kalla, (2013) recommended volar locking plating system to be effective fixation when used for the treatment of initially inadequately reduced distal radial fractures.

Treatment by closed reduction and cast immobilization has been discouraged by other authors as it results in a poor functional outcome with unsatisfactory results reported in up to 92% of cases, usually caused by malunion, non union or synostosis (Kotwal & Singla, 2016).

Non-operative treatment using closed reduction and cast immobilisation provides limited control and stability in these fractures (Jayakumar & Jupiter, 2014).

Ayumba et al., (2015) stated that at MTRH, the main procedures done for open fractures are systematic debridement, irrigation and fractures stabilisation (initial or definitive). Their study was on management of posttraumatic exposed bones.

Plate osteosynthesis (Open Reduction and Internal Fixation with plate and screws) is the most commonly used technique for the treatment of diaphyseal forearm fractures in adults.

However, application of a plate can disrupt the periosteal blood supply and necessitates skin incisions that may be unsightly, and there is a risk of refracture if the implant is removed (Akpinar et al., 2011; Lee Y. H. et al., 2008; Višńa et al., 2008). There is also poor accessibility to the proximal third of the radius, with risks of iatrogenic injury to the deep radial nerve (Višńa et al., 2008).

Burnwell and Charnley, (1964) recommended a 3.5 inch long plate with six screws to be suitable for most fractures, but if there is moderate or severe comminution, or if there is a segmental fracture, longer plates and more screws should be used to provide sound fixation. Severely comminuted fractures with large avascular bone fragments should have the addition of a bone graft at the time of the plating operation in order that union may be assured. Thin strips of iliac bone are preferred.

Wang et al., (2005) concluded in their study that early meticulous debridement, good reduction and rigid internal fixation with a small DCP are very effective in the management of type I and type II open fractures of radial and ulnar diaphyses. They did not make a conclusion on the treatment of Gustillo IIIA and IIIB open fractures due to small sample size.

Matejëiê et al., (2000) preferred the use of tourniquet in closed fractures to ensure bloodless operative field if there was no sign of compartment syndrome. For internal fixation they used DCP with 3.5mm cortical screws. Surgical approach to the ulna is relatively simple. The ulna is a subcutaneous bone and is easily exposed throughout its length. For the radius, there are several standard approaches, i.e. anterior according to Henry, posterior Thompson’s approach to the proximal middle third of the posterior surface of the radius, and Boyd’s approach to the proximal third of the ulna and proximal third of the radius.

Limited Contact DCP (LC-DCP) has also been recommended by some authors for use in internal fixation of forearm fractures. The LC-DCP has groove within the undersurface (leads to an improvement in the blood supply to the underlying plate bone segment) allows for a small amount of callus formation as well as even distribution of stiffness along the plate, undercut plate holes allow extended tilting of plate screws, uniformly spaced as well as symmetrical plate holes and has a optimal screw effect (Perren, 1991).

Manjappa et al., (2011) stated that in comparison to the DCP, the contact area between the bone and the LC-DCP is reduced by about 50%. This theoretically improves the blood supply to the underlying bone cortex and lessens the risk of partial bone necrosis. This in turn may be associated with improved bone healing and lower infection rates.

Locking Compression Plates (LCP) has also been advocated for use in comminuted fractures of the forearm to function as bridging plates and prevents devascularisation of bone fragments and delayed union (Leung & Chow, 2006). Over the past 2 decades, new implants have been devised to minimise the bone-implant contact area.

The point contact fixator (PC-Fix) was developed in which the unicortical locking head screws can be locked into the screw hole on the plate. No compression of the plate on the bone is required (Perren & Buchanan, 1995).

The locking compression plate (LCP) was devised by combining the features of an LC-DCP and a PC-Fix (Frigg, 2003). Each of the screw holes allows insertion of a conventional screw or a locking head screw, as it has features of both a smooth sliding compression hole and a threaded locking hole.

Meena et al., (2013) did a comparison study between LCP and LC-DCP in treatment of adult diaphyseal fractures of the forearm and found the difference between the results of LCP and LC-DCP fixation were significant in terms of mean time to union and callus formation between the two groups, which showed definite advantage in respect to LCP fixation for adult diaphyseal fractures of the both bones of the forearm but difference in overall functional outcome in both groups was not significant.

Gakuu, (2010) stated that locked intramedullary nailing is now possible for nearly all fractures of the femur, tibia, humerus, radius and ulna which had previously remained inaccessible to this method, involving transverse, spiral, oblique, comminuted, double and third fragment fractures even for open fractures with lost bones.

Closed nailing however does have many advantages, including early union, low incidence of infection, small scars, less blood loss, and short operating time with minimal surgical trauma (Akpinar et al., 2011; Moerman et al., 1996). Interlocking intramedullary nailing is advantageous, in particular for treating open, serial and grossly comminuted fractures of the forearm bones (Višńa et al., 2008).

**2.7 Functional outcome**

The return of function of forearm injuries depends on union of the fracture and motion of the forearm (Prakash & Basanthi, 2013). According to Jupiter and Kellam, (2009) the factors which determine the outcome include but not limited to: age of the patient, radial nerve injury, timing of the surgery, surgical technique, surgical approaches, fixation techniques, indication for ancillary bone graft and post operative management.

On the timing of surgery, operating upon first week after the injury is technically a bit easier since the organization of the exudates and shortening of the muscle later on, may make the surgery more difficult (Meena et al., 2013). Good early reduction and rigid fixation restore forearm stability earlier and limit dead space produced as a result of shortening and malposition (Anderson et al.,1975).

Lee et al., (2014) found that the advantages of an interlocking intramedullary nail system for the radius and ulna are that it is technically straightforward, it allows a high rate of osseous consolidation, and it requires less surgical exposure and operative time than does plate osteosynthesis. The average time to fracture union in their study was fourteen weeks. There was one nonunion of an open comminuted fracture of the middle third of the ulna. There were no deep infections or radioulnar synostoses. The average age of the patients was 32 years. Their functional outcomes using DASH scores averaged 15 points (range, 5 to 61 points). They suggested that the interlocking intramedullary nail system be considered as an alternative to plate osteosynthesis for selected diaphyseal fractures of the forearm in adults.

Višńa et al., (2008) evaluated the results after treating diaphyseal fractures of the radius and ulna with an interlocking intramedullary nail among 78 patients with 118 fractures found that the average length of time to demonstrated bone healing was 14.2 weeks. Four cases of prolonged healing were observed. Pseudo-arthrosis formation did not occur. Assessment of function according to Anderson et al., (1975) gave the following results: full range of movement in 88.6% of patients; mild restriction of movement in 10.1%; severe restriction of movement in 1.3% of patients. The implanted material was extracted from 27 patients. Refractures did not occur. Postoperative complications included: 1 superficial infection, 3 cases of incomplete radio-ulnar synostosis; one case of compartment syndrome. They however did not use DASH score for functional outcome.

Manjappa et al., (2011) conducted a prospective study on 20 cases aged 18 years and above with fracture both bones of the forearm. All cases were openly reduced and internally fixed with 3.5 mm LC-DCP. Proximal radius was approached by Dorsal Thompson incision and Volar Henry approach was used for middle and distal radius. Average age was 41 years (18-64 years). While 12 (60%) patients had left sided fracture, 8 patients (40%) suffered right sided fracture. An average time for union was 17 weeks. Results were evaluated by Andersons scoring system. 18 patients (90%) had excellent results, one case (5%) satisfactory and one case (5%) was a failure which required re-fixation. There was one case (5%) with superficial infection, one case (5%) of non-union of radius which required re-fixation with bone grafting. They concluded that LC-DCP can be considered the best mode of treatment for closed diaphyseal fractures of both bones forearm. They also did not use DASH Scores for functional outcome.

Droll et al., (2007) conducted a study at St. Michael Hospital, Toronto, Canada to investigate patient-based functional outcomes and to objectively measure strength following plate fixation of fractures of both bones of the forearm in a cohort of thirty patients (nineteen men and eleven women with a mean age of 43.9 years). Range of motion, quantitative strength measurements, and validated outcome measures—i.e., DASH and SF-36 (Short Form-36) scores—were assessed. The mean DASH score was 18.6 points; (range, 0 to 61 points). Limitations in strength correlated with worse DASH and SF-36 PCS scores. Pain and a work-related injury were independent determinants of the DASH score. They concluded that stabilization with internal plate fixation following fracture of both bones of the forearm restores nearly normal anatomy and motion. However, a moderate reduction in the strength of the forearm, the wrist, and grip should be expected following this injury. They concluded that perceived disability as measured with the DASH and SF-36 questionnaires is determined by pain more than by objective physical impairment.

Lee et al.,(2014) in Korea conducted a prospective study to evaluate and compare the results of plate osteosynthesis and intramedullary nailing for the treatment of diaphyseal fractures in both forearm bones.  Sixty-seven patients (mean age, 41 years; range, 22-76 years) of this prospective study were divided into two groups according to treatment randomly: ORIF group (plate osteosynthesis) and IMN group (intramedullary nail). The results were assessed on the basis of the time to union, functional recovery (range of motion and functional outcomes using the Grace and Eversmann rating system and DASH), restoration of the ulna and the radial bow, operating time, exposure time to fluoroscopy, complications, and patient satisfaction.

The time to union and the exposure time to fluoroscopy were significantly shorter in ORIF group than in IMN group. The presence of butterfly segment and severe displacement were factors leading to the increase in the time of union in IMN group. The functional outcomes did not significantly differ between the two groups, irrespective of the time of assessment. All patients achieved union in both groups, with the exception of a single case of nonunion in IMN group and one case of refracture after implant removal in ORIF group.

Based on the significant differences in the ratio of the contralateral side, plate osteosynthesis resulted in a more excellent extent of restoration to the conditions prior to the injury. Nevertheless, such significant differences in the restoration of the bow had no effect on the final clinical outcome. If the indication is properly selected, their results suggested intramedullary nailing can be acceptable and effective treatment options for fractures in both forearm bones.

**2.8 Complications**

Treatment of forearm fractures by closed reduction and cast immobilisation results in a poor functional outcome with unsatisfactory results reported in up to 92% of the cases, usually caused by malunion, non-union or synostosis (Muller et al., 1999).

Boussakri et al., (2016) stated that asceptic non-union is a major complication of forearm fractures accounting, for 2% to 10% of forearm fractures.

Matejëiê et al., (2000) found the complications of plate osteosynthesis as follows; pseudoarthrosis at 3.9%, refracture at 1.4%, synostosis at 2.8%, compartment syndrome at 0.2% and infection at 2.8%.

Prakash and Basanthi, (2013) found postoperative complications after ORIF with LC-DCP as follows; superficial infections at 10%, interosseous nerve injury at 3.3% and radioulnar synostosis at 3.3%.

Elbow and wrist joints stiffness can occur after treatment of forearm fractures. This can be prevented by active or passive physiotherapy. However, Krischak et al., (2009) opined that prescribed physical therapy is not effective as home exercise programme.

# CHAPTER THREE: METHODOLOGY

## 3.1 Study Site

The study was carried out at Moi Teaching and Referral Hospital Casualty, Orthopaedic clinics and Orthopaedic wards between the months of January 2015 to December 2015. Moi Teaching and Referral Hospital is the second national referral hospital in Kenya after Kenyatta National Hospital (KNH). The Hospital is located along Nandi Road in Eldoret town (310 kilometres Northwest of Nairobi the capital city of Kenya), Uasin Gishu County, in the North Rift region of Western Kenya (Kenya Information Guide, 2015).

According to Population Reference Bureau, (2011), MTRH immediate catchment area population is approximately 16.24 million, from the former Nyanza Province (5.39 million), North Rift (5.50 million) and the former Western Province (5.35 million). The hospital receives patients on referral from other hospitals or institutions within or outside Kenya for specialized health care. It also provides facilities for medical education for Moi University and for research either directly or through other co-operating health institutions.

The Accident and Emergency Department receives high number of cases of road traffic accidents and assaults in the neighbouring communities as well as the high number of patient check-ins and referrals from Western Kenya Region.

The bed capacity is 710 beds and orthopaedic cases constitute 7.1% (51 beds). Due to its wide catchment area, the department experiences high bed occupancy of between 100%-150%, this leads to overstraining of the available resources (MTRH ICT, 2015). There are orthopaedic outpatient clinics run by consultants and assisted by registrars.

### 3.2 Study Design

Prospective descriptive study design was employed in this study. The staffs at the casualty fracture room were informed of the study and told to notify the principal investigator of patients who were treated as out-patients. Participants were recruited upon being attended to at the casualty, out-patient department and orthopaedic wards then followed up on the mode of treatment, and six months post treatment to assess the functional outcomes. Follow up was according to their return dates to the clinic at 2, 6, 12, 18 weeks and at 6 months post treatment.

### 3.3 Study Population

Adults aged 18 years and above with forearm fractures seen at the casualty, attending orthopaedics clinic or admitted in the orthopaedics wards at MTRH during the study period.

### 3.4 Eligibility

#### 3.4.1 Inclusion criteria

1. Adults with forearm fractures who gave consent to be included in the study.
2. Adults with forearm fractures which were less than one month duration and had not had definitive treatment elsewhere.

#### 3.4.2 Exclusion criteria

1. Forearm fractures in adults with intra-articular extension to either the elbow joint or the wrist joint. Elbow and wrist injuries have different management approaches.
2. Forearm fractures associated with neurovascular injuries. Neurovascular injuries could interfere with the functional outcomes, and therefore a confounder.

3. Patients with other ipsilateral fractures of the same upper limb. These could be confounders of the functional outcome since the DASH questionnaire is used for all injuries of the upper limb.

**3.5 Sampling Techniques**

Consecutive sampling technique was used. As the patients came to the casualty or admitted to the wards, those who met the inclusion criteria were recruited into the study during the study period.

**3.6 Sample Size Determination**

The previous records at the MTRH (HRIS MTRH, 2015) showed that the approximate total numbers of adult patients with forearm fractures were in the range of 90 to 120 patients per year. Therefore, 98 adult patients with forearm fractures met the inclusion criteria and were recruited.

**3.7 Data Collection Techniques**

An interviewer administered questionnaire was used by the candidate to collect data from the patients upon consenting to the study. A pilot study had been carried out at Migori County Referral Hospital to validate the questionnaire. Alterations to the questionnaire were submitted to IREC for approval before the actual study was done.

On contact with the patient at the casualty, out-patient clinic or orthopaedic ward, a careful history was taken from the patient or attendants to reveal the mechanism of injury and the severity of trauma. Physical examination was done on the patients to evaluate their general condition and the local injury.

Necessary investigations including radiographs of the radius and ulna i.e. anteroposterior and lateral views including elbow and wrist joints were done. Other laboratory investigations to rule out co-morbidities were done.

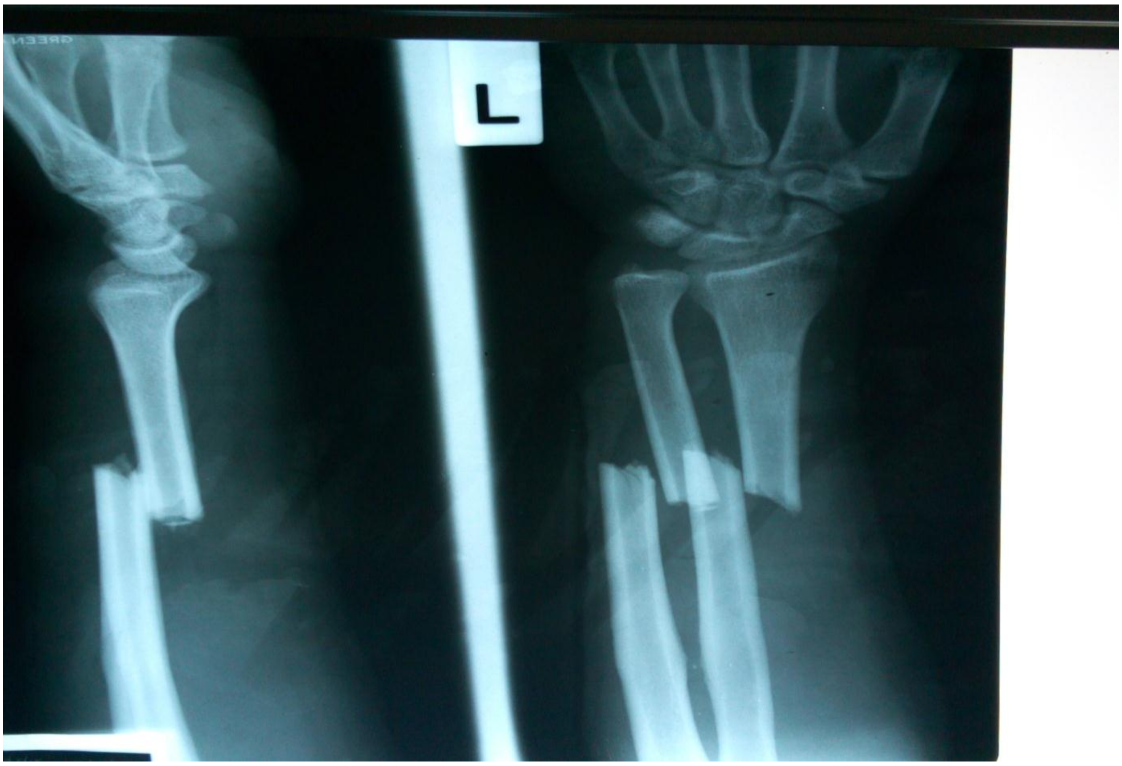


**Fig 3.7.1: Radiographic image of both bones forearm fractures (22-A3)**

Source: Candidate’s photography

The fractures were classified as either open or closed. If open, Gustillo Classification was used. AO classification system was used to categorize the fracture type. The candidate reviewed the radiographs with the supervisors and the consultants at the morning trauma meetings, ward rounds and at the out-patient clinics. Consensus was reached on the fracture pattern by AO Classification.

Initial treatments such as administration of analgesics, tetanus toxoids, antibiotics, debridement, etc were recorded. Thereafter, the definitive treatment method of the fracture was recorded and the patient was followed either up in the ward or at the orthopaedic outpatient clinic.

The non-operative treatment consisted of an initial Sugar Tong splint application for four weeks then it was converted to a below elbow plaster cast for two to four weeks or till radiographic union or clinical union was confirmed. The patients were then reviewed and another X-ray done at six weeks to confirm union. Clinical union was also tested by gentle manipulation of the fracture site to elicit pain. Non tender fracture site was documented as clinical union. For those who had union, the cast was removed and physiotherapy range of motion exercises was started. Time taken for union to occur was recorded. They were then followed up for 6 months and DASH questionnaire administered.

The DASH score was done with the following formula;

$$\text{DASH DISABILITY/SYMPTOM SCORE} = \left[\left(\frac{\text{sum of n responses}}{n}\right) - 1\right] \times 25,$$

where n is equal to the number of completed responses.

Normal union was defined as the presence of periosteal or endosteal callus formation bridging the fracture site or trabeculation extending across it within 6 months. Those that failed to unite in 6 months or those that required additional operative procedure for union were defined as non union or delayed union. Those that united with angulation or rotational deformity of more than $10^0$ were defined as malunion (Anderson et al., 1975). Goniometer was used to measure angulation.

A delayed union is generally defined as a failure to reach bony union by 6 months post-injury, this also includes fractures that are taking longer than expected to heal (Aiyer, n.d.). In this study the term ‘delayed union’ was used for fractures which were taking longer than usual to unite, since the candidate had no control over the management of the patients and could not wait for over six months to document non union.

Those with malunion were recorded as such and follow up stopped and sent for open reduction and internal fixation. Those with delayed union were left with the plaster cast for another 4 weeks. If there was no union at 6 months then this was recorded as non union and sent for ORIF.

The patients who underwent operative treatment were followed up in the ward and their files checked for the indication for surgery, the surgical technique and approaches used and the type of fixation used. Post operative management was documented. Post reduction and fixation radiographs were taken to assess the reduction of the fracture. The patients were discharged after three days depending on their clinical status.

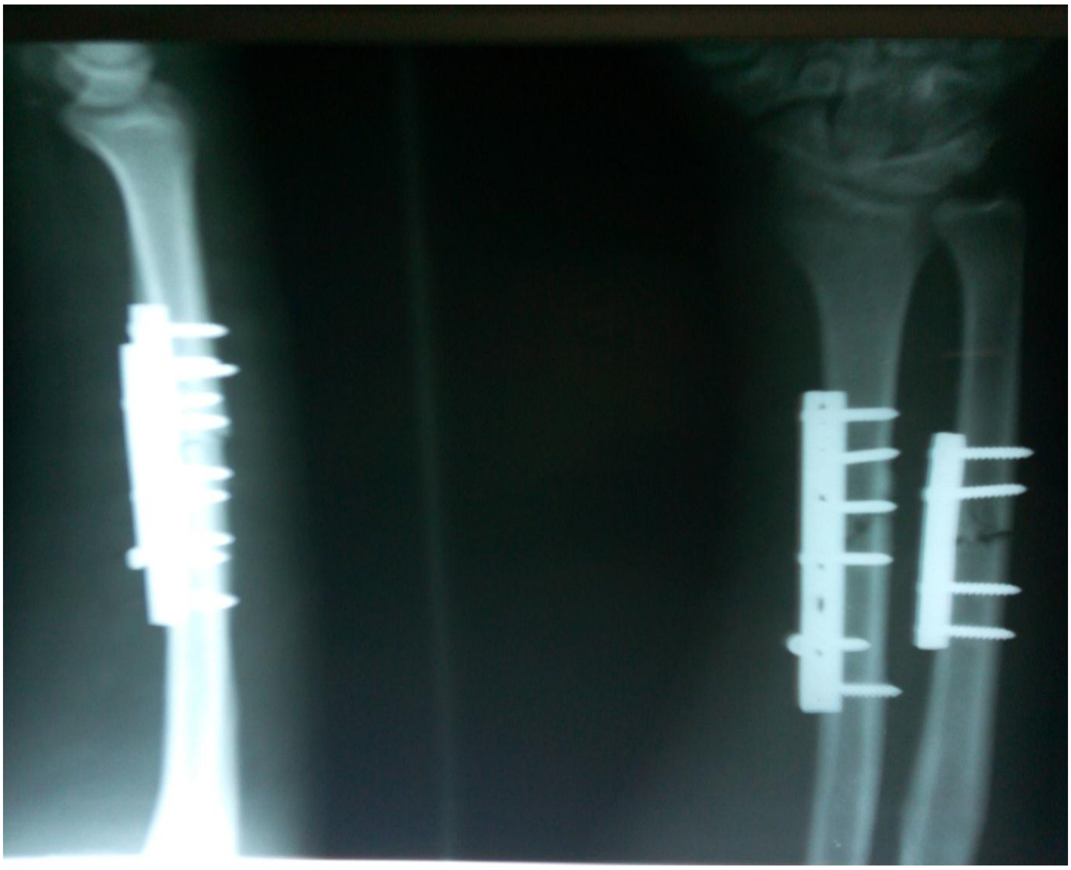

**Fig 3.7.2: Radiographic image of post ORIF for both bones forearm fractures.**

ORIF was done using two 3.5mm DCPs and screws. Source: Candidate's photography.

On discharge, the patients were followed up at the orthopaedic outpatient clinic. At two weeks post operative period, the sutures were removed and wound assessed for any signs of infection or complications such as nerve injury. At three months post operative period, a new forearm radiograph was done in anteroposterior and lateral views to check for signs of fractures healing and union. Time to fracture union was recorded for those with signs of union. Those with delayed union were again reviewed after one to two months and a new forearm X-ray done. Time to fracture union was recorded for those who showed signs of fracture union. The patients were then followed up at six months post operative period to determine the functional outcome of the forearm using the DASH questionnaire. The analysis was done with DASH score at 6 months.

Phone calls were used to remind the patients to come for follow up to enable administration of DASH questionnaire. There was a budget for the study to cater for the expenses of airtime used for calling.

**3.8 Data Processing and Analysis**

Following the completion of data collection process, questionnaires were coded and entered in computerized database designed in Microsoft Excel data entry software. The data was then exported to STATA software V.13 for analysis. Descriptive statistics was used to summarize the data. Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean (SD) and median (IQR). Mann-Whitney U test was used for comparison of median DASH Scores among different variables. Statistical tests of analysis such Chi Square test and Fisher’s Exact tests were used to test association between various variables. The findings were presented in prose, tables and figures.

### 3.9 Limitations

1. The cost of open reduction and internal fixation may have been expensive for some of the patients who required operative treatment since they had to buy the implants and therefore opted for non-operative treatment.
2. There was risk of loss to follow up of some of the patients. The intervention done was to take the patients' phone numbers and call them to come to the clinic for the DASH scoring.
3. DASH questionnaire has certain activities which were not familiar to the respondents. There was explanation of certain activities in a simpler language to enable the patients understand what was being asked.

### 3.10 Ethical Consideration

Approval from the Institutional Research and Ethics Committee (IREC) of Moi University was obtained after the research proposal had been ratified before the research commenced. (Approval Number: 0001236). Thereafter an authority from the administration of Moi Teaching and Referral Hospital to allow the research to take place in the institution was sought and obtained. A pilot study was done at Migori County Referral Hospital and amendment to the questionnaire was made and approved by IREC.

Written informed consent was obtained from the patients who agreed to participate in the study. Participant's confidentiality was observed by not using any form of identity on the data collection tool (using only serial numbers). The questionnaires were kept in a lockable place accessible only to the candidate. Data entered in the computer were protected by use of a password. The patients were treated as per norms and standard without unnecessary influence or discrimination because they are in the study or not. There were no anticipated risks in the study.

There were no expected personal benefits to the participants. There was no conflict of interest on the part of the candidate.

# CHAPTER FOUR: RESULTS

## 4.0 Introduction

During the study period, a total of 98 patients with forearm fractures who met the inclusion criteria were treated at MTRH and followed up. Below are the results of the demographics, causes of the fractures, fracture patterns, treatment and outcome of the study population presented in tables, figures and prose or narratives.

## 4.1 Socio-demographic characteristics

The age of the patients ranged from 18-85 years, with a mean of 41.9 (SD 16.6) years. The median age was 39.5 (IQR 28, 55). Males were 55 (56.1%) while females were 43 (43.9%) i.e. male to female ratio of 1.3:1. On educational level, 45 (45.9%) had secondary education while 34 (34.7%) had primary level education. On the type of occupation, farmers were 39 (39.8%), casual workers were 17 (17.3%) and students were 10 (10.2%). The rest of the socio demographic characteristics are shown in the table on the next page:

**Table 4.1.1: Socio demographic characteristics**

| Variable | Category | Frequency | Percent |
|---|---|---|---|
| *Age | Mean(SD) | 41 (16.6) | |
| **Sex** | Male | 55 | 56.1 |
| | Female | 43 | 43.9 |
| **TOTAL** | | **98** | **100** |
| **Education level** | None | 11 | 11.2 |
| | Primary | 34 | 34.7 |
| | Secondary | 45 | 45.9 |
| | Tertiary | 8 | 8.2 |
| **TOTAL** | | **98** | **100** |
| **Occupation** | Farmer | 39 | 39.8 |
| | Casual construction workers | 17 | 17.3 |
| | Student | 10 | 10.2 |
| | Business | 6 | 6.1 |
| | Driver | 4 | 4.1 |
| | Office secretary | 4 | 4.1 |
| | House wife | 3 | 3.1 |
| | Motor cycle rider | 3 | 3.1 |
| | Teacher | 2 | 2.0 |
| | Security guard | 2 | 2.0 |
| | Mason | 1 | 1.0 |
| | Machine operator | 1 | 1.0 |
| | Turn boy | 1 | 1.0 |
| | Prisoner | 1 | 1.0 |
| | Street boy | 1 | 1.0 |
| | None | 3 | 3.1 |
| **TOTAL** | | **98** | **100** |
| *Variable summarized in mean & SD | | | |

### 4.1.1 Dominant hand

All the patients were right handed.

### 4.1.2 Time taken after injury before seeking help in the hospital

Seventy nine percent of the patients took between hours and one day to seek treatment at MTRH. The results are shown in the figure on the next page:

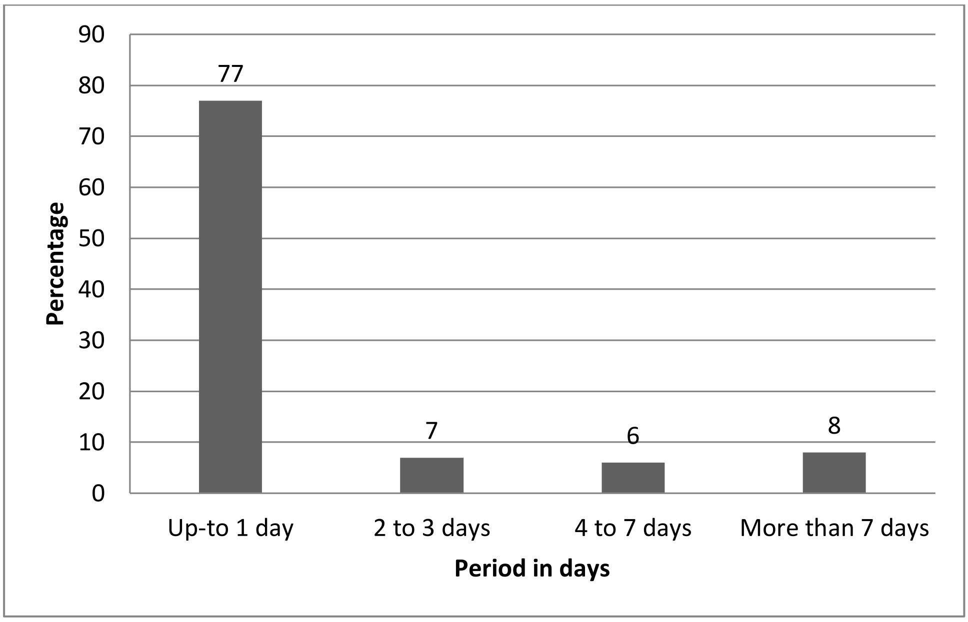


**Figure 4.1.2.1: Time taken after injury before seeking help in the hospital**

### 4.1.3 Referral status

MTRH was the first health care facility where 62 patients (63%) went to after they got injured, while 36 patients (37%) were referred to MTRH from other health facilities. The referring health facilities are as shown below:

**Table 4.1.3.1: Referring facilities**

| Referring facilities | Frequency | Percent |
|---|---|---|
| County hospital | 17 | 47.2 |
| Health centre or dispensary | 8 | 22.2 |
| Private | 5 | 13.9 |
| Sub County hospital | 5 | 13.9 |
| KDF barracks hospital | 1 | 2.8 |
| **Total** | **36** | **100** |

### 4.2 Causes of the fractures

Falls contributed 47% of the forearm fractures followed by road traffic accidents at 28% and assaults at 18%. Other causes were 6% as shown in the figure below:

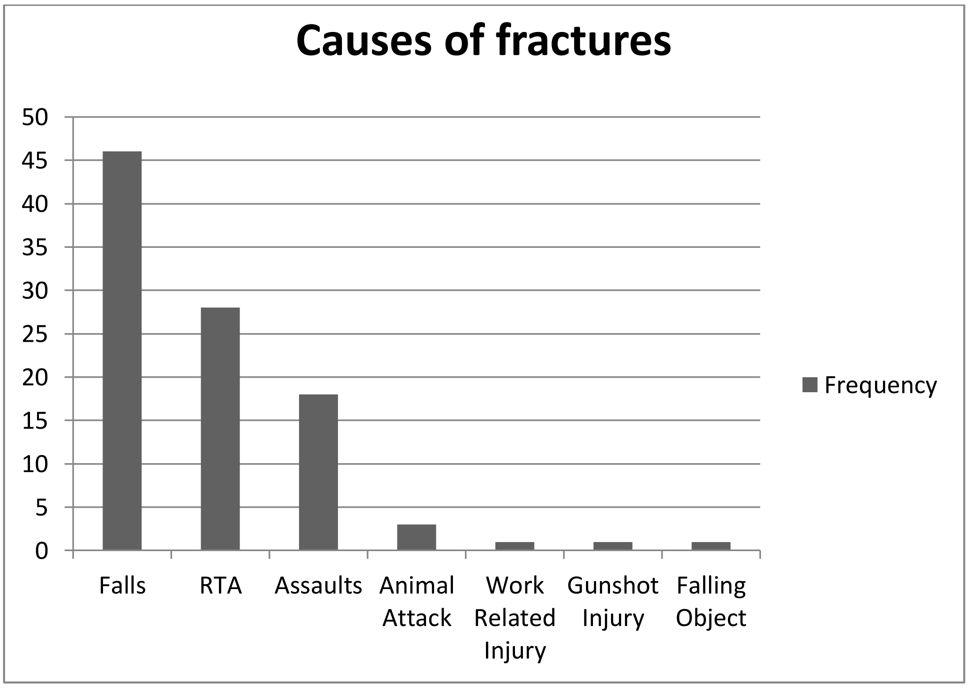


**Fig. 4.2.1: Causes of fractures**

#### 4.2.1 Causes of the fractures compared against their age groups

Falls caused 63.6% of the fractures among the elderly patients in the age group of 51-85 years (p-value $<0.05$). Falls and road traffic accidents caused 38.5% and 35.4% of the fractures respectively among the age group of 18-50 years. RTAs caused more fractures among the age group of 18-50 years as compared to those above 51years of age (p-value <0.05) as shown in the table on the next page:

**Table 4.2.1: Causes of fractures and the age group of the patients**

| | Age | | |
|---|---|---|---|
| **Cause of fracture** | **18-50yrs (n=65)** | **51-85yrs (n=33)** | **p-value** |
| Falls | 25 (38.5%) | 21 (63.6%) | 0.018 |
| Road Traffic Accident (RTA) | 23 (35.4%) | 5 (15.2%) | 0.036 |
| Assault | 14 (21.5%) | 4 (12.1%) | 0.255 |
| Animal attack | 0 | 3 | - |
| Work related injury | 1 | 0 | - |
| Gunshot | 1 | 0 | - |
| Falling object | 1 | 0 | - |

## 4.3 Patterns of forearm fractures

### 4.3.1 Side of the forearm fractured

There were 52 patients (53%) who sustained fractures of the right forearm, while 46 patients (47%) sustained forearm fractures of the left forearm.

### 4.3.2 Presence wound at the fracture site

Closed fractures were found in 82 patients (84%) while open fractures were found in 16 patients (16%). The Gustillo Classifications of the open fractures are shown in the figure on the next page:

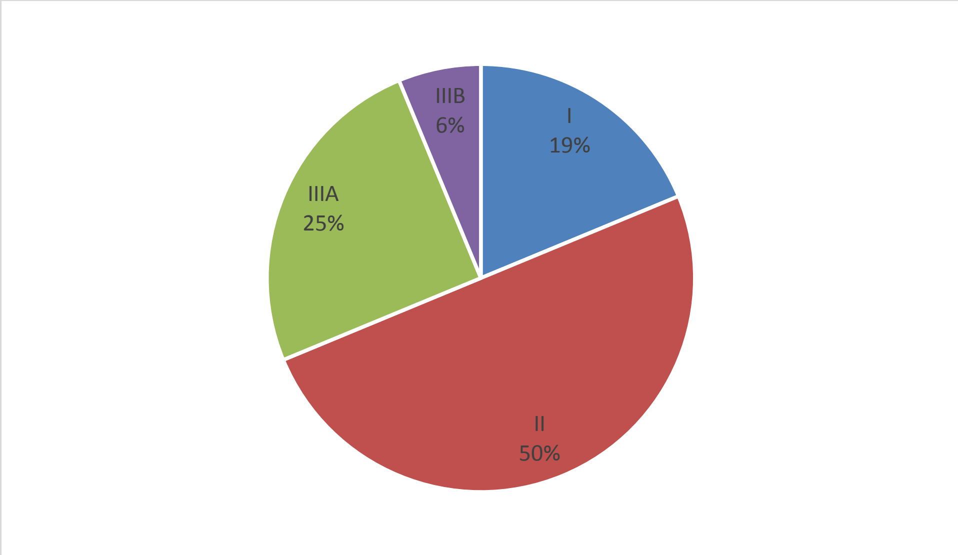


**Figure 4.3.2.1: Gustillo classification of open fractures**

### 4.3.3 Fractured bone

Isolated radius bone fracture was found at 52% followed by both radius and ulna fractures at 27%. Isolated ulna fractures constituted 21% of all the fractures as shown in the figure below:

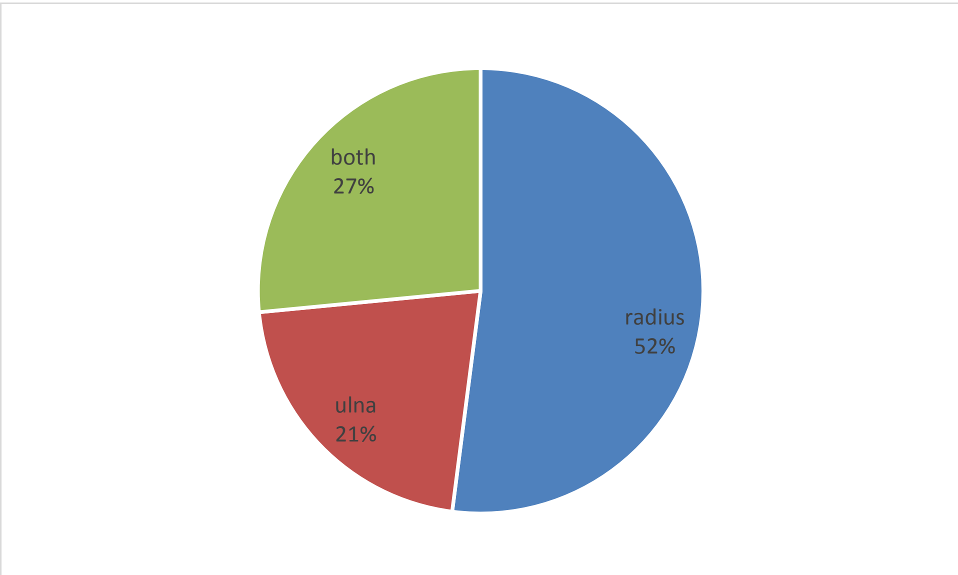


**Figure 4.3.3.1: Fractured bone**

### 4.3.4 State of fracture ends

Non-displaced fractures were 69 (70%) while displaced fractures were 29 (30%).

### 4.3.5 AO classification of the fracture (s)

Simple or impacted metaphyseal fractures of the radius (23-A2) was found in 35.7% of the cases, followed by simple diaphyseal fractures of the radius (22-A2) at 17.3% and simple both radius and ulna diaphyseal fractures (22-A3) at 12.2%. Simple diaphyseal ulna fractures (22-A1) were 7.1 %. The A type fractures (simple fractures) constituted 87.5% of all the fractures. The B type fractures (wedge fractures) were 5% while the C type fractures (complex fractures) were 7.5%. Others are as shown in the table on the next page:

**Table 4.3.5.1: AO Classification of the fractures**

| Classification | Interpretation | Frequency | Percent |
|---|---|---|---|
| 23-A2 | Simple metaphyseal radius fracture | 35 | 35.7 |
| 22-A2 | Simple diaphyseal radius fracture | 17 | 17.3 |
| 22-A3 | Simple fracture both bones | 12 | 12.2 |
| 22-A1 | Simple diaphyseal ulna fracture | 7 | 7.1 |
| 23-A1 | Extraarticular distal ulna fracture | 6 | 6.1 |
| 23-A3 | Comminuted metaphyseal radius # +/- ulna # | 6 | 6.1 |
| 22-C1 | Complex fracture of ulna diaphysis | 4 | 4.1 |
| 21-A1 | Extraarticular proximal fracture of ulna | 2 | 2.0 |
| 22-C2 | Complex fracture of radius diaphysis | 2 | 2.0 |
| 22-B1 | Wedge fracture of ulna diaphysis | 2 | 2.0 |
| 22-B3 | Wedge fracture of diaphysis of both bones | 2 | 2.0 |
| 23-B1 | Partial articular fracture of distal radius | 1 | 1.0 |
| 21-A2 | Extraarticular proximal radius fracture | 1 | 1.0 |
| 22-C3 | Complex fracture of both bones diaphysis | 1 | 1.0 |
| **Total** | | **98** | **100.0** |

### 4.3.6 AO Classification of the fractures against the age group of the patients

Among those aged 18-50 years, 53.9% had AO 22 (diaphyseal fractures) while 57.6% of those aged 51-85 years had AO 23 (distal metaphyseal fractures). Only 3 patients had AO 21 (proximal fractures) distributed among those aged 18-50 and 51-85 years. These results were statistically not significant with p-value > 0.05 as shown in the table on the next page:

**Table 4.3.6.1: AO Classification of the fractures against the age group of the patients**

| | Age | | |
|---|---|---|---|
| **AO classification** | **18-50yrs (n=65)** | **51-85yrs (n=33)** | **p-value** |
| 21 (Proximal metaphyseal fractures) | 1(1.5%) | 2(5.7%) | 0.262* |
| 22 (Diaphyseal forearm fractures) | 35(53.9%) | 12(36.4%) | 0.102† |
| 23 ( Distal metaphyseal fractures) | 29(44.6%) | 19(57.6%) | 0.225† |

*Fishers' Exact test; †Chi Square Test

### 4.3.7: AO classification of the fracture (s) versus causes of the fracture

In comparing the AO classification of the fractures with the causes of the fractures, 23-A2 (simple or impacted metaphyseal radial fracture) were 35 in number out of which 26 (74%) were caused by a fall. Simple diaphyseal radial fracture (22-A2) were 17, out of which 6 each were caused by RTA and a fall and 4 were caused by assault. Other results are as shown in the table on the next page:

**Table 4.3.7.1: AO classification of the fracture (s) versus causes of the fractures of the forearm**

| AO class. | Cause of the fracture | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | RTA | Fall | Assault | Work related injury | Gunshot | Animal attack | Falling object | |
| 23-B1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 23-A1 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 6 |
| 22-B1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 22-A3 | 7 | 1 | 3 | 1 | 0 | 0 | 0 | 12 |
| 23-A2 | 6 | 26 | 1 | 0 | 0 | 2 | 0 | 35 |
| 21-A1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| 22-A2 | 6 | 6 | 4 | 0 | 0 | 1 | 0 | 17 |
| 22-A1 | 0 | 2 | 5 | 0 | 0 | 0 | 0 | 7 |
| 22-B3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| 23-A3 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 6 |
| 21-A2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 22-C2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 22-C1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 4 |
| 22-C3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Total** | **28** | **46** | **18** | **1** | **1** | **3** | **1** | **98** |

**4.3.8: Other associated injuries in other parts of the body**

Thirteen patients (13.2%) had associated fractures in other parts of the body as a result of multiple injuries. They are shown in the figure below:

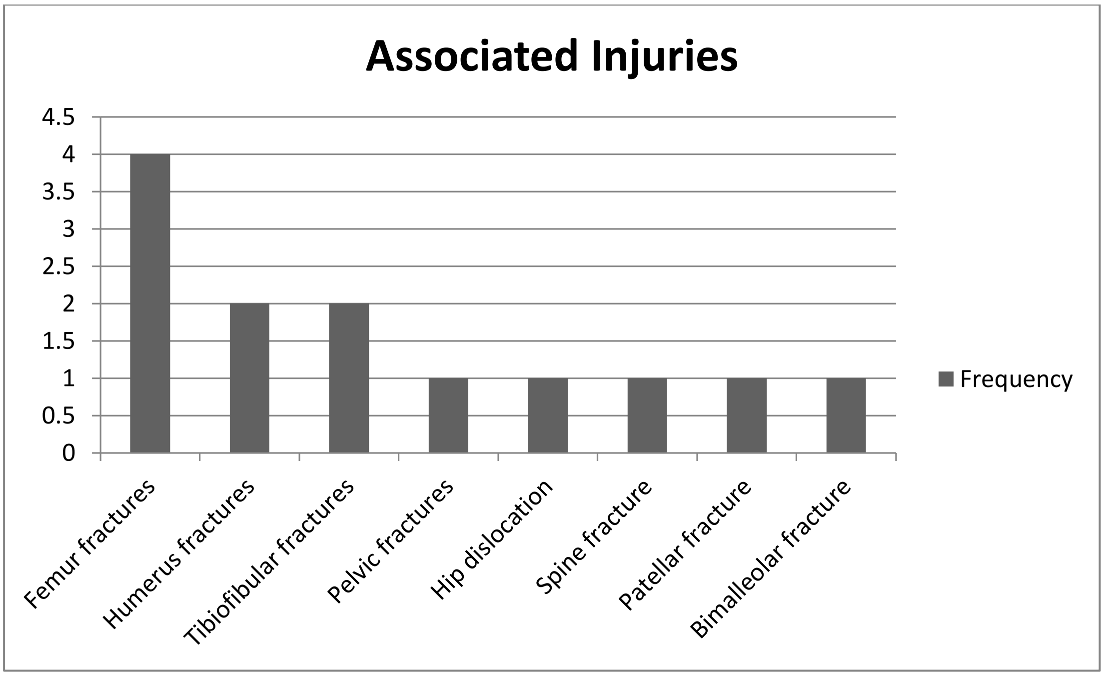


**Fig. 4.3.8.1: Associated injuries in other parts of the body**

**4.4 Proportion of treatment methods of forearm fractures**

**4.4.1 Definitive treatment**

The definitive treatment of the fracture was either non-operative in the form of cast immobilisation in 76% of the patients or operative management by internal fixation or external fixation in 23% of the patients as shown in the figure below:

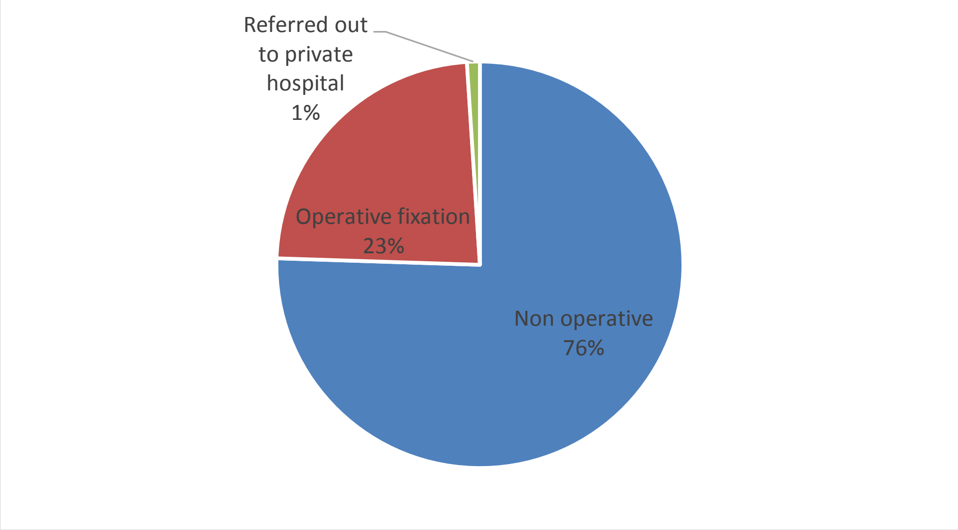


**Figure 4.4.1.1: Proportions of definitive treatment methods**

### 4.4.2: Initial treatment

The initial treatment involved administration of analgesics in almost all the patients, stabilisation of the fracture with a backslab (Sugar Tong splint), antibiotic and tetanus toxoid administration and debridement for open fractures as shown in the figure on the next page:

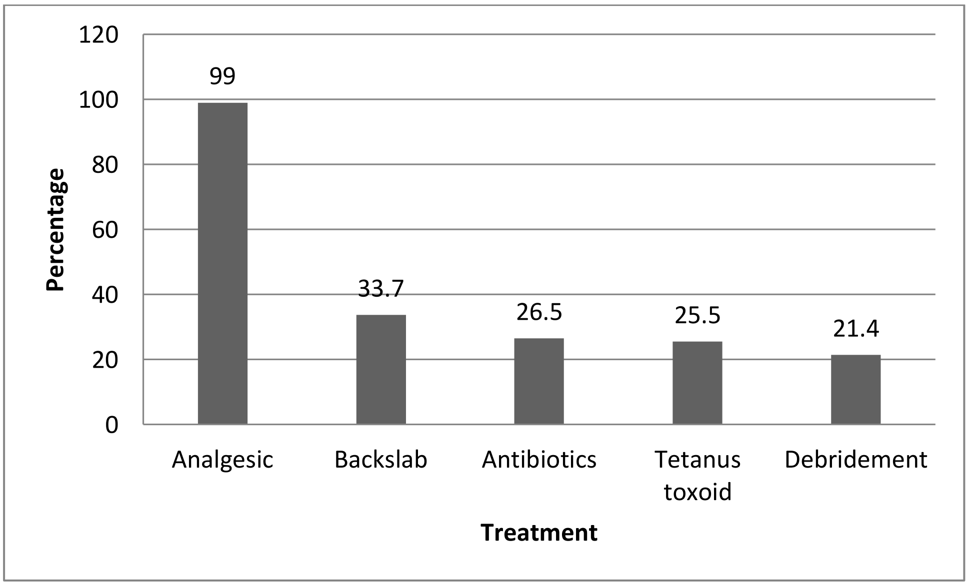


**Figure 4.4.2.1: Initial treatment**

### 4.4.3: Distribution of AO classification by treatment option

Non-operative treatment was done for 32 out of 35 distal metaphyseal radius fractures (23-A2). Simple diaphyseal radius fractures (22-A2) were treated non-operatively in 15 out of 17 fractures. Simple both bone diaphyseal fractures (22-A3) were treated operatively in 8 out 11 cases. Other fractures were treated as shown in the table on the next page:

**Table 4.4.3.1: Distribution of AO classification by treatment option**

| AO classifications | Non operative | Operative | Total |
|---|---|---|---|
| 21-A1 | 1 | 1 | 2 |
| 21-A2 | 0 | 1 | 1 |
| 22-A1 | 7 | 0 | 7 |
| 22-A2 | 15 | 2 | 17 |
| 22-A3 | 3 | 8 | 11 |
| 22-B1 | 1 | 1 | 2 |
| 22-B3 | 1 | 1 | 2 |
| 22-C1 | 2 | 2 | 4 |
| 22-C2 | 0 | 2 | 2 |
| 22-C3 | 1 | 0 | 1 |
| 23-A1 | 6 | 0 | 6 |
| 23-A2 | 32 | 3 | 35 |
| 23-A3 | 5 | 1 | 6 |
| 23-B1 | 0 | 1 | 1 |
| **Total** | **74** | **23** | **97** |

### 4.4.4: Distribution of fracture type (open/closed) by definitive treatment method

Closed fractures were treated non-operatively in 68 out of 82 fractures (83%) while open fractures were treated operatively in 9 out of 15 fractures (60%). There a significant association between fracture type and the definitive treatment method (p<0.001) as shown in the table on the next page:

**Table 4.4.4.1: Distribution of fracture type (open/closed) by definitive treatment method**

| Fracture type | Definitive non-operative | Definitive Operative | p-value |
|---|---|---|---|
| Open | 6(8.1%) | 9 (39.1%) | <0.001 |
| Closed | 68(91.9%) | 14 (60.9%) | |

### 4.4.5: Non Operative treatment

Seventy four patients had non-operative treatment, 9 were then lost to follow up and 1 died. Therefore 64 patients were analysed.

### 4.4.6: Time taken with Plaster Cast

This is the duration of time from application of Sugar Tong splint through to conversion to plaster cast, to the time it was removed. It was removed at 6 weeks in 63% of the patients, 2 months in 25%, 3 months in 10% and more than 3 months in 1 patient (2%) as shown below:

**Table 4.4.6.1: Time taken with plaster cast**

| Time period | Frequency | Percent |
|---|---|---|
| 6 weeks | 40 | 62.5 |
| 2 months | 16 | 25 |
| 3 months | 6 | 9.4 |
| >3 months | 2 | 3.1 |
| **Total** | **64** | **100** |

### 4.4.7: X-ray results at the time of plaster cast removal

There was normal fracture union in 50 patients (78%), mal-union was found in 8 patients (12%) while delayed union was found in 6 patients (10%) as shown below:

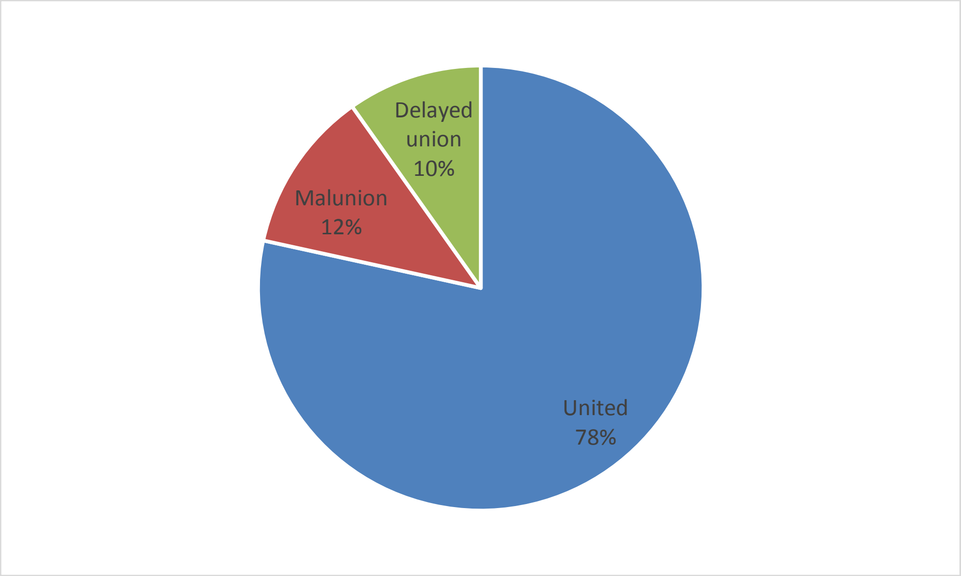


**Figure 4.4.7.1: X-ray results at the time of plaster cast removal**

### 4.4.8: Physiotherapy after non-operative treatment

Physiotherapy was prescribed and done in 14 patients (21.5%). The remaining 50 patients (78.5%) did not have physiotherapy prescribed. The results are shown in the table below:

**Table 4.4.8.1: Physiotherapy after non-operative treatment**

| Physiotherapy | Frequency | Percent |
|---|---|---|
| Yes | 14 | 21.5 |
| No | 50 | 78.5 |
| **Total** | **64** | **100.0** |

### 4.4.9 Operative Treatment: Indications for operative treatment

Open fractures, both bone fractures and failed closed reduction were the main indications for operative treatment.

### 4.4.10 Time taken before operation after injury

Four patients (18.5%) were operated on within 3-10 days of admission while 19 (81.5%) were operated on after 10 days.

### 4.4.11 Type of fixation done

Dynamic Compression Plating using 3.5 mm DCP was the commonest method of internal fixation of these fractures. Others are as shown in the figure below:

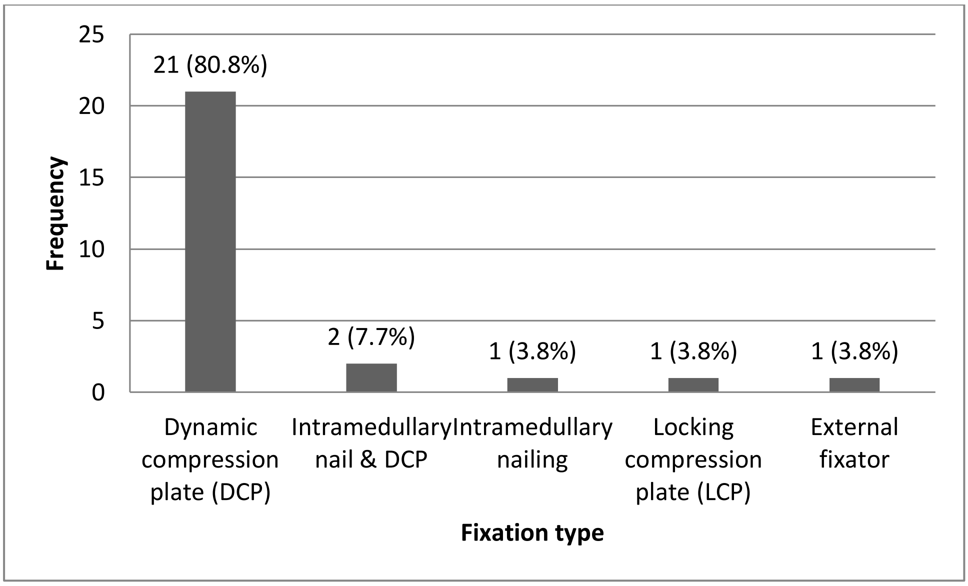


**Figure 4.4.11.1: Type of fixation done**

**4.4.12: Plaster splint application after operation**

Only 5 patients (19.2%) had a plaster splint applied after operation while 21 patients (80.8%) did not.

**4.4.13: Plaster splint time**

For those who got plaster splint after operation, 3(75%) took 2 weeks with the splint, while 1(25%) took >4weeks.

**4.4.14: X-ray results at 6 months of follow-up**

The fractures were united in 20 cases (87%), malunion were 2 (8.7%) and delayed union was one case (4.3%). These are shown in the figure below:

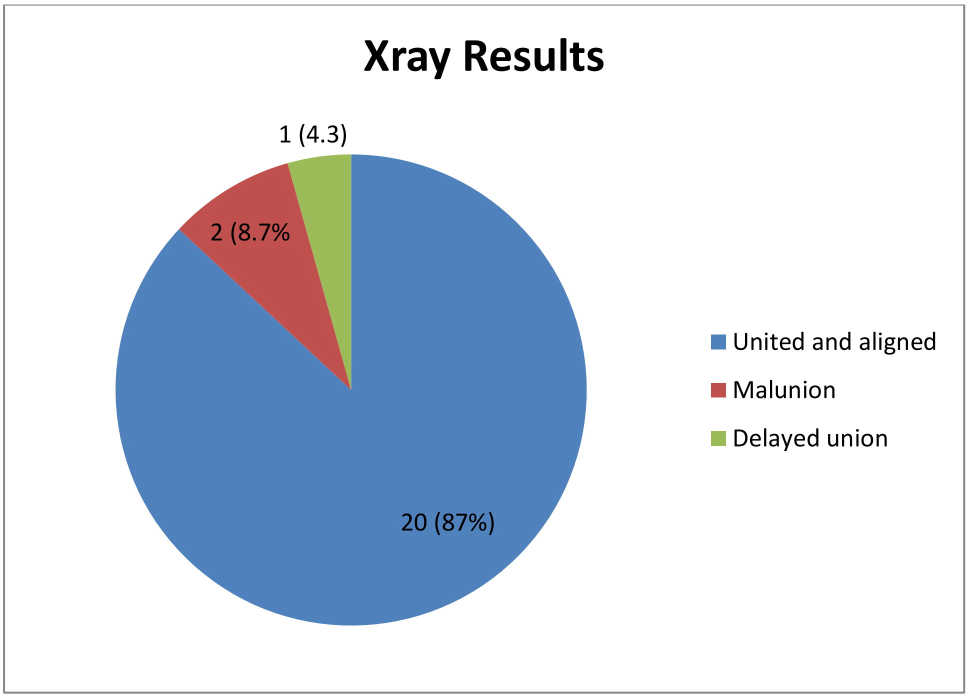


**Figure 4.4.14.1: X-ray results at 6 months follow up**

### 4.4.15: Outcomes after operative treatment

Fracture union with no complication was found in 17 patients (68%). One patient each had united fracture but with complication like infected implant, anterior interosseous nerve injury and elbow stiffness. Malunion was in 2 patients. The results are shown in the table on the next page:

**Table 4.4.15.1: Outcomes after operative treatment**

| Results | Frequency | Percent |
|---|---|---|
| United | 17 | 74 |
| Malunion | 2 | 8.7 |
| Delayed union | 1 | 4.3 |
| United with infected implant | 1 | 4.3 |
| United with anterior interosseous nerve injury | 1 | 4.3 |
| United with elbow stiffness | 1 | 4.3 |
| **Total** | **23** | **100** |

### 4.4.16: Time taken for fracture union in weeks among operative group

Duration of time for fracture union after operative treatment ranged between 12 weeks to 20 weeks with 56% confirmed united at between 13 to 18 weeks. The results are as shown in the table below:

**Table 4.4.16.1: Time taken for fracture union in weeks among operative group**

| Weeks | Frequency | Percent |
|---|---|---|
| 12 | 5 | 22 |
| 13>18 | 13 | 56 |
| 19>20 | 5 | 22 |
| **Total** | **23** | **100** |

### 4.4.17: Physiotherapy after operative treatment

Ten patients (41.7%) had physiotherapy done while 14 (58.3%) did not.

## 4.5 Functional outcomes

### 4.5.1 Comparison of DASH score by treatment method

Those who underwent surgery had higher median DASH score (M=18.4, IQR 5.8 - 25) compared to those who had non-operative treatment (M=11.2, IQR 7.5 – 20), however the difference was not statistically significant (p=0.173), as shown in the table below:

**Table 4.5.1.1: Comparing DASH score by treatment method**

| Treatment method | Mean(SD) | Median(IQR) | Min | Max | p-value |
|---|---|---|---|---|---|
| Non-operative | 13.3(6.9) | 11.2(7.5, 20) | 5 | 32.5 | 0.173 |
| Operative | 22.3(18.4) | 18.4(5.8, 25) | 4.16 | 60 | |

### 4.5.2: Comparison of the DASH Scores by fracture type

Open fractures had higher median DASH score than closed fractures; however the difference was not statistically significant as shown in the table below:

**Table 4.5.2.1: Comparing DASH score by fracture type (open/closed)**

| Fracture type | Mean(SD) | Median(IQR) | Min | Max | p-value |
|---|---|---|---|---|---|
| Open | 23.9 (16.7) | 20.6 (15.8, 25.0) | 4.2 | 58.3 | 0.058 |
| Closed | 14.3 (10.0) | 11.2 (7.5, 18.4) | 4.2 | 60.0 | |

### 4.5.3.: Comparison of DASH score by age groups of the patients

Those above 51 years of age had higher median DASH Scores (M=18.4, IQR 5.8 - 25) compared to those under 51 years (M=11.2, IQR 7.5 – 20), however the difference was not statistically significant (p=0.411) as shown below:

**Table 4.5.3.1: Comparing DASH score by age groups of the patients**

| Age Groups | Mean(SD) | Median(IQR) | Min | Max | p-value |
|---|---|---|---|---|---|
| <51years | 15.1(10.9) | 10.3(7.3, 20.6) | 4.16 | 58.3 | 0.411 |
| ≥51 years | 16.7(12.8) | 12.5(9.5, 20.5) | 5 | 60 | |

# CHAPTER FIVE: DISCUSSION

## 5.1 Socio-demographic characteristics

Fractures of the bones of the forearm were common injuries seen at MTRH affecting the adult population. The mean age of the patients was 41.9 (SD 16.6) years. Males were slightly more than females with a male to female ratio of 1.3:1. This concurs with the study by Goldfarb et al., (2005) which found the mean age of adults patients with forearm fractures as 40 years with a male to female ratio of 1.5:1. This study also concurs with the study by Wang et al., (2005) which found the mean age of the patients with open both bone forearm fractures to be 41 years (range 19-81 years). The current study also concurs with the study by Ogunlade et al., (2002) which found the mean age of adults with distal radius fractures as 43.49 years. This mean age is the productive age group which is at risk of the causes of forearm fractures. The predominance of males could be because they are more exposed to outside environment like riding motorcycles, heavy manual work and sports than their female counterparts.

On the socio-demographic status; almost half of the patients had achieved secondary education level. The occupational activities were mainly farming, casual work and students. This study contrasts the study by Goldfarb et al., (2005) which found that in terms of occupation, majority of their patients were employed outside their homes. Our population consisted of mostly unskilled workforce while their study was done in the United States of America which has a higher socio-economic status. Agriculture is the main economic activity in the Uasin Gishu County and the surrounding counties hence the predominance of farmers among the patients who sustained forearm fractures (Kenya Information Guide, 2015).

All the participants were right handed. The right hand dominance in the general population is 90%-95% hence the possibility of all the patients being right handed. This concurs with Lee Y.H et al., (2008), in which they studied 38 fractures in 27 patients and all the patients were right handed.

The majority of the respondents, 79%, took hours to one day before seeking help in the hospital. This is as a result of the acute nature of the injury and the pain.

On the referral status, MTRH was the first health care facility for almost two thirds of the patients after the injury, while 36.7% were referred to MTRH from other health facilities. Nearly half (47.2%) of the referrals were from a county hospital. This indicates that MTRH is believed to offer appropriate emergency services to trauma patients by virtue of its status as a regional referral hospital. This finding also shows that there are fewer trauma centres in the region that can handle these kinds of injuries. These findings slightly contrast the study by Ayumba et al., (2015) in which 51% of patients with posttraumatic exposed bones were referred to MTRH from other health facilities.

**5.2 Causes of forearm fractures**

Among the causes of forearm fractures in adults, this study found out that falls from heights contributed almost half of the fractures (47%) followed by Road Traffic Accidents (RTA) and assaults. These results concur with the study by Ogunlade et al., (2002) which found that falls were the main cause of forearm fractures at 51.4% followed by RTA and other causes. Their study was focussed mainly on distal radius fractures.

This study however contrasts with the study by Goldfarb et al., (2005) which found that motor-vehicle accidents were the main cause of both bone forearm fractures at 56.5% followed by falls. This contrast could be due to the fact that their study was on both bone fractures which could be caused by high energy kind of injury. The current study is a mixture of all the forearm fractures.

This study contrasts the study done by Lee Y.H et al., (2008) which found the causes of forearm fractures to be motor vehicle accidents at 37%, industrial accidents at 30%, sports injury at 18% and falls at15%. Their study was done in South Korea where there are lots of high energy injuries sustained on the roads and industries. The study was also on diaphyseal fractures only as opposed to this study whereby all extraarticular fractures were included.

Khanbhai and Lutomia, (2012) opined that with increased traffic on the Kenyan roads coupled with increased motorcycle as a means of transport in Kenya, the incidences of road traffic accidents and falls off moving motor vehicles has been on the rise with the resultant limb injuries. The falls being the major cause could also be due to the inclusion of the distal radius fractures which are mostly caused by low energy injury such as falls especially in the elderly population. The assault cases were mainly as a result of domestic disputes, family land disputes and robberies.

Those aged between 18-51 years sustained fractures almost equally from falls and road traffic accidents. The elderly above 51 years sustained more fractures from falls than from other causes (p-value $<0.05$). This can due to fragility fractures as a result of osteoporosis in this age group as documented by Dave, 2013 and Gakuu, 2011.

**5.3 Patterns of forearm fractures**

On the side of the forearm fractured, slightly more than half, 53%, sustained fractures on the right limb, while 47% occurred on the non dominant limb. This contrasts the study by Goldfarb et al., (2005) whereby they found 38% of the fractures occurring on the dominant limb and 62% of the fractures occurring on the non dominant limb. This study also contrasts the study by Ogunlade et al., (2002) which found that in the distal radial fractures, the right side was fractured in 48.6% while the left side was 51.4% of the patients in their study.

In the current study there was no left handedness and this could have contributed to the majority of the fractures occurring on the right limb as the dominant limb could have been used as defence from falling or from assaults.

On the type of fracture, 82 patients (84%) had closed fractures while only 16 patients (16%) had wound on the fracture site, that is, open fractures. This concurs with the ten year review of forearm fractures by Matejëiê et al., (2000) which found open fractures to be 19%. This study also concurs with Lee Y.H et al., (2008) in which among the 38 fractures they studied, 31(82%) were closed fractures while 7 (18%) were open fractures.

In the current study, half of the open fractures were Gustillo II followed by Gustillo IIIA at 25%. This contrasts the study by Wang et al., (2005) which found that the majority of open fractures were Gustillo I at 64% followed by Gustillo II at 24%. There was no Gustillo IIIC. In the current study the Gustillo IIIC were excluded. The few numbers of open fractures in this study could be attributed to the fact that 47% of the fractures were caused by fall from a height, which is a low energy kind of injury, hence not sufficient enough to cause an open fracture.

More than half of the fractures were isolated radius fractures at 52% followed by both bone fractures at 26.5% and isolated ulna fractures at 21.4%. This concur with the study by Okoro and Ohadugha, (2006) which found that among the upper limb bones, the radius is the most affected bone accounting for 8.1% of the fractures followed by the ulna. Their study was done for all extremities fractures while the current study is only on forearm bones. However, the current study contrasts with the study by Matejëiê et al., (2000) which found that among the 354 cases of forearm fractures, bilateral diaphyseal fractures were 34%, radial fractures were 29% and ulnar fractures were 37%. The sample size in their study was large compared to the current study. In the current study, the inclusion of metaphyseal extraarticular fractures of the radius could have contributed to the high number of isolated radius fractures since the aging population are susceptible to fragility fractures especially of the distal radius as documented by Dave, 2013.

Majority (70%) of the fractured ends of the bone were undisplaced while 30% were displaced. This could be due to the causes of the majority of the fractures as falls and therefore the forces were not sufficient to cause displacement.

The common fracture pattern by AO Classification was 23-A2 (simple or impacted metaphyseal radial fracture) accounting for 35.7% of all the fractures. This was followed by 22-A2 (simple fracture of radius diaphysis with ulna intact) accounting for 17.3% of the fractures.

The third commonest fracture pattern was 22-A3 (simple fracture of diaphysis of both bones) at 12.2%. Other categories shared the remainder of 34.8%. This could be attributed to the causes of the fractures especially the falls which cause majority of the distal radius fractures. The A type fractures (simple fractures) were the majority with 87.5% of all the fractures. The B type fractures (wedge fractures) were 5% while the C type fractures (complex fractures) were 7.5%. The complex fractures were mainly caused by high energy trauma such as gunshot injuries and road traffic accidents. These findings concur with the findings of Goldfarb et al., (2005) who also used the AO classification in their study on the fractures of both radius and ulna diaphyses and found most fractures, 18 (78%) were 22-A3 (simple fracture of both bones of the forearm). The current study however included metaphyseal extraarticular fractures.

This study contrasts the findings of Lee Y.H et al., (2008), who found the A type fractures were 32%, B type fractures were 50% and C type fractures were 18%. This difference could be due to the causes of fractures in their study whereby high energy mechanisms like road traffic accidents and industrial accidents were the majority causing 37% and 30% of the fractures respectively while falls were the least cause of fractures at 15% as opposed to the current study where falls were the majority.

Among the younger age group of 18-50 years, more than half (53.9%) of them had AO Class 22 (diaphyseal fractures) while the elderly group of 51-85 years, more than half (57.6%) had AO Class 23 (distal metaphyseal fractures). These findings though statistically not significant (p-value >0.05), means that most of the young and the middle aged patients sustained fractures caused by high energy injury. The elderly mainly sustained fractures caused by low energy injury.

On the AO classification and the causes of the fractures, it was found that 26 out of 35 (74%) AO Class 23-A2 fractures (metaphyseal distal radius fractures) were caused by falls. The causes of 22-A2 fractures (diaphyseal radius fractures) were Road Traffic Accidents (RTA) at 35%, falls at 35% and assaults at 30%. Both bone diaphyseal fractures (22-A3) were mainly caused by RTA at 58%. Isolated diaphyseal ulna fractures (22-A1) were mainly caused by assaults at 5 out of 7 fractures (71%). These results show that falls were the main cause of these fractures and especially the low energy injuries. High energy trauma from RTA mostly caused both bone fractures. Isolated ulna fractures are usually defence injuries caused by assaults.

There were only 13 other associated fractures presenting with the forearm fractures, making 13.2% associated injuries. They were 4 femur fractures, 2 each for humerus and tibiofibular fractures and 1 each for pelvic, hip dislocation, spine, patellar and bimalleolar fractures. This concurs with the study by Prakash and Basanthi, (2013) which found associated injuries with forearm fractures as abdominal injuries, tibial fractures, head injury, rib fractures; each at 3.3%, totalling 13.2% associated injuries. This can be explained that the forearm fractures occur isolated in majority of the situations, however they can be associated with other injuries in multiply injured patients.

### 5.4 Treatment methods of forearm fractures

Initial treatment consisted of analgesia in almost all of the cases (99%). Those who had open fractures received tetanus toxoid injection, intravenous antibiotic administration and surgical debridement. Backslab application was done for initial stabilisation of the fractures. This initial management and especially the pain relief are in keeping with the basic principles of treatment of acute fractures whether open or closed. Haonga et al., (2011) emphasized the need to relieve pain by all possible appropriate means in a timely, efficient and effective manner. The current study concurs with the study by Ayumba et al., (2015) which stated that at MTRH, the main procedures done for open fractures are systematic debridement, irrigation and fractures stabilisation (initial or definitive).

Non-operative treatment was done for all the 7 isolated simple ulna shaft fractures. The 15 out of 17 isolated simple radius shaft fractures were also treated non-operatively. Almost all (32 out of 35) metaphyseal extraarticular distal radius fractures were treated non-operatively. Only 3 out of 11 both bone fractures were treated non-operatively.

These findings concur with other literature by Jupiter and Kellam, (2009), which recommends non-operative treatment for isolated ulna shaft fractures and non displaced radius shaft fractures. These results also concur with the study by Ogunlade et al., (2002) which recommended closed reduction of distal radius fractures and application of plaster cast. However, the current results contrast the study by Jakhar and Kalla, (2013) which recommended volar locking plating system to be effective fixation when used for the treatment of initially inadequately reduced distal radial fractures.

Majority (63%) of the patients treated non-operatively stayed with the plaster cast for 6 weeks before removal while 25% took 2 months with the cast. The upper limb bones usually take between 6 to 10 weeks for radiological and clinical fracture union. Those who had the cast removed at and above three months were the ones with delayed union and were later sent for open reduction and internal fixation (ORIF). Those with mal-union were also sent for ORIF. In total there were 14 patients with mal-union and delayed union but only 4 were able to be done ORIF. The rest could not afford.

Operative reduction and fixation of the forearm fractures were done in 23 patients initially (23%). The indications for surgery concur with the indications for ORIF as documented by Arnander and Newman, (2006) such as: both bone fractures, open fractures, multiple fractures and complex fractures. There were four patients who had failed closed reduction and later on were done open reduction and internal fixation.

Majority (81.5%) of the patients were operated after 10 days from the time of injury while 18.5% were operated early within the first 3 days after injury. This concurs with the study by Ayumba et al., (2015) which found the waiting time before surgery at MTRH ranged from few minutes to 67 days with a mean of 3.43 days (SD= 6.55). Their study was on posttraumatic exposed bones with majority being Gustillo III open fractures.

The current study contrasts the study by Meena et al., (2013) whereby 65% of their patients were operated within the first week of presentation to the hospital. The delay in operation in the present study could have been due to financial reasons or lack of theatre space or contaminated open fractures. This delay however is not unusual as Matejëiê et al., (2000) stated that early operation is desirable but not essential; the operation may be delayed by general or local factors. Under these circumstances, the operation should be performed at the earliest appropriate time.

On the type of operative fixation used for the fractures; Dynamic Compression Plating using 3.5mm DCP was the majority with 21 cases being used (80.8%), Intramedullary nailing together with DCP was used in 2 patients (7.7%) while one patient each had intramedullary nailing, locking compression plating and external fixation using external fixator. These findings concur with other written literature which found that plate osteosynthesis is the most commonly used technique for the treatment of diaphyseal forearm fractures in adults as documented by Akpinar et al., 2011; Lee Y. H. et al., 2008; and Višńa et al., 2008.

The use of DCP in majority of the cases could be due to the availability and the cost of the plates which are relatively cheaper than the intramedullary nails. The external fixator was used on the patient who had gunshot wound with a communited Gustillo III B fracture. The use of locked intramedullary nails for treatment of forearm fractures has been advocated by many authors who prefer it due to short operating time, reduced blood loss, preservation of fracture biology and short duration of fracture union as documented by Gakuu, 2010; Lee S. K. et al., 2014; and Lee Y. H. et al., 2008.

Plaster splint was applied in only 5 patients who underwent ORIF. These patients had complex fractures and the fixation was unstable. Splint application after ORIF is however not absolute but it can be applied for the comfort of the patient and also if the fixation is not stable. Burnwell and Charnley, (1964) stated that immobilisation of the limb after operation is not necessary and is undesirable if the fixation is rigid. The cast was removed after 2 weeks in four patients and after 4 weeks in one patient.

The postoperative check X-ray results after over three to six months of follow-up found that 20 cases (87%) were united. Malunion were 2 cases (8.7%) and delayed union was one case (4.3%). Among the patients who had united fractures, one each had infected implant, anterior interosseous nerve injury and elbow stiffness. The infected implant was later removed. The 2 patients who had malunion were those who had fixation done by external fixator and rush rod intramedullary nailing. The one patient who had delayed union had fixation done by DCP.

These findings concur with the study by Manjappa et al., (2011) which found one case (5%) with superficial infection, one case (5%) of non-union of radius which required re-fixation with bone grafting after fixation with LC-DCP. The complications in this study also concur with those of Prakash and Basanthi, (2013) which found postoperative complications after ORIF with LC-DCP as follows; superficial infections at 10%, interosseous nerve injury at 3.3% and radioulnar synostosis at 3.3%. The current study did not have any radioulnar synostosis. The few post operative complication rates in the study is commendable. However the numbers of patients operated were few.

The time taken for fracture union after operative treatment was between 14 weeks and 20 weeks with a third of the fractures confirmed united at 18 weeks post operative. This concurs with the study by Manjappa et al., (2011) which found the average time to fracture union after ORIF with 3.5 mm LC DCP to be 17 weeks. However their study was based on closed fractures only and the fixation was by 3.5 mm LC DCP while this study is based on both open and closed fractures and the fixation was mainly by 3.5mm DCP. The union time in this study also concurs with the study by Wang et al., (2005) which found that 96% of patients achieved normal union in a mean of 20.2 weeks. However he selected only open fractures and the fixation method was by 3.5mm DCP.

Open reduction and internal fixation of fractures generally increases the time to fracture union due to disruption of the fracture hematoma, which is important for indirect bone healing. ORIF with DCP plate and screws provides absolute stability at the fracture site hence there is no callus formation and fracture union is determined radiographically by the gradual disappearance of the fracture line.

Ten patients (41%) had prescribed physiotherapy while 13 patients (59%) did not. This did not affect the functional outcome. This concurs with the opinion of Krischak et al., (2009) that prescribed physical therapy is not effective as home exercise programme.

**5.5 Functional outcome**

The mean DASH score at 6 months for non operative patients was 13.4 (SD 6.9), with a maximum score of 32.5 and a minimum of 5. The median score was 11.2 (IQR 7.5, 20). This can be interpreted that the majority of the patients who had their fractures united generally recovered their forearm functions with minimal disability. These results concur with the findings of Ogunlade et al., (2002), whereby their patients with distal radius fractures were treated by closed reduction and went on to regain good range of motion following wrist physiotherapy within 6 weeks after removal of the plaster cast. However, they did not use the DASH questionnaire in assessing the functional outcome.

The current results contrasts the opinion of Jayakumar and Jupiter, (2014) that non-operative treatment using closed reduction and cast immobilisation provides limited control and stability in these fractures.

The delayed union rates of 10% concur with the findings in other studies which found that aseptic non union rates in forearm fractures treated non-operatively ranges between 2% to 10% according to Boussakri et al., 2016. The mal-union rates of 12% also concur with other studies which found that healing occurs reliably after closed treatment of forearm fractures but mal-union, with resultant decreased rotation of the forearm, is common and has been associated with poor results, pain and instability of the distal radioulnar joint as documented by Goldfarb et al., 2005; and Jayakumar and Jupiter, 2014. Some of the patients in the current study had DASH score of 32.5 which could be attributed to mal-union or delayed union.

The mean DASH score at 6 months for the operative patients was 22.3 (SD 18.4) with a minimum of 4.2 and maximum of 60. The median score was 18.4 (IQR 5.8, 25). The patient who had a DASH score of 60 was the one treated with external fixator. This is interpreted as a mean disability of 22% six months after operative treatment of forearm fractures. These findings concur with the results of Droll et al., (2007) which found the mean DASH score after plating of both bone forearm fractures to be 18.6 with a range of 0 to 61. Their findings were specific to plating of both bones forearm fractures while this study is a mixture of all fixation methods though the majority were fixed by plating.

In comparing the DASH score for the non operative and the operative treatment methods of forearm fractures, the difference in median scores were used. The median score for those who were managed surgically was higher (18.4) compared to those who were managed non-operatively (11.2). Those who had non-operative treatment had 11% disability six months after treatment while those who had operative treatment had 18% disability six months after treatment. These findings were however not statistically significant (p-value >0.05).

The follow up period was also short and therefore those who underwent operative treatment may not have fully recovered forearm function or there was some residual pain. The non-operative group were also having simpler fracture patterns than the operative group.

Therefore a comparison of the functional outcome of the treatment used in both groups cannot provide an objective conclusion.

The DASH scores among the operative group in this study concur with the conclusions by Droll et al., (2007) in their study that stabilization with internal plate fixation following fracture of both bones of the forearm restores near normal anatomy and motion. They however noted that a moderate reduction in the strength of the forearm, the wrist, and grip should be expected following this injury. They also opined that the perceived disability as measured with the DASH and SF-36 questionnaires is determined by pain more than by objective physical impairment.

Open fractures had higher median DASH scores than closed fractures, though the difference was not statistically significant (p-value >0.05). This could be as a result of the open fractures being managed differently from closed fractures. There was also no statistical difference between DASH scores of the younger age groups of less than 51 years and the elderly of age more than 51 years.

This study cannot objectively comment on suitability of the use of intramedullary nailing of forearm fractures as there were only 2 patients who were treated with this method. However, locked intramedullary nailing of forearm fractures has been advocated by many authors due to its short operation time, less blood loss, shorter union time and less infection rates as documented by Gakuu, 2010; Lee Y. H. et al., 2008; Moerman et al., 1996; and Višńa et al., 2008.

# CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

Forearm fractures in adults were injuries seen at MTRH affecting all ages of the adult population and males were slightly more affected than females. These fractures were mainly caused by falls from heights, road traffic accidents and physical assaults. Majority of these fractures were closed fractures. Metaphyseal distal radius fracture was the commonest fracture pattern followed by diaphyseal radius fracture and both radius and ulna fractures. Treatment modality depended on the fracture pattern. A greater proportion of patients were treated non-operatively. Simple, closed non displaced fractures of one bone and distal radius fractures were managed non-operatively. The non-operative management resulted in good fracture union rates and good functional outcomes and minimal disability using the DASH scores in majority of the cases, though it had higher mal-union and delayed union rates. Open and more complex fractures were treated by open reduction and internal fixation. Plating with 3.5 mm Dynamic Compression Plate was the most common method of internal fixation of these fractures at MTRH. The operative management also resulted in good fracture union rates and good functional outcome and minimal disability using the DASH scores in majority of the patients.

## 6.2 Recommendations

Causes of forearm fractures should be documented as they help in determining the patterns of fractures. Safety measures on road transport, home environment and work place should be enhanced to reduce the risk of occurrence of these forearm fractures.

Careful selection of the patients for either form of treatment should be guided by the patterns of these forearm fractures.

Simple, closed, non-displaced fractures of one bone of the forearm and distal radius fractures can be definitively managed by closed reduction and casting though the surgeon is at liberty to operate on these fractures to prevent mal-union and delayed unions.

Complex, open and both bone fractures of the forearm require definitive management by open reduction and internal fixation.

The functional outcomes in this study are short term outcomes and therefore long term studies to assess long term clinical and functional outcomes of the treatment methods of these fractures are recommended.

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# APPENDICES

## APPENDIX 1: INTRODUCTION AND CONSENT

Hello. I am Dr. Emmanuel Oyier and am a student at Moi University School of Medicine. I am conducting a study on the forearm fractures in adults at MTRH to find out their causes, types and treatment outcomes. We hope to use this information to assist the hospital and doctors in general to decide on the best appropriate method of treatment of these fractures. I will compare the results of this research with other studies done elsewhere. I request your permission to be involved in this study. The study involves you getting the best treatment offered in this hospital for the forearm fracture thereafter you will be followed up at the orthopaedic clinic to find out the outcome of the treatment. You will be asked certain questions to determine whether you are able to use your forearm after the fracture.

Whatever information we gathered will be kept confidential and will not be shared with anyone except members of our study team. Your identity will not be revealed to others. Your participation in this study is entirely **voluntary** and you can stop me anytime for any clarification you might need or if uncomfortable to continue. However, I hope you will participate in this study to the end.

At this time, do you want to ask me anything about this study?

Consent:

I,______________________having been informed about this study to my satisfaction and all my questions and concerns having been addressed, do give consent to participate in the study.

Signed:_______________Date________________

Signature of interviewer:_______________________ Date: ________________

**APPENDIX 2: QUESTIONNAIRE**

Patient code……………………

PART A: SOCIAL DEMOGRAPHICS

1. Age:__________
2. Sex: [1] ○ Male [2] ○ Female
3. Marital status (*Choose one*): [1]Married ○ [2]Divorced ○ [3]Single ○[4] Widow(ed)○ [5] Separated ○
4. Level of Education (*choose one*):

   [1]○Primary [2]○Secondary[3]○Tertiary [4]○University [5]○ None

5. Occupation (*write down*):
6. Which hand is dominant? [1] Right [2] Left
7. Do you suffer from any other medical condition?

   [1] Yes [2] No If yes which condition (write down)

   ____________________

**PART B: CLINICAL AND RADIOLOGICAL PRESENTATION**

8. Side of the forearm fractured: [1] Right [2] Left [3] Both
9. What caused the fracture of the forearm?

   [1] Road Traffic Accident

   [2] Fall from a height

   [3] Physical Assault

   [4] Work related injury

   [5] Gunshot

[6] Others (*state*) ________________

10. How long ago did you sustain the fracture before seeking help in the hospital?

    [1] Hours to one day

    [2] 2 to 3 days

    [3] 4 to 7 days

    [4] More than 7 days

11. How did you reach MTRH:

    [1] Referred from another facility

    [2] First health care facility

12. If referred, from what level of health facility?

    [1] Private hospital

    [2] County Hospital

    [3] Sub County Hospital

    [4] Health Centre or dispensary

    [5] Others (state)_____________________

13. Was there a wound at the fracture site? [1] Yes [2] No. If yes, interviewer to answer question 14.

14. Gustilo Classification of the open fracture

    [1]□ I

    [2]□ II

    [3]□ IIIA

    [4]□ IIIB

[5] IIIC

15. (A). Which bones were fractured? ( interviewer to read the radiograph)

[1] Radius [2] Ulna [3] Both

(B) Presence of fracture dislocation [1] Galleazi [2] Monteggia [3] None

16. How are the fracture ends?

[1] Displaced [2] Non displaced

17. (A). What is the AO classification of the fracture(s): ( interviewer to read the radiograph and write down the result and interpret)

(B). Any other associated fractures in other parts of the body__________________

**PART C: TREATMENT AND FUNCTIONAL OUTCOME**

18. Initial treatment given:

    [1]○Analgesics [2]○ Tetanus Toxoid [3]○Antibiotics [4]○Debridement

    [5] Backslab [6]○ None

19. Definitive treatment given

    [1]○ Non operative in the form of plaster cast [2] ○ Operative fixation

    If [1], answer Q20 to 23. If [2], move to Q24

20. If non operative, how long did you stay with the plaster cast?

    [1]○ 6 weeks [2] 2 months [3] 3 months [4] more than 3 months

21. A.) Check radiograph at the time of removal of the cast, how is the fracture(s)?

    [1] United [2] Malunion [3] Non union [4] Other Complications (state) ________________

    B.) Interviewer to write down the time taken for fracture union in terms of weeks_________

22. In Q21 above, if [1], follow for 1 year then do the DASH questionnaire and write down the score, at the following intervals

    a) 3 months________________ b) 6 months__________________

    c) 9 months________________ d) 12 months_________________

23. Was Physiotherapy done

    [1] Yes [2] No

24. What was the indication for operative treatment? Interviewer to write down

25. How soon after the injury was the operation done?

    [1] Within 12 hours [2] 1 to 2 days [3] 3 to 10 days [4] After 10 days

26. What type of internal fixation was used? Interviewer to check operation notes

    [1] Intramedullary Nailing

    [2] Interlocking intramedullary nailing

    [3] 3.5mm Locking Compression Plate (LCP)

    [4] 3.5mm Limited Contact Dynamic Compression Plate (LC DCP)

    [5] 3.5mm Dynamic Compression Plate (DCP)

    [6] Others (specify) ___________________

27. Which surgical approach was used for plating? Interviewer to check operation notes

    [1] Ulnar approach

    [2] Volar approach of Henry

    [3] Dorsolateral Approach of Thompsons

    [4] Others (specify) ___________________

28. In closure of the wound, was the deep fascia sutured? Check operation notes

    [1] Yes [2] No [3] Not indicated

29. Post operatively, was plaster splint applied?

    [1] Yes [2] No

30. If Yes above, for how long

    [1] 2 weeks [2] 3 to 4 weeks [3] More than 4 weeks

31. A.) Check radiograph at 3 month follow-up, how is the fracture(s)?

    [1] United and aligned [2] Malunion [3] Delayed union [4] Other Complications (state) ________________

    B.) Interviewer to write down the time taken for fracture union in terms of weeks________________

32. If [1] above, follow up for 1 year then do a DASH questionnaire and write down the score, at the following intervals

    b) 3 months_______________ b) 6 months_________________

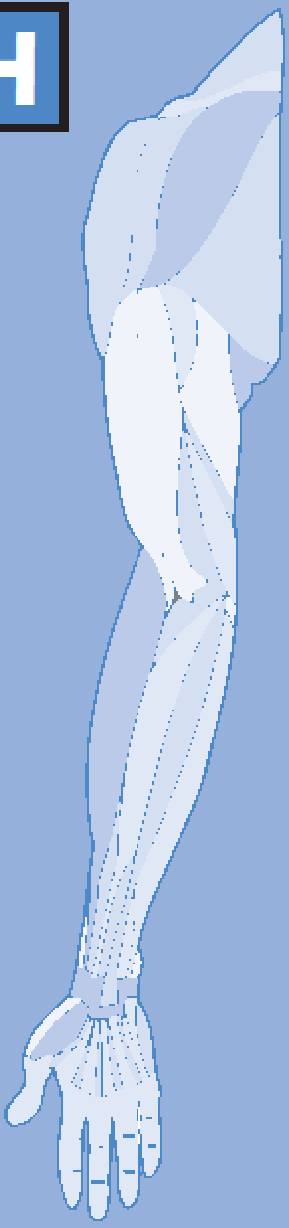
    d) 9 months_______________ d) 12 months______________

33. Was physiotherapy done [1] Yes [2] No

**APPENDIX 3: THE DASH QUESTIONNAIRE**

## Disabilities of the Arm, Shoulder and Hand

# THE DASH



**INSTRUCTIONS**

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer *every question*, based on your condition in the last week, by circling the appropriate number.

If you did not have the opportunity to perform an activity in the past week, please make your *best estimate* on which response would be the most accurate.

It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.

# Disabilities of the Arm, Shoulder and Hand

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. Open a tight or new jar. | 1 | 2 | 3 | 4 | 5 |
| 2. Write. | 1 | 2 | 3 | 4 | 5 |
| 3. Turn a key. | 1 | 2 | 3 | 4 | 5 |
| 4. Prepare a meal. | 1 | 2 | 3 | 4 | 5 |
| 5. Push open a heavy door. | 1 | 2 | 3 | 4 | 5 |
| 6. Place an object on a shelf above your head. | 1 | 2 | 3 | 4 | 5 |
| 7. Do heavy household chores (e.g., wash walls, wash floors). | 1 | 2 | 3 | 4 | 5 |
| 8. Garden or do yard work. | 1 | 2 | 3 | 4 | 5 |
| 9. Make a bed. | 1 | 2 | 3 | 4 | 5 |
| 10. Carry a shopping bag or briefcase. | 1 | 2 | 3 | 4 | 5 |
| 11. Carry a heavy object (over 10 lbs). | 1 | 2 | 3 | 4 | 5 |
| 12. Change a lightbulb overhead. | 1 | 2 | 3 | 4 | 5 |
| 13. Wash or blow dry your hair. | 1 | 2 | 3 | 4 | 5 |
| 14. Wash your back. | 1 | 2 | 3 | 4 | 5 |
| 15. Put on a pullover sweater. | 1 | 2 | 3 | 4 | 5 |
| 16. Use a knife to cut food. | 1 | 2 | 3 | 4 | 5 |
| 17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.). | 1 | 2 | 3 | 4 | 5 |
| 18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.). | 1 | 2 | 3 | 4 | 5 |
| 19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.). | 1 | 2 | 3 | 4 | 5 |
| 20. Manage transportation needs (getting from one place to another). | 1 | 2 | 3 | 4 | 5 |
| 21. Sexual activities. | 1 | 2 | 3 | 4 | 5 |

# DISABILITIES OF THE ARM, SHOULDER AND HAND

| | NOT AT ALL | SLIGHTLY | MODERATELY | QUITE A BIT | EXTREMELY |
|---|---|---|---|---|---|
| 22. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

| | NOT LIMITED AT ALL | SLIGHTLY LIMITED | MODERATELY LIMITED | VERY LIMITED | UNABLE |
|---|---|---|---|---|---|
| 23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

Please rate the severity of the following symptoms in the last week. *(circle number)*

| | NONE | MILD | MODERATE | SEVERE | EXTREME |
|---|---|---|---|---|---|
| 24. Arm, shoulder or hand pain. | 1 | 2 | 3 | 4 | 5 |
| 25. Arm, shoulder or hand pain when you performed any specific activity. | 1 | 2 | 3 | 4 | 5 |
| 26. Tingling (pins and needles) in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |
| 27. Weakness in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |
| 28. Stiffness in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | SO MUCH DIFFICULTY THAT I CAN'T SLEEP |
|---|---|---|---|---|---|
| 29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

| | STRONGLY DISAGREE | DISAGREE | NEITHER AGREE NOR DISAGREE | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| 30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. *(circle number)* | 1 | 2 | 3 | 4 | 5 |

**DASH DISABILITY/SYMPTOM SCORE** = [(sum of n responses) - 1] x 25, where n is equal to the number of completed responses.
n

**A DASH score may not be calculated if there are greater than 3 missing items.**

# DISABILITIES OF THE ARM, SHOULDER AND HAND

## WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including home-making if that is your main work role).

Please indicate what your job/work is:________________________

❒ I do not work. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. using your usual technique for your work? | 1 | 2 | 3 | 4 | 5 |
| 2. doing your usual work because of arm, shoulder or hand pain? | 1 | 2 | 3 | 4 | 5 |
| 3. doing your work as well as you would like? | 1 | 2 | 3 | 4 | 5 |
| 4. spending your usual amount of time doing your work? | 1 | 2 | 3 | 4 | 5 |

## SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing *your musical instrument or sport or both*. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you:________________________

❑ I do not play a sport or an instrument. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. using your usual technique for playing your instrument or sport? | 1 | 2 | 3 | 4 | 5 |
| 2. playing your musical instrument or sport because of arm, shoulder or hand pain? | 1 | 2 | 3 | 4 | 5 |
| 3. playing your musical instrument or sport as well as you would like? | 1 | 2 | 3 | 4 | 5 |
| 4. spending your usual amount of time practising or playing your instrument or sport? | 1 | 2 | 3 | 4 | 5 |

**SCORING THE OPTIONAL MODULES:** Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.
**An optional module score may not be calculated if there are any missing items.**

Institute for Work & Health | Research Excellence Advancing Employee Health

# APPENDIX 4: MULLER AO CLASSIFICATION OF LONG BONE FRACTURES


Diagram showing the AO/OTA classification of diaphyseal fractures of the radius and ulna (reproduced from Müller AO Classification of Fractures/Long Bones Edition 2004)

## APPENDIX 5A: IREC APPROVAL

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET

12th August, 2014

Reference: IREC/2014/144
***Approval Number: 0001236***

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
12 AUG 2014
APPROVED
P. O. Box 4606-30100 ELDORET

Dr. Emmanuel Odhiambo Oyier,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Dr. Odhiambo,

**RE: FORMAL APPROVAL**

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

***"Patterns of Fore-Arm Fractures in Adults and their Treatment Outcomes at Moi Teaching and Referral Hospital."***

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 1236*** on 12th August, 2014. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 11th August, 2015. 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.

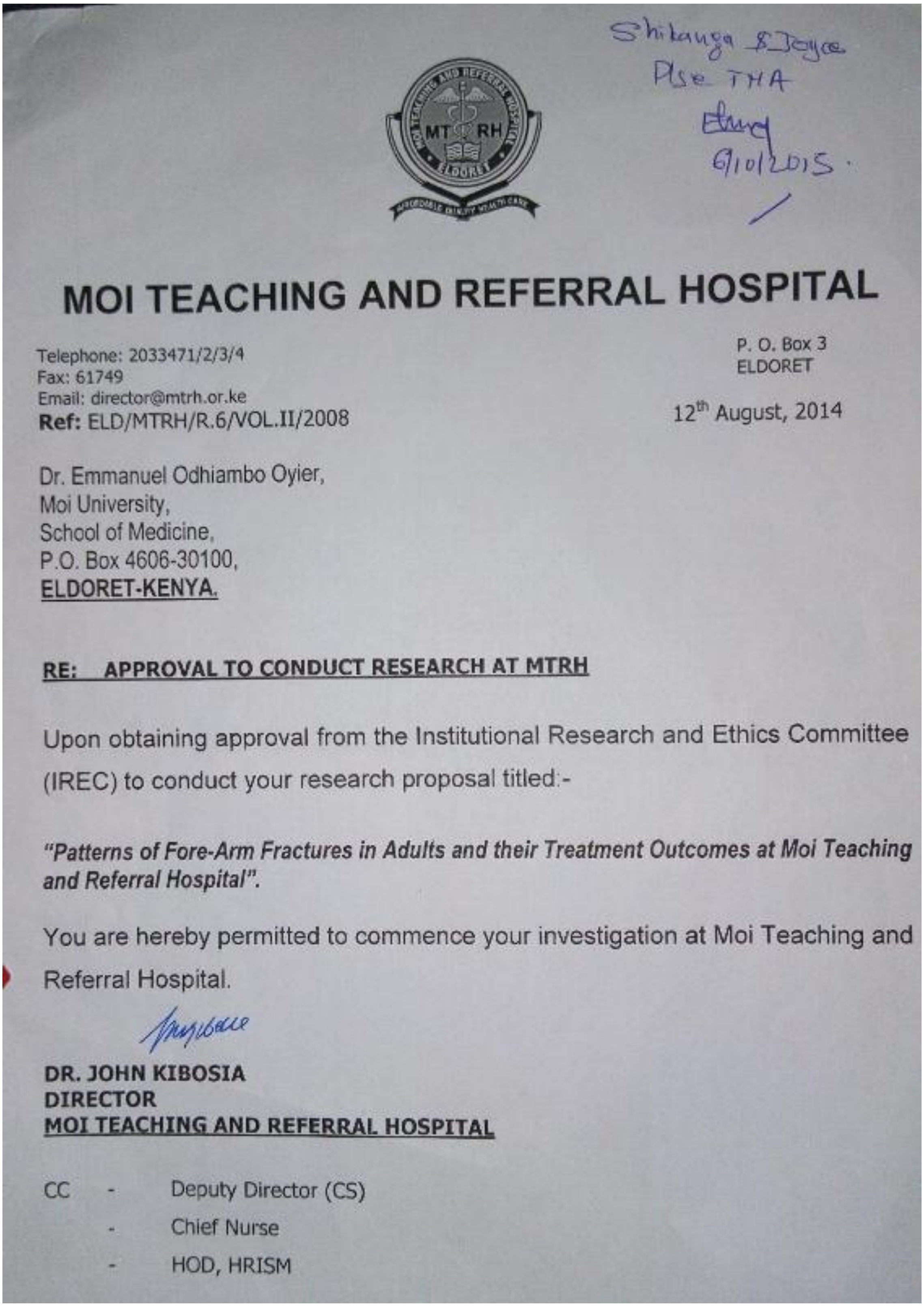
You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects 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 - | SOP | Dean - | SOM |
| | Principal - | CHS | Dean - | SON | Dean - | SOD |

**APPENDIX 5B: MTRH APPROVAL**



Shikanga & Joyce
Pls THA
6/10/2015

# 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

12th August, 2014

Dr. Emmanuel Odhiambo Oyier,
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:-

***"Patterns of Fore-Arm Fractures in Adults and their Treatment Outcomes at Moi Teaching and Referral Hospital".***

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

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

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

## APPENDIX 6: RESEARCH BUDGET

| ITEM | COST (Ksh) |
|---|---|
| Research assistant | 20,000.00 |
| Biostatistician | 30,000.00 |
| Stationery and Printing costs | 40,000.00 |
| Mobile Phone Airtime | 10,000.00 |
| **SUBTOTAL** | **100,000.00** |
| Contingency(10% subtotal) | 10,000.00 |
| **TOTAL** | **110,000.00** |

**APPENDIX 7: WORKPLAN**

| ACTIVITY | TIME FRAME |
|---|---|
| Writing research proposal and defence of the proposal at departmental level. | January 2014 – June 2014 |
| Submitting research proposal to IREC for approval. | July 2014 |
| Pilot study and submission of questionnaire alterations to IREC for approval. | November 2014 – December 2014 |
| Data collection, editing and entry into MS Excel. | January 2015- December 2015 |
| Follow up of patients for DASH scoring at 6 months. | January 2016- June 2016 |
| Data analysis using STATA version 13. | July 2016- December 2016 |
| Thesis writing. | January 2017- April 2017 |
| Mock defence of thesis at departmental level. | May 2017- June 2017 |
| Corrections and finalizing the thesis. | July 2017- August 2017 |
| Submission of thesis abstract and letter of intent to defend thesis. | September 2017 |
| Submission of thesis book for marking. | October 2017 |
| Thesis oral defence. | August 2018 |
| Submission of corrected thesis for re-marking. | November 2018 |
| Final submission of thesis book for binding. | January 2019 |
| Final end of Part II Exams. | March 2019 |