CHARACTERISTICS AND TREATMENT OUTCOMES OF FOREARM SHAFT FRACTURES AMONG PAEDIATRIC 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, MOI UNIVERSITY, SCHOOL OF MEDICINE

DECLARATION

CANDIDATE'S DECLARATION

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DEDICATION

This work is dedicated to Mr. Ali Issack Ibrahim and Mrs. Asli Arale Ibrahim whose love and support have given me strength all through life.

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ABBREVIATION AND ACRONYMS

AMPATH Academic Model Providing Access to Healthcare

CRPP Close reduction and percutaneous pinning

ESIN Elastic Stable Intramedullary Nailing

HRIS Health records and information system

IM Intramedullary

IREC Institutional Research and Ethics Committee

K-WIRE Kirschner wire

KMTC Kenya Medical Training College

MMED Masters of Medicine

MS Microsoft

MTRH Moi Teaching and Referral Hospital

PI Principal Investigator

R.O.M Range of motion

UGCH Uasin-Gishu county Hospital

USAID United State Agency for International Development

DEFINITION OF KEY TERMS

CHARACTERISTICS	Distinguishing features or qualities. This includes age, gender, mechanisms of injury, hand dominance, fractured forearm and fracture patterns.
FOREARM	The segment of the upper limb between the elbow and the wrist.
FRACTURE	A break in continuity of a bone.
OUTCOME	The condition of a patient at the end of the treatment in terms of elbow and the wrist range of motion and forearm rotations (i.e. pronation and supination).
PAEDIATRIC	Persons of age fourteen years and below according to skeletal maturity.
SHAFT	A long slender part, such as the diaphysis of a long bone.
TREATMENT	Refers To the Operative and Non Operative Intervention Offered.

ABSTRACT

Background: Paediatric diaphyseal fractures of the radius and ulna are the third most common fractures in the paediatric population, accounting for 13-40% of all paediatric fractures. Treatment of paediatric forearm shaft fractures in most cases is by closed reduction and immobilization with favourable outcome. Published studies on the characteristics and treatment outcomes of paediatric forearm shaft fractures are scarce regionally.

Objective: To describe the characteristics and treatment outcomes of paediatric forearm shaft fractures at Moi Teaching and Referral Hospital (MTRH).

Methods: This was a prospective descriptive study conducted at Moi Teaching and Referral Hospital from August 2018 to July 2019. All patients aged fourteen years and below diagnosed with forearm shaft fractures were recruited after obtaining consent. Approval was obtained from Institutional Research and Ethics Committee; and from Moi Teaching and Referral Hospital. A total of 121 children participated in the study. Data on socio-demographics, fracture pattern, treatment and outcome were collected using interviewer based questionnaire. Follow up was done at 4,8,12 and 24 weeks. Descriptive statistics including frequencies and percentages were used for categorical variables while measures of central tendency and measures of spread were used for continuous variables. Chi-square and Fisher's exact tests were used to assess the association between categorical variables. The quality of initial reduction was assessed as anatomical, good, fair and poor reduction using Asadollahi *et al.,* 2017 criteria. Clinical outcome was determined as excellent, fair and poor using Flynn *et al.,* 2010 criteria.

Results: The mean age of the participants was 8.6 years (SD=4.7) with a range of 1 and 14 years. Males were more commonly affected than females (65% vs35%). The most common mechanism of injury for patients aged 1-5 years and 5- 10 years was a fall and was at 77.4% and 63.8% respectively, while sports (77.4%) was the commonest cause of injury for children aged 10-14 years (p-value <0.001). Most children had greenstick fractures (67.8%) and the distal third of the radius/ulna shaft was the commonest site of fracture (53.7%). Ninety three percent of the patient had anatomical/good reduction on the initial post-reduction radiograph and were managed non-operatively using sugar-tong splint. Seven percent of the patient had fair/poor reduction on initial post-reduction radiograph and developed re-displacement on follow up and were operated. Percutaneous intramedullary K-wiring was the operative method used. Re-displacement occurred in 6.6% of patients after closed reduction and immobilization. Following non-operative treatment, 98.2% of the patients had an excellent result and 1.8% had fair result (p-value <0.002). In the operated cases, 62.5% were done closed reduction and percutaneous pinning and had an excellent outcome, while 37.5% were done open reduction and percutaneous pinning and had fair outcome.

Conclusion: Males were more commonly affected than females. Fall was the commonest mechanism of injury. Non-operative management using sugar-tong splint was effective treatment for forearm shaft fractures in children. A non-anatomical alignment on the initial post-reduction radiograph was a high risk factor for re-displacement.

Recommendation: Non-operative management of forearm shaft fractures is recommended. Further study is needed on factors contributing to re-displacement of forearm shaft fractures in children managed conservatively.

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CHAPTER ONE

1.0 INTRODUCTION

This chapter covers the background to the study, the statement of the problem, objectives of the study, research questions, conceptual framework and the significance of the study.

1.1 Background to the study

Musculoskeletal injuries in children and adolescents are an important clinical and economical problem (Grabala, 2015). Trauma in children comes only second to acute infection responsible for morbidity in children, with an annual cost of over £200 million per year in UK (Marsh & Kendrick, 1999). Children have a unique profile of risks for injuries because they are unable to recognize and avoid many potential risks on their own (Gome, Mutiso, & Kimende, 2005).

Fractures are associated with 10% to 25% of the childhood injuries (Landin, 1983), where the lifetime fracture risk is up to 40% for girls and as high as up to 64% for boys (Cooper, Dennison, Leufkens, Bishop, & van Staa, 2004). Approximately 40% of girls and 50% of boys experience a fracture sometime in Childhood and adolescence (Kalkwarf, Laor, & Bean, 2011). Paediatric diaphyseal fractures of the radius and ulna, commonly referred to as both bone forearm fractures, are the third most common fracture in the paediatric population and account for 13-40% of all paediatric fractures (Vopat et al., 2014).

In addition to the acute consequences of these injuries, including pain and functional limitation, forearm fractures are unique injuries that may have longer-term implications (Arora, Fichadia, Hartwig, & Kannikeswaran, 2014).

Paediatric forearm fractures are increasing in incidence and result in substantial health care costs (Arora et al., 2014). Of concern, the incidence of forearm fractures has increased over the last 30 years by 42% (Kalkwarf et al., 2011). Most paediatric forearm Shaft fractures are treated by closed reduction with good results. Therefore, operative reduction and stabilization are rarely necessary. The indication for surgical intervention in paediatric forearm fractures include (1) open fractures; (2) fractures shortly before skeletal maturity; (3) irreducible fractures, with or without soft-tissue interposition; (4) unstable fractures after reduction; and (5) Monteggia fractures with an unstable radial head and residual ulna angulations. Several different techniques are available, including pins and plaster, open reduction and internal fixation with plates, and closed intramedullary nailing of one or both bones. The aim of this study is to review and audit the pattern of paediatric forearm shaft fractures, their management and outcome in a local setting.

1.2 Problem Statement

Children with forearm shaft fractures are not rare at Moi Teaching and Referral Hospital (MTRH), Eldoret. They either come directly (non-referral) or as referrals, shortly or long after various forms of trauma. Paediatric patients with forearm shaft fractures seen at MTRH in the year 2017 were one hundred and fifty. Forearm shaft fractures are one of the few paediatric fractures prone to complications such as re-displacement, loss of forearm rotation, compartment syndrome and delayed healing regardless of the type of treatment. There is paucity of data on paediatric forearm shaft fractures regionally and locally.

1.3 Justification

MTRH serves a vast geographical catchment area, mainly the western region of Kenya with a high demand for trauma care and a significant proportion of these trauma victims are paediatrics.

Cause-specific data for paediatric forearm shaft fractures is lacking in Kenya; therefore, paediatric forearm fractures prevention efforts do not receive an appropriate level of resources, hence the need for this research to give highlights on the causes of forearm fractures in children at MTRH.

The vast majority of forearm shaft fractures in children are managed conservatively. However, the results are not always satisfactory and it is important to assess the role of modifiable factors in order to prevent treatment failures and complications, and to ensure good functional recovery.

The importance of analyzing the aetiology of injuries, and the circumstances and settings in which they occur in the various stages of development is to identify risky behaviours or an unsafe environment, which can be corrected by specific preventive measures appropriate for age.

Similar study has never been conducted in this health institution. The study results will provide basis for planning of prevention strategies and establishment of treatment protocols.

1.4 Research Question

What are the characteristics and treatment outcomes of forearm shaft fractures among paediatric patients at MTRH?

1.5 Objectives

1.5.1 Broad Objective

To describe the characteristics and treatment outcomes of forearm shaft fractures among paediatric patients at MTRH.

1.5.2 Specific Objectives

1. To describe the characteristics of forearm shaft fractures in paediatric patients as seen at MTRH.
2. To describe the treatment options of forearm shaft fractures in paediatric patients at MTRH.
3. To describe the treatment outcomes of paediatric forearm shaft fractures at MTRH.

1.6 Conceptual Framework

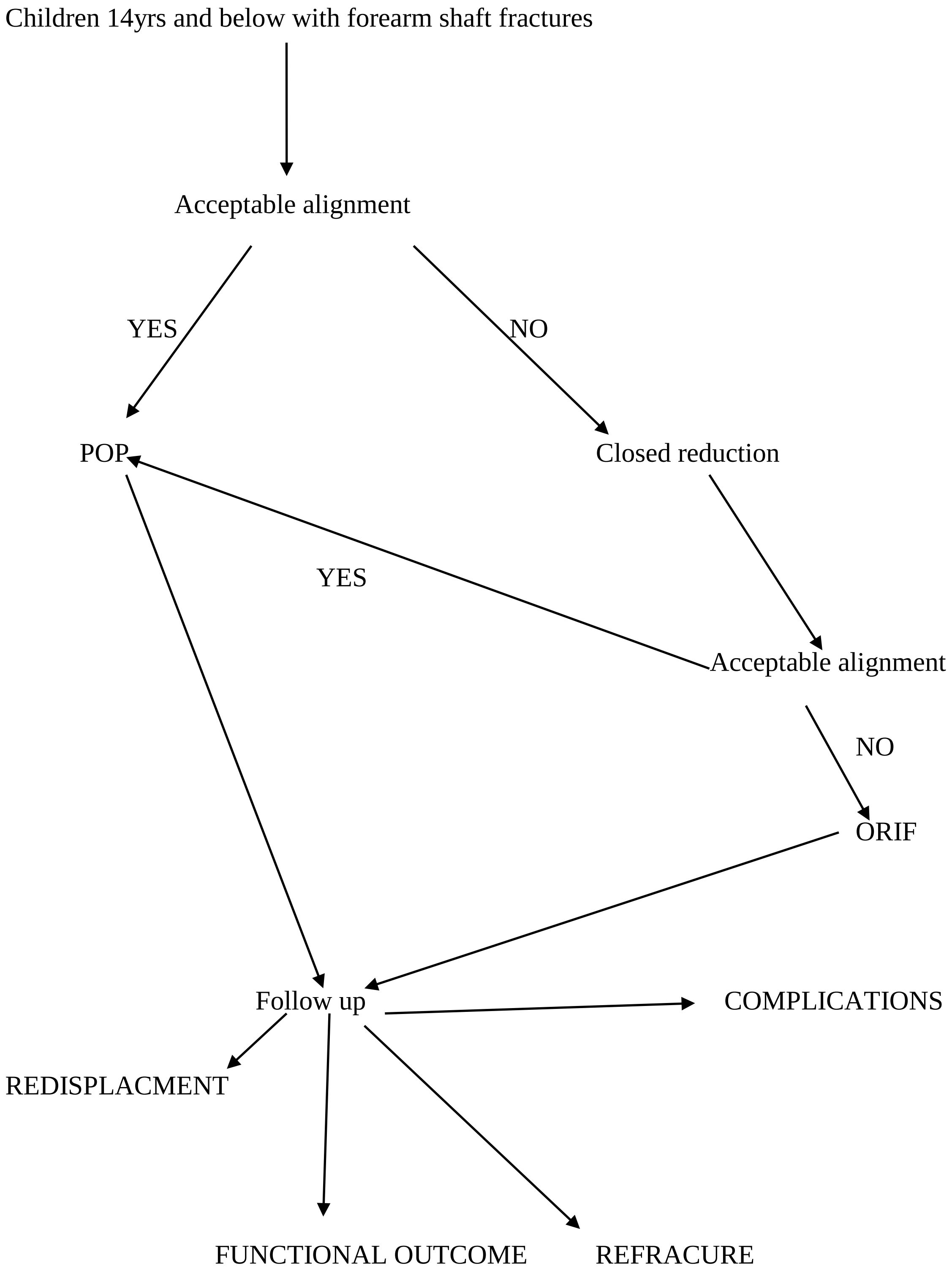

Figure 1: conceptual framework (source: candidate, 2017).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter covers patient's characteristics, which attempt to explain the determinants, occurrences and distribution of health and diseases in a population. It also covers the treatment and outcome details of children with forearm shaft fractures.

2.2 Overview of forearm shaft fractures

2.21 Anatomy and Fracture

The forearm is the part of the upper limb between the wrist and the elbow. It is made up of two bones: the radius and the ulna. Fractures of the forearm are common orthopaedic injuries in children accounting for 30% to 50% of all paediatric fractures. About 18% of all forearm fractures occur in the shaft of the radius and the ulna (Guitton, Dijk, Raaymakers, & Ring, 2010). Diaphyseal forearm fractures are among the most common injuries treated in children (Antabak et al., 2013). Paediatric forearm fractures are increasing in incidence and result in substantial health care costs (Ryan et al., 2012).

A fracture of the forearm is an acute painful condition requiring pain relief and plaster cast splintage. Pain reduces gradually over the course of two weeks. Splintage also helps to prevent increasing deformity while the fracture unites. Once fracture union occurs and motion at the fracture site ceases, splintage can be discontinued and function of the forearm is gradually restored. In addition to the acute consequences of these injuries, including pain and functional limitation, forearm fractures are unique injuries that may have longer-term implications (Ryan et al., 2012).

Diaphyseal or shaft fractures of the radius and ulna are defined as those occurring between the proximal (upper) and distal (lower) metaphyses of each bone. Metaphyses are the diverging areas of bone between the diaphysis (shaft) and the physes (growth plates).

A commonly used method to classify diaphyseal forearm fractures in children is the descriptive, labelling into:

1. Bone - single, i.e. radius or ulna;
2. Level of fracture - upper, mid or lower third; and
3. Pattern of fracture
    - a. Plastic deformation (the bone bends but does not break).
    - b. Greenstick (one side of the bone is broken while the other is bent.
    - c. Complete and comminuted (crushed into several pieces).

In the forearm, either both bones or one bone and one radio-ulna joint (Monteggia and Galeazzi lesions) are typically injured. Isolated fractures are relatively uncommon. Therefore, single-bone fractures should always raise suspicion regarding additional injury to the proximal or distal radio-ulna joint (Guitton et al., 2010).

They are unique and they differ from fractures of any other long bones. They are one of the few paediatric fractures that show a real risk of complications and prolonged morbidity (Landin, 1983).

2.2.2 Functional Anatomy

The human forearm is comprised of two bones: the ulna, medially, and the radius, laterally. Bridging the ulna and radius is an interosseous membrane that transmits forces from ulna to radius and vice versa.

The ulna is a relatively straight bone around which the curved radius rotates during pronation and supination. The axis of rotation passes obliquely from the distal ulna head to the proximal radial head. The two bones are stabilized distally and proximally by the triangular fibrocartilage complex and the annular ligament, respectively. Further stabilization is provided by the interosseous membrane, with oblique fibres passing distally from the radius to the ulna; these fibres are somewhat relaxed in supination and tighter in pronation (Noonan & Price, 1998).

The pronator quadratus (distally) and pronator teres (inserting on the middle portion of the radius) actively pronate the forearm, while the biceps and supinator (proximal insertions) provide supination. The insertions of these four muscles can partially account for fragment position in complete fractures (Noonan & price, 1998).

In distal-third fractures, the proximal fragment will be in neutral to slight supination, and the weight of the hand combined with the pronator quadratus tends to pronate the distal fragment. In proximal-third fractures, the distal fragment is pronated, and the proximal fragment is supinated. Mid-shaft fractures tend to leave both fragments in a neutral position with the distal fragment slightly pronated and the proximal fragment slightly supinated (Noonan & Price, 1998).

The forearm flexes and extends at the elbow, with the articulation of the ulna with humerus at the trochlear notch. The head of the radius also articulates with the humerus at the capitulum, allowing the forearm to pronate and supinate. Pronation and supination also require an intact distal radio-ulnar joint.

The median, ulna, and radial nerve course along the forearm, along with the radial and ulna arteries. The ulna and radial nerves are located most medially and laterally, respectively, thus they are most susceptible to damage with fracture of the shaft of their adjacent bones.

The extrinsic muscles of the hand originate in the forearm (and elbow) and therefore forearm fractures, if not treated properly, can also lead to hand dysfunction. The course of the muscles, likewise, may create deforming forces on the injured bones: for example, the flexor muscles of the fingers and wrist tend to produce dorsal bowing of the radius and ulna, by flexing distal fragments (Noonan & Price, 1998).

Several anatomic differences distinguish paediatric forearms from those of adults. The paediatric radial and ulna shafts are proportionately smaller, with narrow medullary canals, and the metaphysis contains more trabecular bone. In addition, the periosteum in children is much thicker than that in adults; this feature can both hinder and help in the management of paediatric fractures (Noonan & Price, 1998).

2.2.3 Bone Remodelling

In children, a deformed bone can remodel with growth over time. This remodelling potential is greatest in children under the age of five, where remodelling up to 30 degrees of deformity in the forearm is possible. The potential for bone remodelling is considerably reduced in older children, especially as they approach skeletal maturity. The extent of deformity and anticipated capacity for remodelling are likely to influence the treatment decisions (Noonan & Price, 1998).

2.3 Characteristic of Forearm Shaft Fractures

2.3.1 Incidence

The incidence of forearm fractures is 7.8/1000/year. A higher incidence of fractures is found in boys than in girls (boys 66%, girls 34%) (Grabala, 2015). The incidence of all both-bone forearm shaft fractures (proximal, middle and distal) increased 3.1 fold (95% confidence interval (CI) 1.7 to 5.9, $P<0.001$) in 13 years, between 1997 and 2009 ($p<0.001$) (Sinikumpu, Pokka & Serlo, 2013). Forearm fracture incidence peaks between ages 9–12 years in girls and 11–14 years in boys (Kalkwarf et al., 2011).

2.3.2 Age

The age distribution of these fractures is bimodal; the peak incidence occurs between ages 10-14, coinciding with the adolescent growth spurt, with a second smaller peak incidence between 5-9 years of age (Vopat et al., 2014).

The incidence of the forearm fractures goes up over the age of 2 years, which is associated with the increasing physical activity and the peak of the forearm fractures coincides with the period of maturation (Grabala, 2015). Bone quality changes as children progress into puberty and a differential vulnerability to fracture is present that is related to bone characteristics in prepubescent versus peri-pubescent populations (Ryan et al., 2012).

The difference in timing of the peak incidence for boys and girls reflects differences in growth between the sexes. The peak incidence coincides with the pubertal growth spurt, when there is a relative decrease in bone mineral density due to bone expansion and insufficient mineralization (Hedström, Svensson, Bergström, & Michno, 2010).

The fracture risk rises to a peak in the age-group 10-12 in girls and 12-14 in boys. After the age of 14, fractures were 3.5 times more frequent in boys than in girls (Kramhøft & Bødtker, 1988).

2.3.3 Sex-Specific Incidence

Forearm fractures are statistically significantly more common in boys than in girls (Hassan, 2008). The sex-specific incidence is 74 (CI: 65–83) and 43 (CI: 36–50) for boys and girls, respectively; with an incidence ratio of 1.7 (CI: 1.4–2.1) (Hedström et al., 2010) hence the proportion of forearm shaft fractures is nearly twice higher in boys (boys=62%, girls=38%) (Grabala, 2015). The increase of fractures in boys is attributed to their usual activities outside the home; thus, they are more prone to injury (Hassan, 2008).

2.3.4 Fracture Pattern

In children younger than 10 years of age, buckle and greenstick fractures occur most frequently, whereas growth plate and complete fractures are more likely in patients older than 10 years of age and adolescents, respectively (Arora et al., 2014). Plastic deformations of diaphyseal fractures of the forearm occur in children aged up to 10 years of age and are frequently missed (Madhuri, Gahukamble, Dutt, & Tharyan, 2013). Torus and greenstick fractures dominate up to 12 years. This might be due to the relatively strong periosteum in this age-group (Landin, 1983). A typical type of the forearm fracture is greenstick among younger children and complete or short oblique fractures in older children. Comminuted fractures or bowing fractures are unusual (Grabala, 2015).

Fracture dislocations of the forearm can also happen, in which there is a fracture with shortening of one of the two bones with dislocation of the other bone. Monteggia fracture comprises radial head dislocation plus proximal ulna fracture or plastic deformation of the ulna without obvious fracture. Galeazzi fracture is a relatively rare injury characterized by fracture of the distal radial shaft with disruption of the distal radio-ulna joint (Arora, et al., 2014).

Forearm shaft fractures involving both bone forms the most common type, followed by isolated shaft radius fracture and isolated shaft ulna fracture is found to be rarest of forearm fractures (Bochang, et al., 2005). Isolated shaft radius fractures (63.3%) form the most common fracture type, whereas isolated fracture of the shaft of the ulna (3%) is found to be the rarest of forearm fractures (Grabala, 2015).

Forearm shaft fractures involve both the radius and the ulna in most cases. A direct blow, for example, in connection with traffic injury may lead to an isolated single-bone fracture (Grabala, 2015).

Fractures of both bones of the forearm are mostly distal in location (Arora et al., 2014). The distal third of the radius and ulna shaft was the commonest site of fracture, followed by the middle third and proximal third was rarest site (Alrashedan et al., 2018). In another study by Sinikumpu & Serlo, (2015), middle third of the radius and ulna shaft was the commonest site of fracture, followed by distal third and proximal third shaft was the rarest.

2.3.5 Mechanism

Forearm shaft consists mostly of cortical bone, which means that it is strong and requires great trauma energy to damage compared with the metaphysis (Sinikumpu &Serlo, 2015). The most common mechanism is a fall (83%) while direct trauma is a distant second (10%) (Vopat et al., 2014). Road Traffic Accidents (56%) is found to be most common mechanism of forearm shaft fractures followed by fall on outstretched hands (23%), (14%) cases of Assaults, and 4 (7%) cases of Sports injuries (Mastan Basha et al., 2015).

About 72% of fractures of the forearm shaft were caused by falls (Hedström et al., 2010); Falls between planes are most common in the first years of life, with a marked decline after the age of 12. During the first years of life, falls between planes accounted for 54% of all fractures (Hedström et al., 2010). Fall-related injuries were more common in younger children than in older children, whereas direct hit injuries were more common in children>12 years old than in children <12 years old, and this difference was statistically significant ($p < 0.001$) (Alrashedan, et al., 2018).

During the first years of life, children undergo dramatic developments in motor skills. In their explorations, they tend to fall off furniture and staircases in the first year of life, whereas pre-adolescence children fall off playground equipment, bikes, and other structures (Hedström et al., 2010). Typically, a child protects himself/herself by an outstretched upper extremity when falling (Grabala, 2015). In that moment, the hand is usually pronated, which leads to rapid supination of the forearm during landing.

Lack of supervision, inadequate safety standards for household furniture and goods, limited access to safe play areas, and uneven walking surfaces are reported as risk factors for childhood falls in developing countries (Halawa, Barakat, Rizk, & Moawad, 2015).

2.3.6 Activity

Sport (68%) is revealed to be the most common activity causing forearm fractures, particularly football that is associated with the largest number of forearm fractures (27%) (Grabala, 2015). Sport and play contributed to the most fracture events: 39% and

37%, respectively. Play dominates as the activity at injury during the first decade of life, whereas sport was the predominant activity in teenagers (Hedström, et al., 2010).

The risk of sport injuries in girls is approximately half of that in boys with a decreasing tendency in the oldest age groups (Landin, 1983).

2.3.7 Location of Fracture Occurrence

The site of injury occurrence varies with the age of the child. Overall, 28 percent of the injuries occur in the child's home or yard, with the highest proportion of injuries in the home in young children (60.3%). In contrast, the majority of injuries in the oldest age group occur in school or the schoolyard (25.6%), the street (14.2%) or the athletic field (30.2%) (Rivara, Calonge, & Thompson, 1989).

Fractures most frequently occur in homes (41.6%), followed by playgrounds and footpaths (26.2%), sports facilities (18.3%), and educational facilities (13.9%) (Valerio et al., 2010).

The low awareness of fracture prevention in the home in developing countries may contribute to this finding (Saw, Fadzilah, Nawar, & Chua, 2011). Many falls / Fractures happened on cement floor compared to any other types of floorings (Saw et al., 2011).

Younger children are also more likely to be injured at home whereas older children were more likely to be injured on the road or at school (Kiser et al., 2012).

In males the percentage of fractures occurring in the home significantly decreases with age, while the percentage of fractures occurring in educational facilities, playgrounds and footpaths, or in sports facilities increases. In females the home represents the most frequent location at any age, while fractures in the playground and footpath or sports facility significantly decreases with age (Valerio et al., 2010).

2.3.8 Side Preponderance

Fractures in the upper extremity are in the majority of cases affecting the left side, possibly because the right arm is otherwise occupied (Landin, 1983). Fractures in the left upper extremity are almost twice as common as in the right upper extremity (42% versus 25%). By contrast, fractures encountered in the lower limbs are more commonly on the right than left side (21% versus 12%) (Tandon, Shaik, & Modi, 2007). Forearm fractures are more common in the non-dominant hand in right-handed children (58.27%), and more common in the dominant hand in left-handed children (66.66%) (Hassan, 2008). In a study by Bochang et al., (2005) found out that forearm shaft fractures were common on the right forearm than left forearm.

2.4 Treatment

The primary goal of fracture treatment is to restore normal radio-ulna length, to re-establish muscle length, to restore rotational alignment that is essential for forearm rotation, and to restore the normal radial bow.

The gold standard treatment for paediatric forearm fractures remains closed reduction and casting. Given the excellent remodelling potential with younger patients, certain studies have argued that even with 100% displacement of the radius and ulna closed reduction and casting is an excellent treatment choice for children 9 years old and younger (Vopat et al., 2014). In roughly 70–90 % of cases, closed reduction leads to adequate alignment (Truntzer et al., 2015). Anatomic reduction is usually not required for paediatric forearm fractures due to the potential for growth and remodelling (Noonan & Price, 1998).

Closed reduction is indicated in patients' ages 0 to 8 with fracture angulations of greater than 10 degrees and rotation greater than 30 degrees. In patients with angulations less than 10 degrees and rotation less than 30 degrees, splinting without reduction is acceptable (Vopat et al., 2014).

Incomplete greenstick and bowing fractures will be reduced closed without traction (Sinikumpu & Serlo, 2015). There is a general consensus that greenstick and undisplaced fractures in children should be managed conservatively. In the greenstick fracture, where one cortex is broken and the opposite cortex is bent, the surgeon may purposefully complete the break as this may decrease the tendency for the fracture to deform (Madhuri et al., 2013).

Complete fractures require sustained traction to overcome muscle spasm and to correct possible shortening. In the unstable fractures, traction itself may also result in spontaneous reduction of possible rotational malformation (Sinikumpu & Serlo, 2015).

After achieving good alignment, a long-arm cast over elbow-in-flexion is recommended (Sinikumpu & Serlo, 2015). Post reduction, patients should be followed weekly for the first two to three weeks to ensure reduction is maintained (Vopat et al., 2014).

After a closed reduction or after an open reduction and plate osteosynthesis, an above elbow cast should be maintained for 4-6 weeks. With the cast on, finger movements should be encouraged (Mulligan & Barry, 2015).

There is debate on the degree of rotation of the forearm that is required for immobilisation after reduction of forearm fractures. Distal radius fractures are usually immobilised in the prone position, whereas proximal radius fractures are generally immobilised in the supine position. Less commonly, proximal forearm fractures are immobilised in a cast extending above the elbow, with the elbow in extension (Madhuri et al., 2013).

Usually, all the fractures in the proximal third can be immobilized in the supination position, those in the middle third in the neutral position and fractures in the distal third in pronation (Sinikumpu & Serlo, 2015). After 3 weeks, the above elbow cast may be converted into a below-elbow cast to improve cast comfort in cases with non-reduced fractures without increasing the risk of re-displacement (Sinikumpu & Serlo, 2015).

Immobilisation of forearm fractures with the elbow extended produced better results than with the elbow flexed (Bochang C et al., 2005). The application of a plaster cast with the elbow extended is easy and, provides better mechanical immobilisation of the fracture, thereby avoiding re-displacement (Bochang C et al., 2005). Immobilisation with either an extended or flexed elbow interfered with daily activities and children in both groups require help with eating and dressing, and none could write a sentence easily (Bochang C et al., 2005).

Most paediatric forearm fractures are treated by closed reduction with good results, operative reduction and stabilization are rarely necessary. The indications for surgical intervention in paediatric forearm fractures include (1) open fractures; (2) fractures shortly before skeletal maturity; (3) irreducible fractures, with or without soft-tissue interposition; (4) unstable fractures after reduction; and (5) Monteggia fractures with an unstable radial head and residual ulna angulations (Noonan & Price, 1998).

Complete diaphyseal fractures, especially those that are oblique, occur on the same level or show huge displacement (>10mm), as well as greenstick fractures with a large (>45°) angular curve may justify primarily surgical osteosynthesis (Sinikumpu & Serlo, 2015).

Patients' age affects the treatment strategy; children of preschool age are not usually treated by any osteosynthesis. School-age children are most commonly operated by ESIN(elastic stable intramedullary nailing), which is the primary method for osteosynthesis in children's forearm shaft fractures in that age group (Sinikumpu & Serlo, 2015). Adolescents nearing skeletal maturity will be treated like adults with a rigid plate and screw fixation to achieve a hairline reduction using a suitable surgical approach (Sinikumpu & Serlo, 2015).

Recent reports on intramedullary fixation of forearm fractures in children documented excellent clinical results and promoted the advantages of this technique over plating in paediatric patients (Yung et al., 1998). Van der Reis et al., (1998) reported that intramedullary fixation allows a short operative time, excellent cosmesis, minimal soft tissue dissection, ease of hardware removal, and early motion. Percutaneous intramedullary fixation with K-wires and proper technique is an appropriate, effective and safe operation for unstable diaphyseal fractures of the forearm in children who cannot be treated by closed manipulation (Altay et al., 2006). Intramedullary Kirschner wiring is a better option than plating for the treatment of unstable forearm fractures in older children (Kose et al., 2008).

Elastic stable intramedullary nailing (ESIN) osteosynthesis for diaphyseal forearm fractures remains a valid technique with very good functional results (Antabak et al., 2013). Operative stabilization by ESIN is the primarily method of treatment in cases of unstable fractures, in particular, in children between preschool age and adolescence and usually results in good outcomes (Sinikumpu & Serlo, 2015). Elastic stable intramedullary nails offer good fixation to control deformity in mid-shaft forearm fractures for paediatric patients. However there is a high rate of possible complications around the radial insertion point (Cumming et al., 2008). Compartment syndrome was more frequent when IMN was used and older children had poorer outcomes and higher rates of delayed union (Flynn et al., 2010). Patients with ORIF using plate and screws had more major complications, often requiring a return to the operating room. IM nailing, when done correctly, is as acceptable and safe a form of treatment (Smith et al., 2005).

The currently available literature shows no difference in functional outcome between intramedullary nailing and plate and screw fixation, even in older children with less remodelling potential. Intramedullary nailing may therefore be the treatment of choice for simple fracture patterns due to shorter operative time, better cosmesis and ease of removal. Plating may still have a role in more complex injuries (Westacott et al., 2012).

After ESIN stabilisation, a cast is not strictly required as the fractures are well stabilised but in practice, a short below elbow cast for 2 weeks is used to provide some pain relief (Mulligan & Barry, 2015).

The timing for removal of IM implants for paediatric forearm fractures has historically been based on the rate of re-fracture, which can be as high as 4–8 % in patients treated non-operatively. Due to this experience, intramedullary implants are typically left in place for at least 6–12 months prior to removal to provide mechanical protection against re-fracture (Kelly, Shore, Bae, Hedequist, & Glotzbecker, 2016).

Elastic stable intramedullary nailing are recommended to be removed not earlier than 6 months postoperatively because of the risk of re-fractures and plates not earlier than 12 months postoperatively for the same reason (Sinikumpu & Serlo, 2015).

Patients managed with ESIN went on to osseous union and regained a full range of movement after rehabilitation. There were no cases of delayed union, non-union or mal-union (Cumming, Mfula, & Jones, 2008).

2.5 Treatment Outcomes

2.5.1 Re-Displacement

An acceptable restoration of forearm function is achieved in most children after non-operative treatment of diaphyseal forearm fractures. However, re-displacement is common after closed treatment (Voto et al., 1990). Fracture re-displacement is the most frequently reported complication, which can lead to mal-union, causing impairment of forearm rotation (Asadollahi, Pourali, & Heidari, 2017).

Re-displacement has been reported to occur in 7–20% of cases, with rates as high as 62% for older children (Madhuri et al., 2013). Voto et al., (1990) found that the rate of re-displacement in non-operatively treated shaft fractures was 19% (Voto, Weiner, & Leighley, 1990). Bowman et al., (2011) conducted a retrospective study of children with both-bone forearm shaft fractures who underwent closed treatment. They reported that 5% of children experienced re-displacement over 4 weeks of follow-up. About 10% of all children had re-displacement after closed fracture reduction and immobilization (Asadollahi et al., 2017). Loss of reduction is the most common complication in paediatric forearm fractures with rates between 10 and 60% (Vopat et al., 2014).

Over half of participants who failed angulation criteria at follow-up had their first radiographic evidence of failure during the first week, with 95% failing within three weeks (Bowman et al., 2011). Bowman et al., (2011) showed that 84% of participants who had post-reduction angulations exceeding the acceptable angulation criteria failed to meet the criteria at follow-up, illustrating that residual angulation generally does not improve within the first month following reduction. This suggests that anatomic reduction is imperative.

Angular deformation will correct spontaneously not more than 1° in a year until skeletal maturity. Accepted alignment in children's forearm shaft fractures is therefore related to the age of the patient. Not more than 10°–15° of angulations or 5°–10° of angulations should be accepted in children less than 8 years of age or of 8 years of age or more, respectively (Sinikumpu & Serlo, 2015). Angulations of up to 20° is acceptable in children less than 8 years old, but no more than 10° is acceptable in older children with less than 2 years of expected additional growth. Displacement should be accepted not more than that of bone diameter; no more than 10mm shortening should be accepted (Sinikumpu & Serlo, 2015). Acceptable rotational malformation is under 45° and 30° in children less than 9 years and more than 9 years of age respectively (Sinikumpu & Serlo, 2015). It is uniformly agreed that post-traumatic angular deformities in children have variable remodelling potential; however, it has not been consistently proved that deformities characterized by rotational mal-alignment will also remodel (Noonan & Price, 1998).

There is association between the rate of re-displacement and several baseline factors including sex, falling during running, the presence of fracture in the radial bone, fracture with a spiral pattern, initial angulations of >10°, and initial displacement of > 10 mm (Asadollahi et al., 2017). Re-displacement was more common in fractures with a greater initial degree of displacement (Asadollahi et al., 2017). Single bone fracture, might reduce the need for initial re-manipulation and is protective against re-displacement (Asadollahi et al., 2017). Both-bone forearm fracture is associated with a higher probability of incomplete reduction and re-displacement (Hang, Hutchinson, &Hau, 2011; Zamzam & Khoshhal, 2005).

2.5.2 Range of Motion

Maintenance of pronosupination is a key element in the management of forearm fractures. “Normal” pronation and supination are somewhat difficult to accurately quantify, secondary to wrist and hand movement as well as difficulty in determining the neutral position (Franklin et al., 2012). The American Academy of Orthopaedic Surgeons (1965) defines normal pronation at 71 degrees and supination at 84 degrees. Clinical studies of both bone forearm shaft fractures in children show that range of motion is significantly affected by residual angulation of fractures (Bowman, Mehlman, Lindsell, & Tamai, 2011). Carey et al., (1992) revealed that 60% of their patients 11–15 years had residual loss of motion, up to 30 degrees. In the first three months after removal of the plaster cast a full range of elbow movement and forearm rotation is regained in both groups (Bochang C et al., 2005). Loss of forearm rotation mainly occurred in the patients who had re-displacement (Asadollahi et al., 2017). Tarmuzi et al., (2009) reported excellent functional outcome in 86% of patients treated conservatively and none had poor outcome. Sinikumpu et al., (2014) found excellent 11-year outcome of non-operatively treated both-bone forearm shaft fractures in children. They found no restriction in pronosupination. Yung et al., (1998) documented that all patient in his study treated with percutaneous intramedullary K-wiring had good functional results with an excellent range of movement**.** Altay et al., (2006) reported 96% excellent functional outcome in patient treated with intramedullary K-wiring.

2.5.3 Complications

The potential complications of forearm shaft injuries include compartment syndrome, mal-union, non-union, re-fracture, nerve and arterial injuries, muscle or tendon entrapment, reflex sympathetic dystrophy, and infection.

2.5.3.1 Compartment syndrome

Compartment syndrome is uncommon after fracture of the forearm (Rodriguez-Merchan, 2005). Compartment syndrome is a rare complication, the risk of which increases with multiple attempts at closed reduction and prolonged operation time (Sinikumpu & Serlo, 2015). One serious complication arising from closed management is Volkmann's ischemia, also referred to as a compartment syndrome, where there is a lack of blood flow due to increased tissue pressure, perhaps from overly tight bandages, often resulting in contractures of the forearm muscles (Madhuri et al., 2013). Compartment syndrome, a rare but potentially devastating complication, has been described as being associated with forearm and distal radial fractures with a higher risk in open than in closed fractures (Kalyani et al., 2011).

The cardinal symptom of a compartment syndrome is pain that is frequently out of proportion to the injury. Usually it is aggravated by passive stretch of the muscles in the involved compartment. Once confirmed, fasciotomy of the forearm (volar forearm decompression) must be done immediately (Rodriguez-Merchan, 2005).Yuan et al., (2004) in their study of 235 patients evaluating compartment syndrome, none of the 205 patients managed with closed reduction and splinting had compartment syndrome while 3 (10%) out of the 30 patients done closed reduction and pinning had compartment syndrome.

2.5.3.2 Mal-union

Mal-union is a potentially avoidable complication with careful follow up (Rodriguez-Merchan, 2005). The common causes of mal-union are improper positioning of the forearm in pronation or supination, failure to correct an inadequate reduction, failure to do cast changes when appropriate, and delay in diagnosis until after the fracture is united (Rodriguez-Merchan, 2005). Mal-union occurs in less than 1% of shaft fractures treated with closed reduction (Asadollahi et al., 2017).

2.5.3.3 Non-union

Non-unions in children are rare. They are more likely to occur as a result of high-energy trauma, after an open fracture, or in fractures associated with considerable soft tissue loss or infection (Rodriguez-Merchan, 2005). Non-unions occurs in less than 1% of shaft fractures treated with closed reduction (Asadollahi et al., 2017). Repeated manipulation may contribute to this complication. If both bones are fractured, the ulna is more likely to be affected by delayed healing. With time and patience, most fractures will heal (Rodriguez-Merchan, 2005).

2.5.3.2 Neurovascular injuries

In closed forearm fractures, nerves and arteries are injured relatively infrequently. However, injury to the anterior interosseous nerve secondary to a fracture of the radius has been reported, as has entrapment of the median nerve and ulna nerve within a greenstick fracture (Rodriguez-Merchan, 2005). The anterior interosseous nerve anatomically is susceptible to injury in displaced fractures of the proximal radius, especially those requiring open reduction (Rodriguez-Merchan, 2005). Hypoesthesia in the area of the superficial radial nerve is a common complication in forearm shaft fractures treated with ESIN. Lesions of the superficial radial nerve occur in the primary fracture treatment or at the time of material removal (Antabak et al., 2013). Complications occurred due to the nails being inserted through stab incisions at the radial insertion point (Cumming et al., 2008). Therefore the nail should be inserted on the radial aspect between the first and second compartments after careful dissection to identify the superficial radial nerve and extensor tendons (Cumming et al., 2008). Being usually a traction-based neuropraxia, watchful waiting is recommended for 3 months in injury-related nerve disturbances (Sinikumpu and Serlo, 2015)

2.5.3.3 Re-fracture

Although uncommon, re-fracture can occur as long as 6 months after the original injury (Noonan & Price, 1998). Re-fracture of the forearm in paediatric patients with IM implants in situ is a rare but recognized complication, occurring in approximately 1.2 % of patients treated with IM implants (Kelly et al., 2016). Re-fractures occur more frequently after forearm shaft fracture than after other fractures in children, with an incidence of approximately 6–10% (Asadollahi et al., 2017). They were more likely to occur in older children and in a region of the forearm more proximal to the usual pattern for the specific age group. Warning the family of the possibility of re-fracture can help relieve anxiety should this complication occur (Rodriguez-Merchan, 2005). Pountos et al., (2010) indicated that no children were reported to have re-fractures at 6 months follow-up time.

2.5.3.4 Cross-union

Synostosis between the radius and ulna occurs rarely. The risk of this complication is increased by high energy trauma or associated head injury (Noonan & Price, 1998). Synostosis may occur after closed management of high-energy fractures and may require resection depending on functional limitations (Vopat et al., 2014).

2.5.3.5 Infection

Infection is a potential complication of open fractures and open reduction of closed fractures of the forearm. It can occur after a closed fracture, but this is rare (Rodriguez-Merchan, 2005). Pin track infection is also a frequent complication in patients in whom K-wires were left for an extended time and especially out of the skin (Altay et al., 2006). Yung et al., (1998) left K-wire ends outside the skin and reported one infection in 57 patients.

CHAPTER THREE

3.0 METHODOLOGY

This chapter covers the details about the design and the methodology of the study.

3.1 Study Design

Prospective descriptive study design was employed in this study. The staffs at the plaster room were informed of the study and told to notify the principal investigator of paediatric patients with the forearm shaft fractures. Participants were recruited upon being attended to at the casualty, out-patient department and orthopaedic wards then followed up for six months to access functional outcomes. Follow up was done 24 hours later to check with post-reduction radiograph. Long term follow up was according to their return dates to the clinic at 4 weeks, 8 weeks, 12 weeks and 6 months post treatment.

3.2 Study Site

The study was carried out at Moi Teaching and Referral Hospital plaster room, paediatric outpatient fracture clinic and orthopaedic wards between August 2018 and July 2019. Moi Teaching and Referral Hospital is situated along the Nandi road, in Eldoret, country's fifth largest town, the headquarters of Uasin Gishu County in the North rift of Kenya. It is approximately located 320 kilometers North West of the Nairobi, the capital city of Kenya. MTRH was upgraded from former Uasin Gishu County Hospital (UGCH) in late 1990s; however another UGCH was established on temporary basis on Uganda road in Eldoret municipality.

MTRH is currently about 1000 total bed capacity tertiary health institution; it is the second largest teaching and referral hospital in the country after Kenyatta National Hospital. It serves as teaching hospital, where Moi University College of Health Sciences is based, and taking care of the scholars (medical, dental, environmental and public health, nursing and pharmacy). The health institution currently runs its own schools of nursing. Several other institutions make use of this hospital, including the KMTC, University of Eastern Africa (Baraton). Several other scholars from various educational institutions come to this hospital for attachment.

It also serves as referral health institution with a wide catchment area including western part of Kenya, eastern part of Uganda and southern Sudan with at least 20 million people almost half of Kenya population.

The health institution is also the home for AMPATH. This institution is involved in research and care of the HIV/AIDS patients, through collaboration with Indiana University in partnership with Moi University and USAID.

The health institution has a busy functioning casualty that caters for critical patients; at least 50% are surgical. It has orthopedics and trauma (fracture) clinics serving both referred and non-referred patients and their follow up. The heath institution has wards for generalized and specialized surgery, medical, psychiatry, obstetrics and gynecology, pediatrics and renal patients. There are also respective clinics.

The health institution has functional intensive care unit and busy six operating rooms in Majaliwa theatre serving patients, majority with orthopedics and trauma ailments. Two other theatre (minor) serving mainly the orthopedics and trauma patients also exist in the outpatient section. There is also another main theatre in memorial hospital, a private wing of the hospital displaying similar trend.

The Riley Mother-Baby hospital is an extension, designed to offer the ultramodern care to the pregnant mothers and babies. This wing of the hospital has even an ultramodern operation theatre.

The shoe 4 Africa children hospital is also an extension designed to offer quality care to all children aged 14 years and below. It has 250 bed capacities with a busy casualty and several wards both surgical and medical (pediatrics). It also has operation theatre.

According to the central statistics of the hospital, MTRH has an average outpatient of 210,000 per year or an average of 600 outpatients per day, with accident and emergency department receiving over 10,000 outpatients per year. It also has cumulative 35,000 inpatients per year with the orthopedic department having over 1300 inpatients per year.

3.3 Study Population

Children aged 14 years and below with forearm shaft fractures seen at the casualty, attending fracture clinic or admitted in the orthopedic wards at MTRH during the study period.

3.4 Eligibility

3.4.1 Inclusion Criteria

1. Children aged 14 years and below with forearm shaft fractures were included in the study.
2. Forearm shaft fractures with concomitant dislocations (e.g. Monteggia or Galeazzi).

3.4.2 Exclusion Criteria

The exclusion criteria included:

1. Polytrauma patients (patients with other long bone fractures in addition to forearm shaft fractures)
2. Patients with pathological fractures.
3. Patients who have been managed non-operatively elsewhere and referred to MTRH for follow up and further management.

3.5 Sample size determination

The previous records at the MTRH (HRIS, MTRH 2017) showed that the approximate numbers of paediatric patients with forearm shaft fractures were in the range of 150 to

200 patients per year. Census study was done and 130 paediatric patients with forearm shaft fractures who met the inclusion criteria during the study period (August 2018-July 2019) were recruited.

3.6 Data Management

3.6.1 Data Collection Tool and Methods

Interview based questionnaire was used by the candidate to collect data from the patients upon consenting to the study. On contact with the patient at the plaster room the patient's age, gender, hand dominance and the fractured forearm were recorded. Thereafter, a careful history was taken from the parents or next of kin to reveal the mechanism of injury. Physical examination was done on the patients to evaluate their general condition and the local injury. Fractures were classified as either open or closed. The fracture pattern was recorded as either greenstick or complete. The site of fracture was also recorded as distal 1/3 shaft, middle 1/3 shaft and proximal 1/3 shaft. All patients were put on sugar-tong splint after initial reduction. Patients were reviewed 24 hours later with post-reduction radiograph and the quality of initial reduction recorded.

The quality of initial reduction was assessed using the criteria developed by Asadollahi et al., 2017.

- Anatomical reduction (no translation or angulation),
- Good reduction (dorsal angulation of < 10° or translation of ≤ 2 mm),
- Fair reduction (angulation of 10–20° or translation of 2–5 mm, or any radial deviation < 5° or a combination of dorsal angulation of 5–10° and translation of ≤ 2 mm).
- Poor reduction if the degree of angulation was ≥ 20°.

Repeat close reduction and splinting was done in patients with fair and poor reduction and check radiograph was done after 4 weeks to reassess re-displacement. Thereafter all patients were followed up at the paediatric outpatient fracture clinic to assess radiologic union and functional outcomes. At 4 weeks radiographs were taken to check for re-displacement. Re-displacement was considered to have occurred if there was (1) increased angulation of > 10°, (2) increased translation of > 20%, or (3) increased angulation of > 5° and increased translation of > 10% (Asadollahi et al., 2017). Goniometer was used to measure angulation. All patients with no re-displacement, the sugar tong splint was removed and wrist, elbow, forearm range of motion initiated after confirmation of radiologic union (sufficient callus formation on three cortices).

The patients with re-displacement were operated using percutaneous intramedullary K-wiring sizes 2.0 mm and supplementation with sugar-tong splint done for 4 weeks.

Post-reduction radiograph was taken to assess the reduction of the fracture and upon discharge they were followed up in the outpatient fracture clinic for pin site infection and neurovascular injuries. Four weeks after operation, the K-wires and the splint were removed and elbow, wrist, forearm range of motion initiated.

At 12 weeks and 6 months functional outcome was assessed using goniometer and recordings done based on Flynn et al., (2010) criteria. An excellent, fair, or poor classification was assigned using this outcome tool as described in Table 1.

Table 1: Flynn et al., (2010) criteria

Clinical outcome score	Criteria
Excellent	Full range of motion (supination and pronation) and no post-operative Complication.
Fair	Minimal loss of range of motion (< 30 degrees of supination and /or pronation) and / or minor resolving postoperative complications.
Poor	Loss of range of motion (supination and pronation) >30 degrees and / or major postoperative complication (i.e infection, compartment syndrome, or delayed union).

3.7 Quality control

Data was collected using interviewer based questionnaire and cross checking with patients file done. Review of data after collection to check for missing data and counter checks on data entry was done by researcher using MS excel. This was to verify the data collected.

3.8 Data processing and analysis

Following the completion of the data collection process, questionnaires were coded and entered in computerized data base designed in Microsoft excel data entry software. The data was then exported to STATA software version 15 for analysis. Descriptive statistics was used to summarize the data. Categorical variable were summarized as frequencies and percentages. Continuous variables were summarized as mean, standard deviation and ranges. Statistical test of analysis such as Chi-square and Fisher's exact tests were used to test the association between variables. The findings were presented in prose, tables and figures.

3.9 Ethical Consideration

Ethical approval to conduct the study was obtained from the Institutional Research Ethics Committee (IREC). The study approval number was IREC 0002073. Permission to conduct the study was sought from the hospital administration before the commencement of the study. The parents of the patients were informed appropriately on the benefits and the risks of the study in a language that they fully understood and informed written consent (Appendices 1& 2) was obtained from each participant's parent. Children above 7 years of age were also informed appropriately about the benefits and the risk of the study in a language that they fully understood and informed written assent (Appendices 3 & 4) was obtained.

The participating patients and their parents were informed that they were free to withdraw from the study anytime they wished to do so without any consequences. All patients were informed that they will be given equal treatment, whether they consent, do not consent or withdraw from the study.

The collected data was locked in a secure cabinet that was only accessible to the investigator. Electronic data was stored in a password protected laptop. Backup copies were stored in a password protected external hard drive kept by the Principal Investigator. The disposal of the patient's particular after the completion of the Masters of Medicine programme will be as per the IREC guidelines, for example shredding. The copy of this thesis will be available at Moi University Library and Website. A publication after completion of MMED programme to disseminate information has been planned for.

3.10 Study Limitation

Some patients did not come for their follow up visits because they had forgotten. This was mitigated by messaging or calling parents to remind them about their appointment.

CHAPTER FOUR

4.0 RESULTS

Chapter four covers the documentation of research results/findings as per the stated objectives.

4.1: Characteristics of forearm shaft fractures in children seen at MTRH

A total of 121 children participated in the study. The mean age was 8.6 years (SD=4.7) with a range of 1 and 14 years. The modal age was 5-10 years. Boys were more commonly affected than girls (65.3% versus 34.7%) as shown in Table 2. Majority of the patients were in primary school and one patient was in the first year of high school. One patient was mentally challenged and was in a special school. Fourteen patients did not start school because they were in the preschool age group.

Table 2: Age, gender and education distribution

Variable	Frequency (n=121)	Percentage (%)
Age in years		
<5 years	31	25.62
5-10 years	58	47.93
10-14	32	26.45
Gender		
Male	79	65.3
Female	42	34.7
Education		
None	14	11.6
Nursery	30	24.8
Special(mentally challenged)	1	0.8
Primary	75	62
High school	1	0.8

One hundred and nineteen patients were right handed and only 2 patients had their left hand as the dominant side. Majority of the fracture occurred in the left forearm compared to the right forearm (64.5% versus 35.5) as shown in Table 3. This was because possibly the right forearm was occupied at the time of injury.

Table 3: Hand dominance and fractured forearm

Variable	Frequency	Percentage (%)
Dominant hand		
Right	119	98.3
Left	2	1.7
Fractured forearm		
Left	78	64.5
Right	43	35.5

The main mechanism of injury for forearm shaft fractures in children was a fall, followed closely by sports injury. Road traffic accident was the least cause of injury as shown in Figure 2.

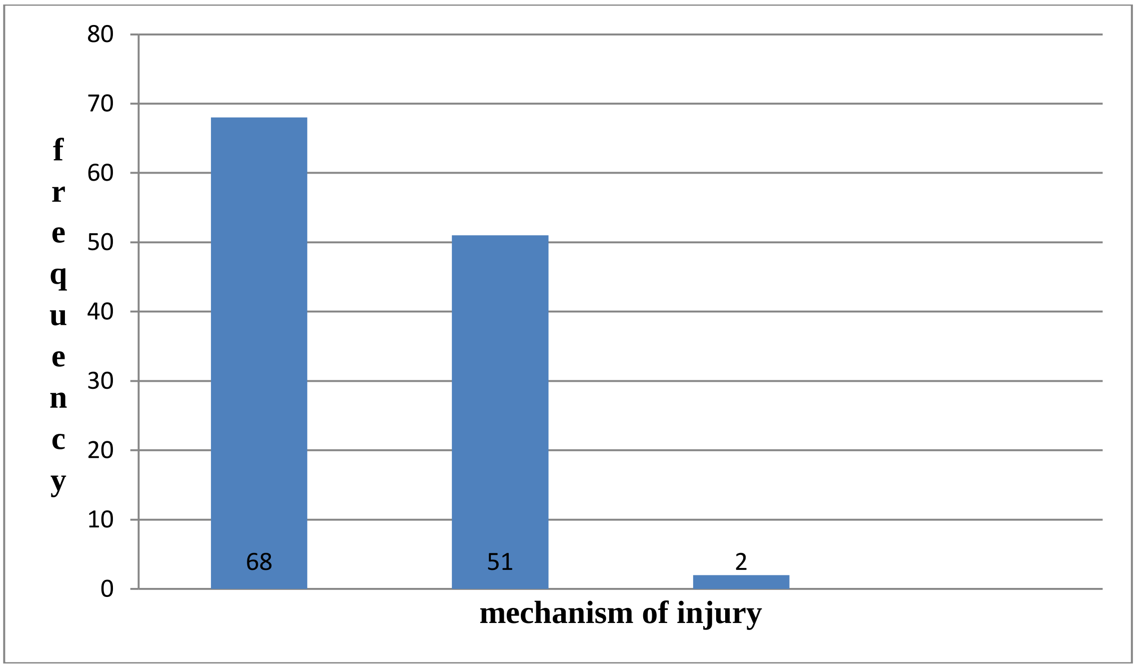

Figure 2: Mechanism of injury

Most fractures occurred indoors at home and only 19.8% of patients had fractures outdoors at schools. Majority (97.5%) of the fractures occurred during day time compared to 2.5% that occurred during the night period as shown in Table 4. This was thought to be due to good supervision of children at night because many parents were away during day time attending to their jobs and day to day activities. It could also be at night they slept instead of playing.

Table 4: Place and time of fracture occurrence

Variable	Frequency	Percentage (%)
Location of fracture occurrence		
Home	95	78.5
Schools	24	19.8
Others	2	1.7
Time of fracture occurrence		
Day	118	97.5
Night	3	2.5

Distal third shaft of the radius and ulna fracture was the commonest site of injury (53.7%), followed closely by middle third shaft (44.6%). Only 2 patients (1.7%) had proximal third shaft of the radius and ulna fracture. All the patients in the study had closed forearm shaft fractures as shown in Table 5.

Table 5: Site and type of fracture

Variable	Frequency	Percentage (%)
Site		
Distal 1/3	65	53.7
Middle 1/3	54	44.6
Proximal 1/3	2	1.7
Type of fracture		
Closed	121	100
Open	0	0

Most children had greenstick fractures (67.8%) and only 39 patients (32.2%) had complete fractures. Both bones fractured in 76 patients while isolated radius and ulna fractures occurred in 36 and 9 patients respectively as shown in Table 6.

Table 6: Fracture pattern and fractured bone

Variable	Frequency	Percentage (%)
Fracture pattern		
Greenstick	82	67.8
Complete	39	32.2
Fractured bone		
Both bones	76	62.8
Radius	36	29.8
Ulna	9	7.4

In patients less than 10 years old, 64 had greenstick fractures compared to the 25 who had complete fracture while in the older patients 10-14 years old, complete fracture was as common as greenstick fractures (45.2 versus 54.8).This was statistically significant with a p-value of 0.027.The most common mechanism of injury for patients aged 1-5 years and 5- 10 years was a fall at 77.4% and 63.8% respectively; while sports (77.4%) was the commonest cause of injury for children 10-14 years as shown in Table 7. This was statistically significant with a p-value <0.001.

Sixty five percent of right handed patients had their fractures on the left forearm compared to 35 % who fractured their right forearm as shown in Table 8. This was not statistically significant with a p-value of 1.000.

Table 7: Association between Age and Type of fracture, Cause and fractured forearm

	Age in years			
	<5yrs	5-10 yrs	10-14 yrs	
Variable	Freq (%)	Freq (%)	Freq (%)	p-value
Type of fracture				0.027[1]
Complete	13 (41.9)	12 (20.7)	15 (46..9)	
Greenstick	18 (58.1)	46 (79.3)	17 (53.1)	
Place of Occurrence				0.007[2]
Home	29 (96.7)	47 (79.7)	21 (65.6)	
School	1 (3.3)	12 (20.3)	11 (34.4)	
Cause				<0.001[2]
Fall	24 (77.4)	37 (63.8)	8 (25)	
Motor vehicle	1 (3.2)	0 (0)	0 (0)	
Sports	6 (19.4)	21 (36.2)	24 (75)	
Fractured forearm				0.702[1]
Left	20 (65)	37 (62.7)	22 (71)	
Right	11 (35)	22 (37.3)	9 (29)	

[1] Chi square test [2] Fisher's exact test

Table 8: Association between fractured forearm and dominant hand

	Fractured forearm		
	Left	Right	
Dominant hand	Freq (%)	Freq (%)	p-value
Left	1 (50.0)	1 (50.0)	1.000[2]
Right	77 (64.7)	42 (35.3)	

[2] Fisher's exact test

4.2: Treatment of forearm shaft fracture

Most children were treated non-operatively using sugar tong splint 113(93.4%) and only 8 (6.6%) were operated after failed closed reduction and immobilization using sugar tong splint. Percutaneous intramedullary K-wiring was the operative method used.

Twenty four (24) hours after closed reduction, post-reduction radiograph was done and the quality of initial reduction assessed using Asadollahi et al., (2017) criteria to assess for re-displacement and the result is as shown in Figure 3.

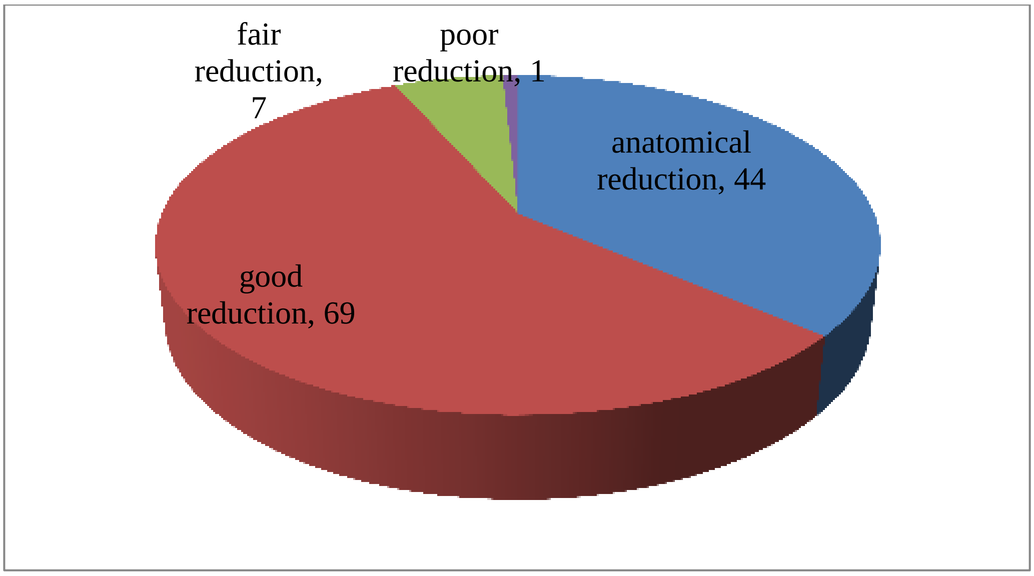

Figure 3: Treatment of paediatric forearm shaft fracture

All the patients who were operated had both bones fractured. Among the 8 patients who were operated 7 (87.5) had fair reduction and the remaining 1(12.5) had poor reduction. In the operated cases, 5 patients were done close reduction and percutaneous pinning while 3 had failed CRPP and was done open reduction and percutaneous pinning.

4.3: Treatment Outcome of Forearm Shaft Fractures

The study patients were followed up for six months to assess for outcomes in terms of forearm rotation i.e. pronation and supination and other complication**s.**

One hundred and sixteen patients had excellent outcomes ((Full range of motion (supination and pronation) and no complications)) and only 5 patients had fair outcomes ((Minimal loss of range of motion (< 30 degrees of supination and /or pronation) and / or minor resolving complications)).

One hundred and eleven (98.2%) of the patients managed non-operatively had excellent outcome and only 2 (1.8%) had fair outcome and this was statistically significant with a p-value <0.002 while 5 (62.5%) of patients operated had excellent outcomes and 3 (37.5%) had fair outcome as shown in table 5.2. Among the 8 who were operated both bones had been fractured with 7 (87.5) had fair reduction and the remaining 1(12.5) had poor reduction.

Table 9: Association between functional outcome and management modality

	Functional outcome		
	Full range	**Minimal**	
Management	**Freq (%)**	**Freq (%)**	**p-value**
Non-operative	111 (98.2)	2 (1.8)	0.002[2]
Operative	5 (62.5)	3 (37.5)	

[2] Fisher's exact test

CHAPTER FIVE

5.0 Discussions

Chapter five covers the discussions of the research findings as per the stated objectives.

5.1 Characteristics of Forearm Shaft Fractures

5.1.1 Age and Sex

One hundred and twenty one patients were successfully recruited in this study. Higher incidences of fractures were found in boys than girls. The proportion of the forearm shaft fractures was nearly twice higher in boys (boys=65.3%, girls=34.7%). This concurs with a study by Grabala (2015) which had boys=62%, girls=38%. The increase of fractures in boys is attributed to their usual activities outside the home; thus, they are more prone to injury. The mean age of the patients in this study was 8.6 years (SD=4.71) with a range of 1 to 14 years. This concurs with a study by Sinikumpu and Serlo, (2013) which had mean age of 8.7 years old (SD =3.8; range 1–15) but contrasted study by Grabala (2015) which had a mean of 9.85 (SD =3.79). This was due to the above author recruiting a larger age group up to 18 years. Fracture peak occurred in the age of 5-10 years. This may be due to association with the increased physical activity in this age group.

5.1.2 Side Preponderance

Fractures in the left forearm are almost twice as common as in the right forearm (64.46% versus 35.54%). This finding concurs with that in a study by Hassan (2008) which had fractures in the non-dominant hand comprised 59.17% (58.89% for right-handed and 66.66% for left handed children) and study by Tandon et al., 2007 (42% versus 25%). The study by Tandon et al., (2007) was comparing the lower limb and the upper limb fractures hence the low percentage (percentage not adding up to 100 %.). The above finding was contrasted by study of Bochang et al., (2005) which had a finding that forearm shaft fractures were more common in the right forearm than the left forearm. The reason why the fractures were commoner in the non-dominant hand could be due to the non-dominant hand more likely to strike the ground first than the dominant one, which is clinging to an object or otherwise occupied (Hassan, 2008).

5.1.3 Location of Fracture Occurrence

Regarding the locations where fractures commonly occur, it has been reported by Valerio et al., (2010) that the home accounts for 41.6 % of forearm shaft fractures in children, while the school represents 13.9%. In this study as well, home (78.5%) was the place where fractures most frequently occurred followed by school (19.8%). The low awareness of fracture prevention in the home in developing countries may contribute to this finding (Saw et al., 2011).

5.1.4 Mechanisms of Injury

The most common mechanism of injury was a fall, with road traffic accident being the rarest. This was in agreement with studies by Grabala, 2015 and Vopat et al., 2014. This finding contrasted that in a study done by Mastan Basha et al., (2015) which states RTA to be the commonest cause followed by fall with sports being the least cause. The most common mechanism of injury for patients aged 1-5 years and 5- 10 years was fall at 77.4% and 63.8% respectively while sports (77.4%) was the commonest cause of injury for children 10-14 years (p-value <0.001). This was in agreement with a study by Alrashedan et al., (2018) that found fall-related injuries were more common in younger children than in older children, whereas direct hit injuries were more common in children >12 years old than in children <12 years old, and this difference was statistically significant ($p < 0.001$). During the first years of life, children undergo dramatic developments in motor skills. In their explorations, they tend to fall off furniture in the first year of life, whereas pre-adolescence children fall off playground equipment, bikes, and other structures (Hedström et al., 2010). Lack of supervision, inadequate safety standards for household furniture and goods, limited access to safe play areas, and uneven walking surfaces are reported as risk factors for childhood falls in developing countries (Halawa, Barakat, Rizk, &Moawad, 2015).

5.1.5 Fracture Patterns

Concerning the fractured bone, forearm shaft fractures involving both the radius and the ulna were the commonest (62.81%), followed by isolated radius (29.75%). This finding concurs with study findings by Bochang et al., (2015) of 67% both bones fractures followed by 25% radius and 8% the ulna, but contrasts that by Grabala, (2015) and Alrashedan et al., (2018) which states that isolated radius fracture was the commonest. Isolated fracture of the shaft of the ulna (7.4%) is found to be the rarest of forearm fractures. This finding is in agreement with studies by Bochang et al., (2005) and Grabala, (2015) of 8% and 3% fracture shaft ulna respectively. Most children had greenstick fractures (67.8%) and only 32.2% had complete fractures. Fracture pattern was analyzed by age. In children below 10 years of age, greenstick fractures were commoner than complete fractures; while in children above 10 years of age complete fractures were as common as greenstick fractures (45.2 versus. 54.8). This finding is in agreement with studies by Grabala, (2015), Arora et al., (2014) and Madhuri et al., (2013) but contrasts that in study by Bochang et al., (2005) that had most children having complete fractures (65%) compared to greenstick fractures (35%).The distal third of the radius and ulna shaft was the commonest site of fracture (53.7%), followed by the middle third (44.6%).This finding is in agreement with those in studies by Bochang et al.,(2005) and Alrashedan et al., (2018) which had distal third shaft of the radius/ulna as the most common site of fracture occurrence followed by middle third and the proximal third shaft was the most rare site but contrasts a study by Sinikumpu &

Serlo, (2015) which had middle third radius and ulna shaft as the commonest site of fracture followed by distal third.

5.2 Treatment of Forearm Shaft Fractures

The gold standard treatment for paediatric forearm shaft fractures remains closed reduction and casting because of the excellent remodelling potential in younger patients. From this study finding, majority (93.4%) of the children were managed non-operatively using sugar-tong splint. This is agreement with studies by several authors (Madhuri et al., 2013; Sinikumpu & Serlo, 2015; Truntzer et al., 2015; Vopat et al., 2014). However, 6.6% of the patients who were initially treated with closed reduction and splinting got re-displacement within 4 weeks and were operated. There are different operative techniques available in literature and these include plate and screw fixation, ESIN, flexible intramedullary nailing, percutaneous intramedullary K-wires and external fixation. In this study percutaeous intramedullary K-wire was used for the patient who had unsuccessful close reduction and splinting. Due to the availability of K-wires at MTRH and the financial challenges patients had, K-wires were used in all patients who needed operations. Yung et al., (1998) reported excellent clinical results on intramedullary fixation of forearm fractures in children and promoted the advantages of this technique over plating in paediatric patients. Altay et al., (2006) reported that percutaneous intramedullary fixation with K-wires and proper technique is an appropriate, effective and safe operation for unstable diaphyseal fractures of the forearm in children who cannot be treated by closed manipulation. Kose et al., (2008) documented that intramedullary Kirschner wiring is a better option than plating for the treatment of unstable forearm fracture.

5.3 Treatment Outcomes

5.3.1 Re-Displacement

An acceptable restoration of forearm function is achieved in most children after non-operative treatment of diaphyseal forearm fractures. However, re-displacement is common after closed treatment (Voto et al., 1990). Bowman et al., (2011) conducted a retrospective study of children with both-bone forearm shaft fractures who underwent non-operative treatment. They reported that 5% of children experienced re-displacement over 4 weeks of follow-up. Voto et al., (1990) found that the rate of re-displacement in non-operatively treated shaft fractures was 19%. Sinikumpu et al., 2015 found that 22% of the cases in the non-operatively treated group had re-displacement during follow up. Asadollahi et al., (2017) found out that 10% of all children had re-displacement after closed fracture reduction and immobilization. In this study, 6.6% of all children had re-displacement after closed fracture reduction and immobilization. Both-bone forearm fracture is associated with a higher probability of incomplete reduction and re-displacement (Hang et al., 2011; Zamzam & Khoshhal, 2005). In this study all the patients who had re-displacement had both bone fractures.

5.3.3 Functional Outcome (R.O.M)

Maintenance of pronosupination is a key element in the management of forearm fractures. “Normal” pronation and supination are somewhat difficult to accurately quantify, secondary to wrist and hand movement as well as difficulty in determining the neutral position (Franklin et al., 2012). Clinical studies of both bone forearm shaft fractures in children show that range of motion was significantly affected by residual angulation of fractures (Bowman et al., 2011). Carey et al., (1992) revealed that 60% of their patients 11–15 years old had residual loss of motion, up to 30 degrees. Tarmuzi et al., (2009) reported excellent functional outcome in 86% of patients treated non-operatively and none had poor outcome. Sinikumpu et al., (2014) found excellent 11-year outcome of non-operatively treated both-bone forearm shaft fractures in children. They found no restriction in pronosupination. In this study, 98.2% of the patients treated non-operatively had an excellent result and 1.8% had fair result (p-value <0.002). Yung et al., (1998) documented that all patient in his study treated with percutaneous intramedullary K-wiring had good functional results with an excellent range of movement**.** Altay et al., (2006) reported 96% excellent functional outcome in patient treated with intramedullary K-wiring. In this study, 62.5% of the operated patient had an excellent outcome and 37.5% had fair outcome and no operated patient had poor outcome. The difference could be explained by the former researcher having larger sample size of 48 patients compared to the 8 patients in this study.

5.3.3 Complications

Compartment syndrome, a rare but potentially devastating complication, has been described as being associated with forearm and distal radial fractures with a higher risk in open than in closed fractures (Kalyani et al., 2011).Yuan et al., (2004) in their study of 235 forearm shaft fracture patients evaluated for compartment syndrome, none of the 205 patients managed with closed reduction and splinting had compartment syndrome while 3 (10%) out of the 30 patients done closed reduction and percutaneous pinning had compartment syndrome. No child in this study had compartment syndrome. Mal-union is a potentially avoidable complication with careful follow up (Rodriguez-Merchan, 2005). Mal-union occurs in less than 1% of shaft fractures treated with closed reduction (Asadollahi et al., 2017). Mal-union was not observed in this study. Non-unions in children are rare. They are more likely to occur as a result of high-energy trauma, after an open fracture, or in fractures associated with considerable soft tissue loss or infection (Rodriguez-Merchan, 2005). Non-unions occurs in less than 1% of shaft fractures treated with closed reduction (Asadollahi et al., 2017). In this study there was no patient who had non-union. Although uncommon, re-fracture can occur as long as 6 months after the original injury (Noonan & Price, 1998). Pountos et al., (2010) indicated that no children were reported to have re-fractures at 6 months follow-up time. Similar findings had been observed in this study. In closed forearm fractures, nerves and arteries are injured relatively infrequently. However, injury to the anterior interosseous nerve secondary to a fracture of the radius has been reported, as has entrapment of the median nerve and ulna nerve within a greenstick fracture (Rodriguez-Merchan, 2005). In this study no patient had neurovascular injuries. Synostosis between the radius and ulna occurs rarely. The risk of this complication is increased by high energy trauma or associated head injury (Noonan & Price, 1998). There were no cases of synostosis in this study. Pin track infection is a frequent complication in patients in whom K-wires were left for an extended time and especially out of the skin (Altay et al., 2006). Yung et al., (1998) left K-wire ends outside the skin and reported one infection in 57 patients. In this study, there were no cases of pin track infection.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

6.1: Conclusion

Males were more affected than females with fall being the most common mechanism of injury. Left forearm shaft fractures were the highest and home was the most common setting where the fractures occurred. Non-operative management using sugar tong splint was effective treatment for forearm shaft fractures in children. A non-anatomical alignment on the initial post-reduction radiograph was a high risk factor for re-displacement. Percutaneous intramedullary K-wiring was an affective surgical management for patient with failed closed reduction. Majority of the patient treated non-operatively had an excellent functional outcome.

6.2: Recommendation

Public health education, i.e creating awareness in injury prevention among the parents, teachers and other stakeholders is recommended. Provision of day cares at work places, public health interventions aimed at improved safety at home and training of nannies on safety could help reduce these fractures.

Non operative management of forearm shaft fractures is recommended despite increase in surgical trend in western countries. Patients with fair and/or poor reduction in the 24 hour post-reduction radiograph should be operated. Percutaneous K-wiring is recommended for patient with failed closed reduction and splinting.

Further study is needed on factors contributing to re-displacement for forearm shaft fractures in children managed non-operatively.

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APPENDICES

Appendix I: Letter to Respondents /Introduction Letter /Consent Form

English Version

My name is Dr. Abdullahi Ali Issack.

I am pursuing Masters of Medicine degree in the Department of Orthopaedic and Rehabilitation at Moi University.

I am doing my research / study on matters related to characteristics and treatment outcomes of paediatric forearm shaft fractures.

I am requesting to use your data and findings for the purposes of improving the management of children with forearm shaft fractures.

No name is required and your information will be treated as confidential. Only the radiographs will be used. Your investigative imaging findings shall be utilized only for the purpose of research. There will be no other chargeable repeat investigations performed for the purpose of research.

All information obtained in this study will be treated with utmost confidentiality and shall not be divulged to any unauthorized person.

Please note that your participation is voluntary and you have the right to decline or withdraw from the study.

Patient’s signature _________________________Date ________________________

I certify that the patient has understood and consented to participate in this study.

Dr. Abdullahi Ali Issack

Signature _________________________Date ________________________

Appendix 2: Fomu ya Ridhaa (Ruhusa) ya Mgonjwa

Jina langu ni daktari Abdullahi Ali Issack

Nasomea shahada ya uzamili katika idara ya upasuaji wa mifupa na ukarabati katika chuo kikuu cha Moi.

Nafanya utafiti kuhusu mambo yanayofungamana na miundo na natija ya mivunjo ya vigasha kwa watoto.

Naomba kutumia data na matokeo yenu kwa lengo la kuboresha uuguzaji wa watoto wenye mivunjo ya vigasha.

Majina hayatahitajika na data na matokeo hayo yatahifadhiwa kwa usiri wa hali ya juu. Radiografu peke yake ndizo zitakazotumiwa.

Udadisi wa matokeo ya picha hizo zitatumika kwa ajili ya utafiti huo peke yake. Hakutakuwa na udadisi mwengine wowote wa kulipishwa kwa lengo la utafiti.

Habari zote zitakazopatikana katika utafiti huu zitachukuliwa na kuhifadhiwa kwa usiri wa hali ya juu na hazitapewa yeyote ambaye si mhusika.

Tafadhali, kumbuka ya kuwa, kushiriki kwako ni kwa hiari na ukona haki ya kukataa au kujiondoa kutoka utafiti huo.

Sahihi ya mgonjwa …………………………Tarehe ……………………………………

Nathibitisha ya kuwa, mgonjwa ameelewa na kukiri kushiriki katika utafiti huu.

Dr. Abdullah Ali Issack

Sahihi …………………………......Tarehe ……………………………………

Appendix 3: Minor Assent Form

PROJECT TITLE: CHARACTERISTICS AND TREATMENT OUTCOMES OF FOREARM SHAFT FRACTURE IN CHILDREN

INVESTIGATOR: ABDULLAHI ALI ISSACK

I am doing a research study about **causes, treatment and outcomes of childhood forearm shaft fractures.** A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked questions regarding your condition (fracture).

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you.

If you do not want to be in this research study, we will tell you what other kinds of treatments there are for you.

When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. Your parents know about the study too.

If you decide you want to be in this study, please sign your name.

I, ______________________________, want to be in this research study.

_______________________________ ______

(Sign your name here) (Date)

Appendix 4: Fomu ya Ridhaa na Makubaliano ya Mtoto

AZIMIO: MIUNDO NA NATIJA YA MIVUNJO YA VIGASHA KWA WATOTO

MPELELEZI: ABDULLAHI ALI ISSACK

Nafanya utafiti kuhusu sababu, uguzaji na natija ya mivunjo ya vigasha kwa watoto. Utafiti ni njia ya kuelimika zaidi kuhusu watu. Ikiwa utafanya uamuzi wa kushiriki katika utafiti huu, basi utaulizwa maswali kuhusu shida yako (mvunjo).

Si kila anaeshiriki katika utafiti huu anafaidika. Kufaidika maana yake, ni natija nzuri kupatikana kwako kama mshirika wa utafiti huu.

Ikiwa hutaki kushiriki katika utafiti huu, basi tutakuelezea aina zingine za matibabu zitakazotumiwa kwako.

Tukishamaliza utafiti huu, tutaandika ripoti kuhusu faida iliopatikana. Ripoti hii haitaonyesha jina lako au ya kwamba ulishiriki katika utafiti huu. Si lazima ushiriki katika utafiti huu ikiwa hutaki. Ukifanya uamuzi wa kutoendelea na utafiti huu baada ya kuanza, basi pia ni sawa. Wazazi wako pia wanajua kuhusu utafiti huu.

Ikiwa utaamua kushiriki katika utafiti huu, tafadhali weka sahihi jina lako.

Mimi, ………………………………….,nimekubali kushiriki katika utafiti huu.

…………………………………………… ……………………………..

(Weka sahihi jina lako hapa) (Tarehe)

Appendix 5: Questionnaire

Patient NO ....IP.NO..
Age...Address...
Mobile no..Date...
Sex: Male ☐ weight (KG)........................

Female ☐ height (M)...........................

Education: kindergarten ☐ BMI..........................

Nursery ☐

Primary ☐

High school ☐

None ☐

1. Which hand is the dominant?
   Right handed ☐ left handed ☐
2. What is the duration of the injury? .... (hours, days,weeks)
3. Which forearm is fractured?
   Right ☐ left ☐

4. What caused the injury in the child?

Fall ☐

Motor vehicle accident ☐

Sports ☐

Others (specify)..

5. Was the child a passenger when the injury occurred? Yes ☐ No ☐

6. If no, was the child a pedestrian when the injury occurred? Yes ☐ No ☐

7. When the injury occurred to the child where did it happen?

Home ☐

School ☐

Others (specify)...

8. When the injury occurred to the child what time did it happen?

Day ☐
Night ☐

PHYSICAL EXAMINATION

9. Anatomical site of the fracture..

10. Type of fracture

Open ☐ Green stick ☐ radial ☐ Both bones ☐

Closed ☐ Complete Fracture ☐ ulna ☐

11. Provisional diagnosis..

12. Is there any imaging done pertaining to the fracture? Yes ☐ No ☐

13. If yes, what is the finding of the imaging done?...

14. Final diagnosis..

15. What type of management was given to the child?

Operative ☐

Non operative ☐

16. Pre-manipulation displacement....................................

17. Quality of initial reduction

Anatomical reduction (no translation or angulations) ☐

Good reduction (dorsal angulations of < 10° or translation of ≤□2 mm) ☐

Fair reduction (angulations of 10–20° or translation of 2–5 mm, or any radial deviation ☐ <5° or a Combination of dorsal angulations of 5–10° and translation of ≤□2 mm) ☐

Poor reduction (if the degree of angulation was ≥ 20°) ☐

18. Post-operative complication

a. Pin tract infection Yes ☐ No ☐

b. Wound infection Yes ☐ No ☐

c. Neurological deficit Yes ☐ No ☐

19. Compartment syndrome

a. Pain not relieved by pain killers Yes ☐ No ☐

b. Paraesthesia Yes ☐ No ☐

c. Pallor Yes ☐ No ☐

d. Paralysis Yes ☐ No ☐

e. Pulselessness Yes ☐ No ☐

20 Functional outcomes

Full range of motion (supination and pronation) ☐

Minimal loss of range of motion (<30 degree of supination and/or pronation) ☐

Loss of range of motion (supination and pronation) >30 degree ☐

Thank you

Appendix 6: Sensorimotor Assessment of Common Upper-Limb Nerves

Nerve	Sensory	Motor
Radial	Dorsum of first web space	Thumbs-up sign
Ulnar	Volar aspect of little finger	Make a star (Spread fingers wide)
Median	Volar aspect of index finger	Make a fist with thumb flexion
Anterior Interosseus	No sensory function	"OK" sign (Making a circle with the thumb and index finger)

Appendix 7: Proposed Budget

ITEM	QUANTITY	UNIT PRICE	TOTAL
Stationeries		**15000**	15000
Internet services		**10000**	**10000**
Biostatician fees		**30000**	**30000**
Research assistants	2	60000	120000
TOTAL			**175000**

Source of funding: RESEARCHER.

Appendix 8: Time Plan

ACTIVITY	**START**	**END**
PROPOSAL CONCEPT DEVELOPMENT	**AUGUST 2017**	**SEPTEMBER 2017**
PROPOSAL WRITING	**SEPTEMBER 2017**	**OCTOBER 2017**
IREC APPROVAL	**NOVEMBER 2017**	**DECEMBER 2017**
DATA COLLECTION	**JANUARY2018**	**DECEMBER 2018**
DATA ANALYSIS	**JANUARY 2019**	**JUNE 2019**
THESIS WRITING	**JULY 2019**	**OCTOBER2019**
THESIS SUBMISSION FOR MARKING	**MAY 2020**	**JUNE 2020**
THESIS BINDING AND SUBMISSION (FINAL COPIES)	**AUGUST 2020**	**SEPTEMBER 2020**

Appendix 10: IREC Formal Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

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

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET

Reference: IREC/2017/194
Approval Number: 0002073

1st March, 2018

Dr. Abdullahi Ali Issack,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
01 MAR 2018
APPROVED
P. O. Box 4606 - 30100 ELDORET

Dear Dr. Abdullahi,

RE: FORMAL APPROVAL

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

"Characteristics and Treatment Outcome of Paediatric Forearm Shaft Fractures at the Moi Teaching and Referral Hospital, Eldoret, Kenya ".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 2073*** on 1st March, 2018. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 28th February, 2019. 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	CEO	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

Appendix 11: IREC Continuing Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

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

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2017/194
Approval Number: 0002073

1st March, 2019

Dr. Abdulahi Ali Issack,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
01 MAR 2019
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Dr. Abdullahi,

RE: CONTINUING APPROVAL

The Institutional Research and Ethics Committee has reviewed your request for continuing approval to your study titled:-

"Characteristics and Treatment Outcome of Paediatric Forearm Shaft Fractures at the Moi Teaching and Referral Hospital, Eldoret, Kenya".

Your proposal has been granted a Continuing Approval with effect from 1st March, 2019. You are therefore permitted to continue with your study.

Note that this approval is for 1 year; it will thus expire on 28th February, 2020. 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,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc:	CEO	-	MTRH	Dean	-	SOD
	Principal	-	CHS	Dean	-	SPH
	Dean	-	SOM	Dean	-	SON

Appendix 12: Hospital Approval MTRH

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone:(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

7th March, 2018

Dr. Abdullahi Ali Issack,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

APPROVAL TO CONDUCT RESEARCH AT MTRH

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

"Characteristics and Treatment Outcome of Paediatric Forearm Shaft Fractures at the Moi Teaching and Referral Hospital, Eldoret, Kenya".

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

MOI TEACHING AND REFERRAL HOSPITAL
CEO
APPROVED
07 MAR 2018
SIGN........ 30100, ELDORET

07/03/2018

DR. WILSON K. ARUASA, *MBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

cc - DCEO, (CS)
- Director of Nursing Services (DNS)
- HOD, HRISM

All correspondence should be addressed to the Chief Executive Officer
Visit our Website: www.mtrh.go.ke
A WORLD CLASS TEACHING AND REFERRAL HOSPITAL