PATTERN OF LONG BONE FRACTURES IN A PAEDIATRIC POPULATION AT KENYATTA NATIONAL HOSPITAL

BY

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Dedication

I dedicate this work to my son, Jason.

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Definition of Terms

Child: Biologically, a child is a person whose age is between two years and fourteen years (usually considered to be the age of puberty).

Paediatric: of or relating to the medical care or illnesses of children

Long bone: These are bones that are longer in one dimension than another and are found in the appendicular skeleton. They have a middle shaft (diaphysis), flaring towards the ends (metaphysis) and hyaline cartilage covered articulating ends (epiphysis). They include the humerus, radius, ulnar, femur, tibia, fibular, metaphalanges, phalanges, metatarsus and the tarsus bones. For the purpose of this study, only the humerus, radius, ulnar, femur, tibia and fibular will be considered.

Fracture: This is a break in cortical continuity of a bone. The break maybe complete or incomplete.

Injury: This is a physical lesion or loss of function of a part of the human body following exposure to intolerable amounts of energy.

Mechanism of injury: The manner in which an injury occurred e.g. fall from a height, road traffic accident

List of Abbreviations

AO PCCF	Arbeitsgemeinschaft für Osteosynthesefragen Paediatric Comprehensive Classification of Long-Bone Fractures
AO/OTA	Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic and Trauma Association
WHO	World Health Organization
AO COIAC	Arbeitsgemeinschaft für Osteosynthesefragen Comprehensive Injury Automatic Classifier software
KNH	Kenyatta National Hospital
UoN	University of Nairobi
RTA	Road Traffic Accident
ICD	International Classification of Diseases
ERC	Ethics and Research Committee

1. ABSTRACT

Background

Paediatric injuries, both accidental and non-accidental are a global public health problem. In developed countries injuries account for majority of the mortality in the paediatric age group after 1 year of age. Musculoskeletal trauma is the most common form of injury in childhood. Locally, there is a paucity of data on the distribution, cause and severity of childhood fractures.

Objective

This study aimed to determine the pattern long bone fractures, common mechanisms of injury, severity and location at time of injury in the paediatric age group.

Study design and setting

This was a cross-sectional study conducted at the Accident and Emergency department, Paediatric Orthopaedic ward and Fracture Clinics in Kenyatta National Hospital.

Study methodology

The study had 104 participants. All paediatric patients presenting with long bone fractures between October 2016 and December 2016 were registered, listed and assigned consecutive numbers. Sampling was done for those who met the inclusion criteria and they were recruited into the study.

Data obtained has been stratified and analysed based on age of patient, anatomic site of fracture, fracture classification based on the AO PCCF classification system, mechanism of injury and location at the time of injury. Chi- square test was used to analyse categorical variables. The data was summarized in terms of means, medians and modes and categorical data was presented in form of tables, charts and graphs.

Results

One hundred and four participants who had sustained 119 fractures were recruited. Males were 61(59%) and females 43(41%) in number with a median age of 6years and 5 months (2 – 14years). Majority had single (84%) and closed (96%) fractures. Majority of the fractures were due to falls (56%) and commonly occurred at home or its surroundings (56%). Upper limb fractures predominated at 53% with majority involving the distal metaphysis of the humerus (70%).

Conclusion

Majority of the long bone fractures in children in our setting occur due to falls in the home or its surroundings and the distal metaphysis of the humerus is the most commonly fractured region. The fractures showed a bimodal type of distribution with peaks at 4 ~ 6 years and at 12 ~ 14 years of age. Fractures secondary to RTAs were higher than in other studies.

2. BACKGROUND

2.1 Introduction

Childhood injuries are a global public health problem. It is estimated that in 2011 over 630 000 children under the age of 15 were killed by an injury and that for every injured child who died, there were several thousand children who went on to live with varying degrees of disability (1). Up to one in four children sustain an injury annually (2,3). Out of all these injuries, it is estimated that fractures contribute 10 ~25% with the majority of the injuries resulting from falls (4,5,6). The lifetime risk for sustaining a fracture in childhood is estimated to be up to 64% in boys and 40% in girls (7,8,9). Though some of these fractures occur in patients who already have factors like skeletal dysplasia that significantly increase the risk of fractures, majority are in healthy children. Most fractures in children heal without loss of function, but still there are significant associated costs for the child and family that include time away from school, medical costs and reduced activity for prolonged periods of time due to pain (10).

Various studies have shown an increasing trend in the incidence of fractures in children (3,4). This is attributed to increased sporting activity, which cause up to 39% of the fractures (11,12). Different geographical regions demonstrate differences in the pattern and mechanism of injury of fractures sustained. This could be due to the differences in the activities the children participate in in different geographical regions e.g. in Scandinavian countries skiing is common while it is very rare in Sub-Saharan countries. In a study carried out in Washington D. C., it was shown that neighbourhood characteristics affected fracture rate (13). In South Wales, U.K, Lyons *et al* (14) found that children from different electoral ward quarters had similar fracture rates but those from affluent quarters had more sport related fractures and those from deprived quarters had more assault related fractures.

Majority of childhood fractures are caused by falls, usually within the home environment (5). Most of these falls are preventable by institution of simple measures like supervision during play, use of soft landing surfaces in play areas and making play equipment safe. With the continuing urbanization and more people living in high-rise apartments, there is a likely increase in serious injuries resulting from falls beyond 3 meters. Another common mechanism of injury in childhood fractures are road traffic accidents. A significant increase in injuries in young adults has been noted locally with the increased popularity of motorbikes as a means of transport. The same would be expected in childhood injuries secondary to road traffic accidents but the data is insufficient.

The data on pattern of paediatric fractures and the mechanism of injury is essential in developing fracture prevention and intervention guidelines. The data currently available is mainly obtained from the western and developed world population. This data is not necessarily applicable in our region and cannot be reliably be used in guiding preventive or interventional guidelines in our setting. This study aimed to determine the fracture pattern and the common mechanisms of injury amongst children as seen in a tertiary referral hospital. With this data, policy change aimed at addressing common mechanisms of injury and reallocation of resources in orthopaedic departments to facilitate appropriate and timely intervention may be sort. The study will also form a baseline for further research in childhood fractures secondary to trauma.

3. LITERATURE REVIEW

Injuries constitute the largest proportion of conditions requiring medical attention in both the developing and developed worlds. With increasing modernization and industrialization, there has been a concomitant increase in injuries essentially across all age groups in the developing world (15).

In a study on paediatric surgical admissions in Gambia, Bickler *et al* (16) found that injuries formed the majority of admissions accounting for 46.9%. Of these, fractures were second to burns (18.1%) at 9.8% of all the admissions. In Lilongwe, Malawi, 9.7% of paediatric admissions are due to injuries with 32% of these being fractures (17). In Egypt, in a cross-sectional survey of non-fatal injuries in children across 27 governorates from June 2011 to October 2011, Halawa *et al* (5) found that fractures accounted for 28.7% of the injuries.

Locally, in 2007, Kihiko D. (18) found that fractures constituted 43.3% of injuries sustained by children falling from a height as seen at an urban Kenyan hospital. Mburugu Patrick in his thesis on home based injuries in children presenting in Kenyatta National Hospital in 2011 found that 37.1% of the injuries were due to falls with fractures contributing 58.3% (6). This is approximately 21.6% of the total injuries reported.

Majority of these fractures involve the long bones of the upper and lower limbs. In majority of studies from the developed world, the distal forearm is the most involved location in paediatric fractures (4,16,19).

3.1 Definition of long bones

Based on shape, bones are classified into four groups:

i) Long,
ii) short,
iii) flat and
iv) Irregular bones.

Long bones are longer in one dimension than the other and consist of a shaft/ diaphysis which has a thick cortical wall around a marrow filled cavity, the medulla and a metaphysis towards either end formed by a flaring of the bone which has a thinning outer cortical bone covering a cancellous bone core. At either end of the long bone is the hyaline cartilage covered epiphysis (20,21). The long bones are also generally considered to be formed via endochondral ossification (21).

The long bones are only found in the appendicular skeleton and include the femur, tibia, fibular, humerus, radius and ulnar. They may also include the clavicle, metacarpals, meta-phalanges and the phalanges. The feet and hands are generally considered separately in orthopaedics due to their uniqueness in terms of injury patterns and modes of clinical management. This is reflected in the AO PCCF classification system which only considers the femur, tibia, fibula, humerus, ulnar and radius (22). These are the bones that will be considered in this study.

3.2 Distribution

1. *Age of Patient*

The incidence of fractures in children has been noted to increase from birth reaching a peak earlier in girls at a mean age of 9 years and later at 14 years in boys (7,10,23). It is noted that the peak coincides with the period of pubertal peak height velocity during which there is a relative decrease in bone mineral density (23,24,25). Faulkner *et al* (24) found that size-corrected bone mineral density decreased significantly before age of peak height velocity and then increased until 4 years after peak height velocity. The peak height velocity varies from one region to another depending on environmental, nutritional and genetic factors.

In road traffic injuries, 5-14 year olds have been found to be most at risk. Children account for 5 – 10% and 30 – 40% of all road traffic deaths in high-income and in low-income countries respectively (26).

2. *Place of Injury*

A large proportion of childhood injuries (61% ~ 64.4%) occur in or around the home (5,27). Kihiko D. (18) noted that most of the injuries (78.75%) sustained by children who fall from a height as seen at an urban Kenyan hospital occurred in the home environment. In a study carried out in Naples in Italy only 41.6% of paediatric fractures occurred at home or its surroundings (19). This is in contrast to the high levels found in the less developed countries. Some studies have noted that despite children spending considerable amounts of time in school, proportionally fewer injuries occur there. This figure is estimated at 10% and is associated with sports (28).

With increasing industrialization and urbanization, children are spending more and more time on roads walking, playing or even carrying out chores. In 2004, 260,000 fatalities occurred in children on roads. In most countries, road traffic accidents are amongst the top two causes of deaths and disabilities especially amongst children. The morbidity and number of children disabled each year from road traffic accidents is not known but is estimated at about 10 million.

This partly because not all injured children are taken to hospital and due to poor record keeping (26).

3. *Mechanism of injury*

The leading cause of long bone fractures in children is falls (7,8,11). Mutto *et al* (29) in Kampala City noted that play and daily living activities were the commonest injury times with falls, burns and traffic accidents accounting for 70.5% of unintentional childhood injuries. Hedström *et al* (11) in Sweden noted majority of long bone fractures were secondary to falls whereas those of the axial skeleton, hand and foot were mainly secondary to collisions, road traffic accidents and blunt trauma. This has also been noted in other studies as shown in the table below:

First author	Age group	Study period	Location	Incidence per 10^4	Most common fracture site	Most common mechanism of injury
Landin	0–16	1950–1979	Sweden	212	Distal forearm 23%	Falls
Cooper	0–17	1988–1998	Great Britain	133	Forearm 30%	N.A.
Kopjar	0–12	1992–1995	Norway	128	Distal radius 27%	Falls 71%
Tiderius	0–16	1993–1994	Sweden	193	Distal forearm 26%	Falls on ground level 40%
Lyons [a]	0–14	1996–1996	Scandinavia	156–178	Forearm 20%	Falls
Lyons [b]	0–14	1996–1996	Wales	361	Forearm 36%	Falls
Brudvik	0–15	1998–1998	Norway	245	Distal forearm 27%	N.A.
Rennie	0–15	2000–2000	Scotland	202	Distal forearm 33%	Falls < 1 m 37%
Our results	0–19	1993–2007	Sweden	201	Distal forearm 26%	Falls < 0.5 m 24%

[a] Lyons' results from districts in Sweden, Norway, and Finland.

[b] Lyons' results from a Welsh district.

(Extracted from Hedström, E M Epidemiology of fractures in children and adolescents. Acta Orthop. 2010; 81(1): p. 148-153.)

For activity specific fractures, in Lørenskog, Norway, it was noted snowboarding led in terms of fractures sustained in sporting activities, while trampolining was lower than other sporting activities but resulted in more severe injuries (10).

4. *Anatomic site of fracture*

Locally there is no available data on the anatomic location of long bone fractures in children. Amongst adults, P. Waithiru (30) found that majority of appendicular skeleton fractures involved the lower limb, the tibia in particular in Kenya. In Britain, fractures of the forearm lead followed by those of the humerus, tibia/fibula and femur in that order amongst children

(8). Valerio *et al* in the study on pattern of fractures across paediatric age groups: analysis of individual and lifestyle factors, noted a similar pattern (19). Randsborg *et al* (10) in Norway found the most common fracture site being the distal part of radius at 31.1% of the fractures sustained. The non-dominant arm was also more likely to be fractured at 52.9% of the upper extremity fractures.

In Britain, it was also noted that the incidence of tibia/fibula fractures followed a different pattern compared to that of other long bone fractures. In girls, a steady reduction in rate was noted with age whilst in boys, the converse was true (8).

3.3 Fractures in Paediatrics

There are several main differences between paediatric and adult bones. These result in differences in bone biomechanics in the two groups with resultant unique fractures in children.

One of the main differences between paediatric and adult bones is the periosteum. In children, the periosteum is thicker and stronger than in adults. It is loosely attached to much of the shaft of the bone, but it attaches densely into the physeal periphery (the zone of Ranvier) through intricate collagen meshwork, thereby playing a role in fracture mechanics (31). It limits fracture displacement and reduces the likelihood of open fractures. Open fractures in children are estimated to occur in only 2% (32,33).

Paediatric bone is less dense, more porous, and is penetrated by more vascular channels than adult bone. The porosity is due to a greater number of osteon systems traversing the cortex. This gives it a comparatively lower modulus of elasticity, lower bending strength, and lower mineral content. The increased porosity of paediatric bone also helps prevent propagation of fracture lines, explaining the infrequency of comminuted fractures in children (34). This porosity also predisposes the paediatric bone to failure either in tension or in compression unlike the adult bone that fails almost exclusively in tension (34).

The above features result in some fracture patterns that are unique to children:

1. Plastic Deformation/Bowing fracture: Most common in the forearm and the fibular regions. It is a result of a bending force exceeding the bone's ability to recoil to its normal position. If the tension side cannot propagate the fracture, microscopic fractures occur to dissipate the impact energy, thus creating a plastic deformity (35). If no sub periosteal hematoma forms, remodelling is unlikely as no significant callus formation occurs. This may lead to a permanent deformity (36).

2. Buckle/Torus Fracture: Often occur at the junction of the more porous metaphysis and denser diaphysis secondary to a compressive force (35). The denser diaphysis segment is pushed into the more porous metaphysis segment creating a bump on the cortex. If its circumferential its then referred to as a torus fracture. It is common in the distal radius but is also seen in the distal tibia, fibula and femur. Soft tissue swelling is usually minimal as the incompletely fractured cortex prevents escape of blood into the soft tissues (32).
3. Green stick Fracture: Occurs when a bending force causes failure of the tension side of the bone only. The compression side of the bone undergoes plastic deformation. Due to this plastic deformation, the fracture usually has to be completed to allow for correction (31).
4. Classic Metaphyseal Lesions (CML, corner/bucket handle fractures): This is a sub-epiphyseal planar fracture through the cancellous metaphyseal bone. It occurs at the 'corner' of where the metaphysis joins the physis. Commonly secondary to shearing and tensile forces through these regions. These fractures are associated with uncommon mechanisms of injury like yanking the limb of child, violent shaking, slamming of a child while using the limb as a lever. As can be noted, these are actions commonly associated with child abuse. The fractures can also be iatrogenic like in forceful manipulation of a clubfoot (37).

3.3.1 Physeal fractures

Physis or growth plate is a temporary cartilaginous tissue situated between the primary and secondary ossification centres of all long bones responsible for longitudinal growth from 9 – 10 weeks' gestational period to 15- 19 years of age (36). The growth plate is an important distinguishing feature in paediatric bones. It is composed of at least four zones of cells in different stages of maturation. These zones are:

i) Germinal zone – closest to the physis. Contains small rounded cells

ii) Proliferation zone – cells in this zone undergo mitosis increasing in numbers

iii) Hypertrophy zone – cells in this zone undergo hypertrophy increasing in size to 5 to 10 times their original size. Some of the cells undergo apoptosis. This is the weakest zone of the physis (38).

iv) Ossification zone – the hypertrophied cell columns are invaded by blood vessels that bring in osteoblasts leading to ossification of the cells closest to the metaphysis.

The physis is the prime mover of longitudinal bone growth and injury to it is likely to lead to disturbances in growth. It is also a weak point near various joints and it tends to give way before the ligaments surrounding the joint do. Children, especially during the period of peak longitudinal growth, are more likely to sustain fractures involving the growth plate in injuries whose mechanism would have otherwise caused a sprain in an adult.

Physeal fractures make up about 20% of fractures in children (32,39). Severity of physeal fractures largely depends on the involvement of the germinal layer. Extension into the germinal layer is likely to cause a physeal bar with resultant growth arrest around it. If more than 7% of the physis distal femur physis is involved, then a clinically significant disturbance in growth is likely to occur (40).

3.4 Classification of long bone fractures:

Taxonomy, the science of naming and classifying things, is not unique to orthopaedics or to fractures. It has been used in various fields and it helps in naming, describing, comparing, guiding actions/interventions and in predicting outcomes (41,42).

Fracture classification systems are grouped into four main categories:

1. Fracture-specific systems - designed to describe fractures of a precise and exclusive skeletal location. For example, Schatzker classification of tibia plateau fractures apply only to the tibia plateau.
2. Patient specific systems apply only to a certain category of patients, such as children, or patients with cancer, but are not restricted to a specific bone.
3. Generic or universal classification systems – designed to classify any fracture of any bone by always applying the same logical methodology. The AO/OTA classification system - a numerical – alphabetical coding system – is essentially the only universal classification system in use today (41). These systems are best suited for research.
4. Classification systems that deals with the soft-tissue injury associated with the fracture, rather than with the fracture itself. An example is the Oestern and Tscherne Classification of Closed Fractures (41).

A valid fracture classification needs to be accurate, reliable, comprehensive, clinically useful and easy to use (43).Majority of available studies have used the International Classification of Diseases (ICD) type of classification (8,10,14). The ICD system is used to classify nearly all the diseases known to man. This makes it complex and difficult to use. The ICD version 10 has been improved over the previous versions by allowing for coding of fracture type (44). This, makes it difficult to compare different studies as no fracture morphology is included. Other studies have used fracture specific classifications while others have simply grouped fractures by the bone affected without including the fracture morphology further complicating the situation (8,2).

3.4.1 AO Paediatric Comprehensive Classification of Long-Bone Fractures (PCCF)

The commonly used fracture classification systems in paediatrics tend to focus on particular aspects of the fractures or specific types of fractures e.g. Salter-Harris classification for fractures involving the physis and Gartlands classification for supracondylar fractures respectively. Other classifications that have tried to include all fracture patterns have not been scientifically validated (45).

The AO PCCF is a validated classification system based on the AO/OTA Classification of fractures of the adult skeleton but it adds child-specific relevant fracture features (22,46). In the first to the third phases of development and validation, the accuracy for AO PCCF was above 90% amongst experienced surgeons.

The overall structure of the classification system is based on fracture location and morphology. The fracture location comprises the different long bones and their respective segments and sub-segments. The morphology of the fracture is documented by a specific child code that stands for the fracture pattern, a severity code, and an additional code that is used in certain types of displaced supracondylar humeral, displaced radial head and neck, and femoral neck fractures.

This classification has the advantage of being very similar to the widely accepted and used AO/OTA Classification of fractures of the adult skeleton. This brings with it familiarity in its usage by the surgeon. In a validation study by Slongo *et al* (46), after only four sessions of classification, a group of surgeons had an overall kappa coefficient above 0.80 with estimates of classification accuracy being above 90%. Slongo *et al* went ahead to validate it using a web based multi-centre agreement study. He found a median accuracy of above 80% for each bone and fracture type amongst surgeons of varying experience (46,47).

The AO PCCF has the disadvantage of having a steep learning curve but this is outweighed by the advantages.

In applying the AO PCCF fracture classification system, there are several questions that must be answered for each fracture:

- Which bone? The major bones in the body are numbered, with the humerus being No.1, the forearm No.2, the femur No.3, the tibia/fibula No.4 (Fig. 1). This is the first number of the fracture code.

- Where in the bone is the fracture? The answer to this question identifies a specific segment within the bone and is the second number of the code. The segments are **1** – proximal segment; **2** – diaphysis**(D)**, **3** - distal segment. The proximal and distal segments are composed of two sub-segments i.e. epiphysis**(E)** and metaphysis**(M)**. The proximal and distal segments are defined by a square extending from the physis towards the shaft whose sides are equal to the widest distance across the physis in addition to the epiphysis. In paired bones i.e. radius/ulna and tibia/fibula, both bones must be included in the square. The proximal femur is an exception. Its metaphysis is not defined by a square but located between the trochanteric growth plate and the sub trochanteric line (48). Apophysis fractures are considered as metaphyseal.

- Which fracture pattern? This is where there is a big difference from the AO/OTA adult fracture classification. This is due to some of the unique fracture patterns found in children. The fracture patterns are specific to the sub segment they are located in and therefore grouped accordingly as E, M, or D. The patterns are best illustrated as in figures 3 and 4 below.

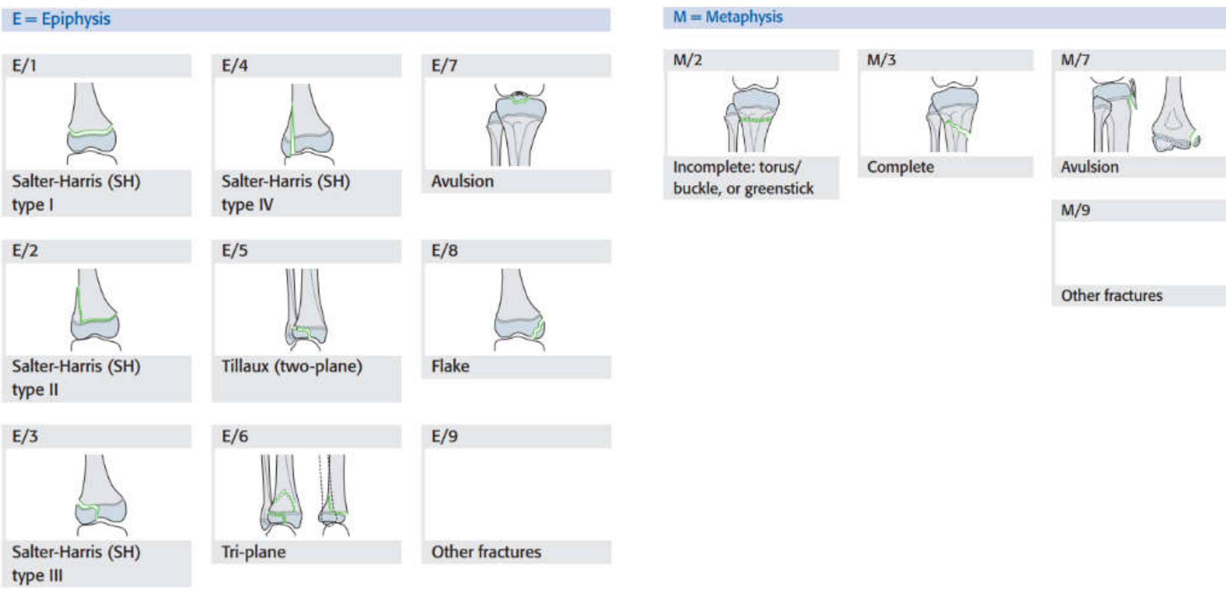

FIGURE 3.1: FRACTURE PATTERNS IN THE EPIPHYSEAL AND METAPHYSEAL SEGMENTS

(Extracted from Slongo T. et al. AO Paediatric Classification Group (2007) AO Paediatric Comprehensive Classification of Long-Bone Fractures (PCCF). Copyright © 2010 by AO Foundation, Switzerland)

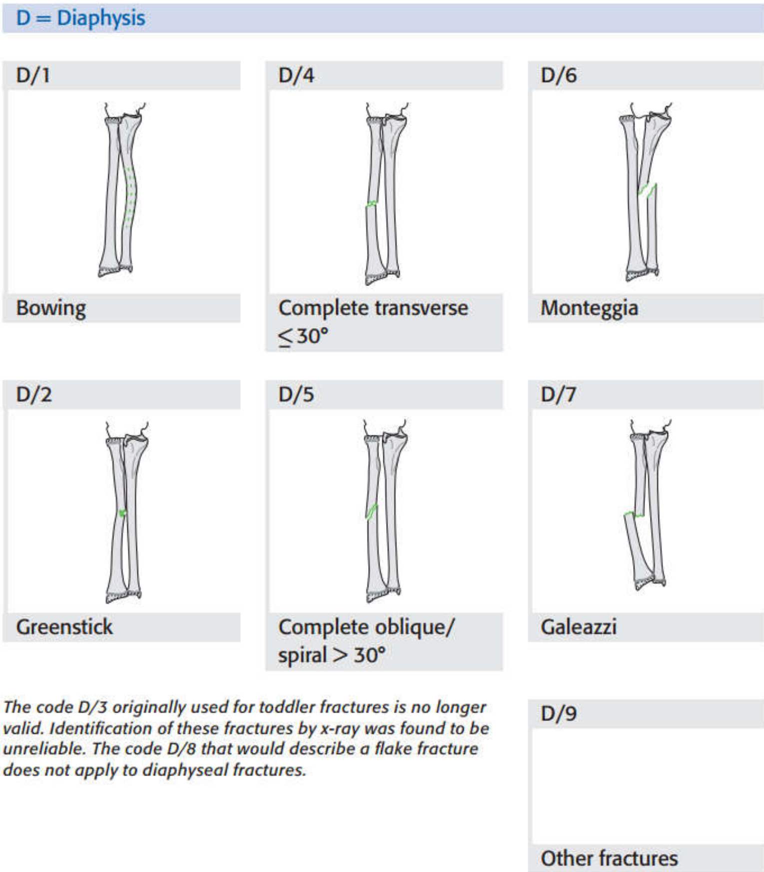

FIGURE 3.2: FRACTURE PATTERNS IN THE DIAPHYSEAL SEGMENT

(Extracted from Slongo T. et al. AO Paediatric Classification Group (2007) AO Paediatric Comprehensive Classification of Long-Bone Fractures (PCCF). Copyright © 2010 by AO Foundation, Switzerland)

- What is the pattern of each of the paired bones? If both paired bones have the same fracture pattern, then one classification code is assigned. If the fracture patterns are different, then a small letter is used to designate the bone involved e.g. 22u D/5 describes an isolated spiral diaphysis fracture of the ulnar.

- What is the severity of the fracture? Grouping further divides the fractures according to fracture severity i.e. simple **(.1)** and multi fragmentary **(.2)**.

- If it's a humerus supracondylar fracture, what's the degree of displacement? Additional code (level I to IV) indicates displacement from incomplete fracture to a complete fracture with no contact between fragments e.g. **13-M/3.1 I** can be considered to be a Gartlands I fracture.
- If it's an avulsion fracture, then an "m" is used to stand for medial and "l" for lateral sides of avulsions.
- For radial head and radial neck fractures, a code is added ranging from I for non-displaced to III for displacement more than half the bone diameter.

- For femoral neck fractures, an additional code is used to indicate the location i.e.: Type I – Mid-cervical, Type II – Basi-cervical, Type III – Trans-trochanteric.
- The overall structure of the coding is as follows:

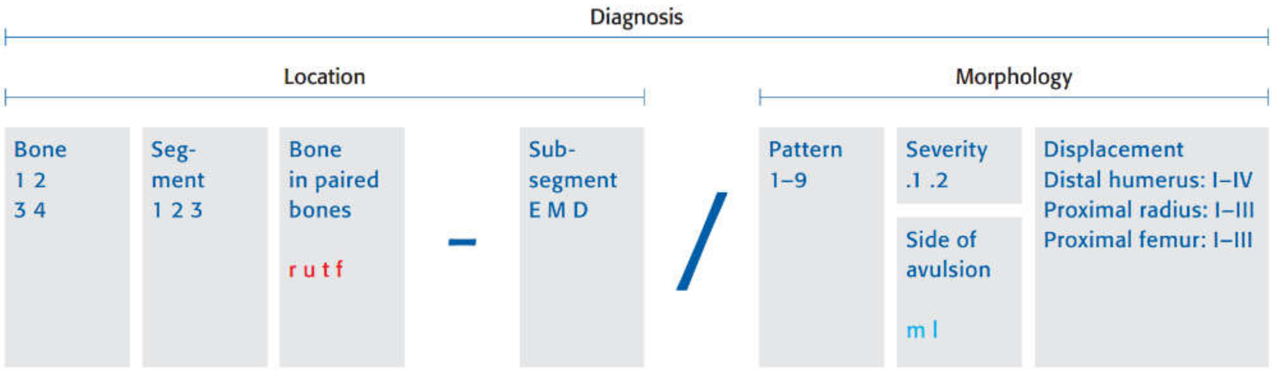

FIGURE 3.3: OVERALL STRUCTURE OF PAEDIATRIC FRACTURE CODING

(Extracted from Slongo T et al. AO Paediatric Classification Group (2007) AO Paediatric Comprehensive Classification of Long-Bone Fractures (PCCF). Copyright © 2010 by AO Foundation, Switzerland)

Appendix IV (22) gives an overview of the coding for the various fractures.

3.5 Conclusion

It is noted that locally no studies evaluating the epidemiology of long bone fractures in children could be identified. For the studies that have been done elsewhere, there is a lack of a uniform universal fracture pattern classification in the studies. The settings in these regions are also different from our setting. This makes comparison of results difficult. The AO -PCCF may help solve any discrepancies arising from usage of different classification methods. Other local studies have looked at injuries in childhood in general and have not gone into details about fractures and the bones involved. This means there is no solid linkage between the various variables and specific fractures.

4. STUDY JUSTIFICATION AND OBJECTIVES

Though data exists on incidence of various long bone fractures in childhood, there is a lack of classification of fracture by severity. Most studies focus on specific fractures, activities, age groups or special populations. Most studies are also retrospective in nature and this comes with the disadvantages associated with retrospective studies.

The medical personnel must understand the patterns, causes and preventive strategies of childhood injuries if they are to share this with the patients and caregivers. For development of any programs aimed at reducing injuries, impacts of injuries and interventions, reliable data is necessary. In other countries, it has been shown that childhood injuries can be reduced by implementation of simple safety guidelines. This is usually done using the Haddon Matrix (49,50). Locally, data on childhood fractures is lacking making it difficult to design preventive programs.

Focusing orthopaedic interventions and allocating of resources is difficult without prerequisite data identifying the various needs. Some of the paediatric fractures are "fractures of necessity" requiring surgical intervention (51). Without this data, it is difficult to allocate resources.

This study aims at determining the pattern, severity, magnitude and mechanisms of long bone fractures in children as seen at Kenyatta National Hospital.

4.1 Objectives:

4.1.1 Primary Objective

i) To determine the pattern of long bone fractures in the paediatric age group presenting at Kenyatta National Hospital.

4.1.2 Secondary Objectives

i) To determine the common mechanisms of injury in long bone fractures in paediatric age group presenting at KNH.
ii) To determine severity of long bone fractures according to the AO PCCF classification in the paediatric age group presenting at KNH.
iii) To determine physical location of fracture occurrence among the paediatric age group presenting at KNH.

5. MATERIALS AND METHODS:

5.1 Study Design

Cross-sectional study.

5.2 Study Site

The study was carried out in the accident and emergency department, paediatric orthopaedic ward and fracture clinics at Kenyatta National Hospital. Kenyatta National Hospital is the largest tertiary hospital in Kenya.

All trauma patients visiting KNH were initially seen at the accident and emergency department where triaging is done. They were reviewed by the casualty medical officers, who manage any cases that fall within their scope. These patients were usually managed on an outpatient basis. These include simple shaft fractures in paediatric patients requiring only casting. Any patients outside the scope of the casualty medical officers were referred to the orthopaedic resident on call, who in concert with the orthopaedic consultant on call, decides on whether the patient could be managed as an outpatient or as an inpatient. Patients managed on an outpatient basis were usually reviewed the following day in the fracture clinics. Paediatric orthopaedic inpatients were managed in ward 6B, which was the main paediatric orthopaedic ward within the hospital.

5.3 Study Population

All children and adolescents older than two years and younger than fourteen years of age presenting at Kenyatta National Hospital with a fracture/fractures between October 2016 and December 2016 were included.

Exclusion criteria included:

1. Pathologic fractures
2. Patients on long term steroid treatment
3. Healed fractures
4. Patients/ guardians who decline to have radiographs of fractures taken

5.4 Sample Size:

It is estimated that fractures contribute about 25% of all childhood injuries (4,5,6).

Using the Cochran formula to estimate sample size when population size is infinite (52,53):

$$n_o = \frac{Z^2 pq}{e^2}$$

Where *n* is the sample size, *Z* is desired confidence level (95%), *p* is the estimated proportion of an attribute that is present in the population (0.25), *q=1-p* and *e* is the desired level of precision (0.05).

Substituting:

$$n_o = \frac{1.96^2(0.25)(1-0.25)}{0.05^2} = 288.12$$

From KNH registry records, 139 paediatric patients with long bone fractures were seen between February 2016 to April 2016, then our sample size was calculated to be:

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}}$$

Where *N* is the population size. Substituting:

$$n = \frac{288.12}{1 + \frac{(288.12 - 1)}{139}} = 93.98 \approx 94$$

Adding 10 % for non-responsive participants gave a total of **104 participants**.

5.5 Study Procedures

5.5.1 Sampling

Convenience sampling was carried out. All children above the age of two years and below the age of fourteen years presenting at the accident and emergency department, orthopaedic paediatric ward or fracture clinics with long bone fractures were eligible for recruitment into the study.

5.5.2 Participant enrolment

The principal investigator or one of two research assistants did the enrolment using convenience sampling. Recruitment was done in the Accident and Emergency department on all days of the duration of the study between 8.00am and 8.00pm and any patient not captured during this period was captured within 72 hours in the orthopaedic paediatric ward in case of admission or the fracture clinic for those allowed home after treatment in accident and emergency department.

5.5.3 Consenting

The guardian/parent and the patient, if above 10 years of age, were explained to about the study. Consent was sought from the guardian. Assent will was also obtained from those patients who were above ten years of age. If consent and the assent were given, then the patient was recruited into the study.

The participants were assigned a study number which was used in filling of the questionnaires and fracture coding forms.

5.5.4 Data Collection

The principal investigator or the research assistants, using a questionnaire and a fracture coding form collected data from the participants. The following data was collected using the questionnaire: Age of patient, sex of patient, mechanism of injury, anatomic site of the fracture, whether open or closed fracture, if a fall, approximate height of fall, place of occurrence of accident, whether accompanied or not at time of injury, history of previous fractures, type of road accident and type of sport.

The fractures were classified according to the AO Paediatric Comprehensive Classification of Long-Bone Fractures guidelines. This was done using the AO PCCF charts and the AO Comprehensive Injury Automatic Classifier (AO COIAC) software by the principal investigator.

5.5.5 Data Management and Analysis

Collected data was stored in a database within AO-COIAC software and at the end of the study exported to Microsoft Excel 2016 for analysis. The data was stratified and analysed based on age of patient, anatomic site of fracture, fracture classification based on the AO PCCF classification system, mechanism of injury and place of injury. The data was summarized in terms of means, medians and modes and will be presented in form of tables, charts and graphs.

5.6 Ethical Considerations

Ethical approval was obtained from Kenyatta National Hospital – University of Nairobi ethics and research committee as per the attached letter of approval.

All guardians or parents were required to give consent on behalf of the participants prior to enrolment into the study. For participants above 10 years of age, assent was also sought from them. The principal investigator or one of the research assistants undertook this process after explaining to the guardian and the participant, if above 10 years of age, the details of the study.

5.7 Study Limitations

The study had the following limitations that we tried to mitigate:

i) Inter - observer variability in classification of fractures – This was mitigated by using both the fracture coding form and the AO – COIAC software.

ii) Quality of radiographs – the hospital currently has digital radiographs. We liaised with the radiology department in cases of poor quality radiographs.

6. RESULTS

The study was carried out between October 2016 and December 2016. 104 patients with a total of 119 fractures met the inclusion criteria. Of these, 17(16%) had sustained more than one fracture. The males formed a majority at 59% giving a male: female ratio of 1.4:1. The mean age was 7years and 2 months. Most of the fractures occurred in the 2 ~ 6 years age groups accounting for 45%. The 6 ~ 8 years age group had the least number of patients at 28%. Most of the fractures occurred at 'home or its surroundings' (56%) followed by fractures occurring on the 'road' (22%). The predominant mechanism of injury was falls at 56 %. Only 13% of the patients sampled sustained fractures during sports. A big majority of the patients (84%) sustained single fractures giving a single fracture: multiple fractures ratio of 21:4. A summary of these and other characteristics of the patients are as in the Table 6.1 below:

CHARACTERISTIC		**NUMBER(n=104)**	**%**
Gender	Male	61	59%
	Female	43	41%
Age	Mean	7yrs 3mnths	-
	Median	6yrs 5mnths	-
	IQR	6yrs 1mnths	-
Age groupings	2yrs ~ 6yrs	47	45%
	6yrs ~ 10yrs	28	27%
	10yrs ~ 14yrs	29	28%
Place of Injury	Home	58	56%
	School	10	10%
	Public Playground	14	13%
	Road	22	21%
	Other	0	0%
Mechanism of Injury	Fall	58	56%
	RTA	22	21%
	Sport	13	13%
	Assault	0	0%
	Gunshot	0	0%
	Other	11	11%
Fractures	Single	87	84%
	Multiple	17	16%
	Open	5	4%
	Closed	114	96%

TABLE 6.1: GENERAL CHARACTERISTICS

6.1 Fracture Distribution

Fracture distribution by age demonstrated two peaks, one at 4 ~ 6 years of age and another at 12 ~ 14 years of age. The 4 ~ 6 year olds accounted for 21% of all the fractures recorded while the 12 ~ 14 years age group accounted for 16%. Males accounted for most of the fractures in all age groups except at 10 ~ 12 years age group where females dominated at 58% as shown in Figure 6.1 below.

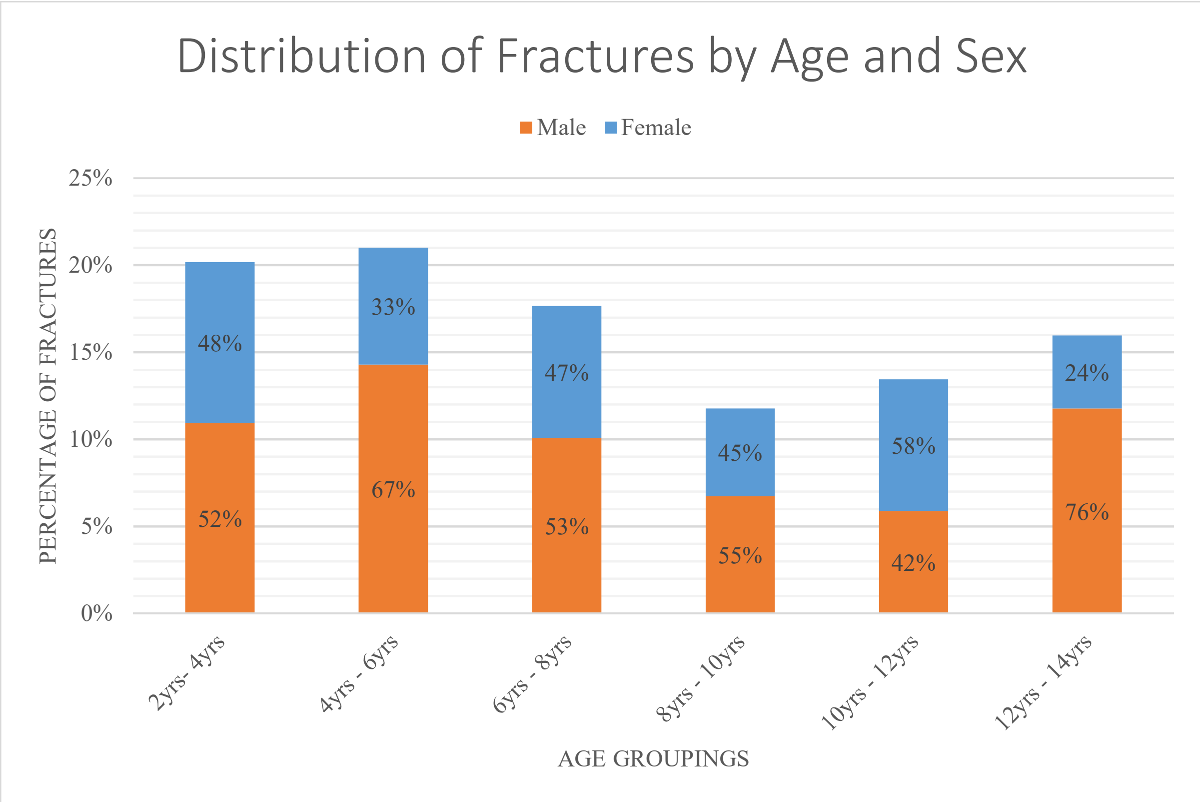

FIGURE 6.1: DISTRIBUTION OF FRACTURES BY AGE AND SEX

Overall, the upper limb was involved in 53% of the fractures compared to 47% for the lower limb. This was significant having a p value of 0.007. Looking at the different age groups in Figure 6.2 below, it is noted that in the 2 ~ 4 years and 4 ~ 6 years age groups, most of the fractures involved the lower limb, but, from the 6^{th} year of age up to 14^{th} year of age, the upper limb was predominantly fractured. There was no significant difference in involvement between the right and left sides (p=0.33).

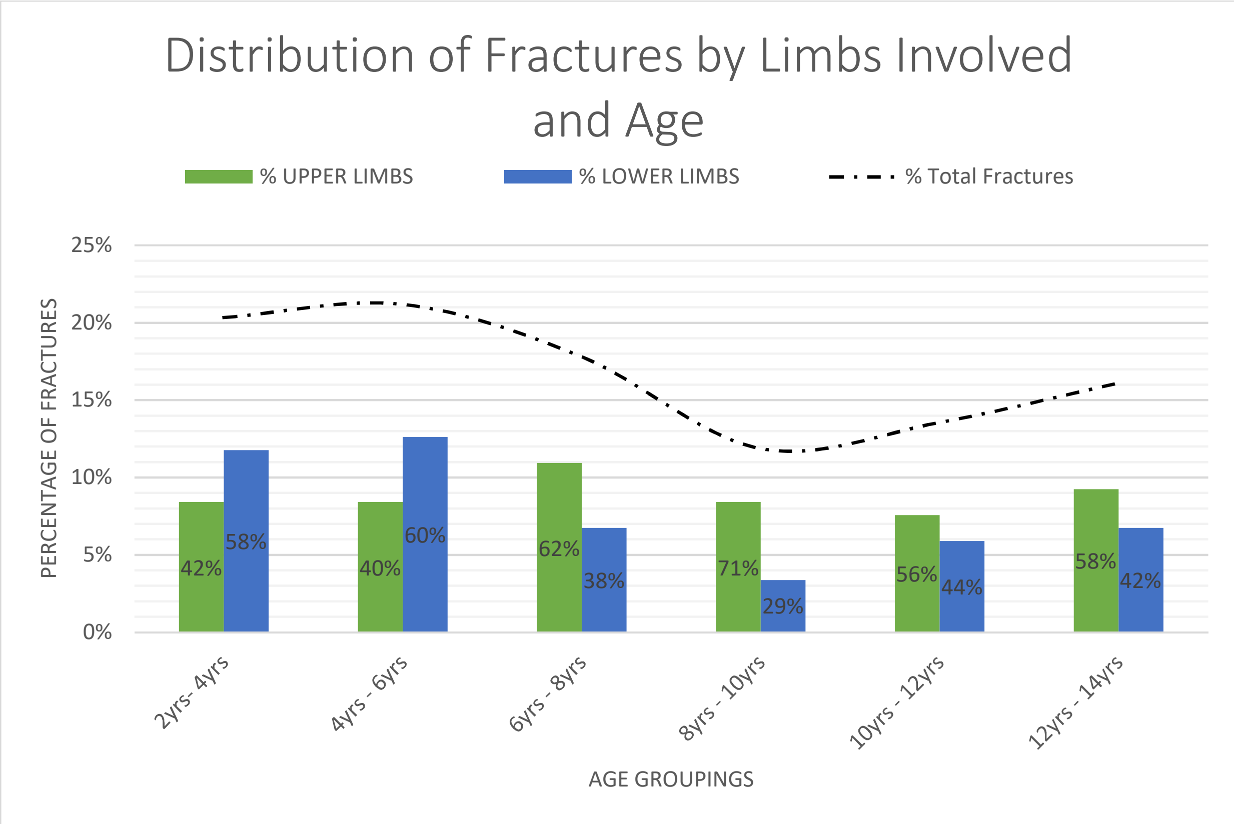

FIGURE 6.2: DISTRIBUTION OF FRACTURES BY LIMB INVOLVED AND AGE

6.2 Place of Injury

Majority of the fractures occurred at the home and its surroundings (56%). 21% of the fractures happened on the road, 13% in public playgrounds and only 10% in schools.

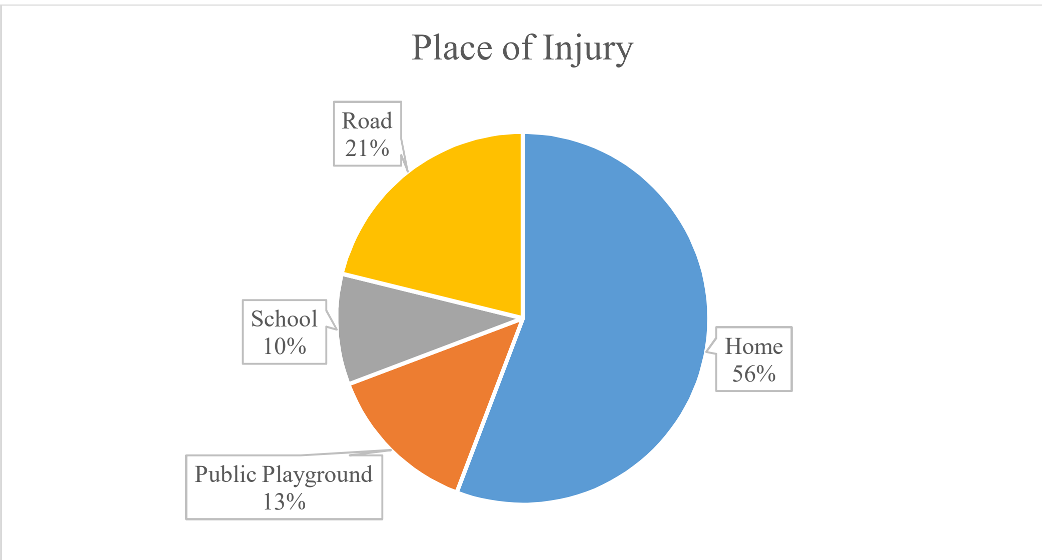

FIGURE 6.3: PLACE OF INJURY

Majority of the fractures occurring at home or its surroundings were in the 2 ~ 6 years old with a mean age of 6 years compared to the whole population mean of 7.3 years. Fractures occurring in the school environment peaked in the 8 ~ 14 years age groupings with a mean age of 9years 6 months. Accidents on the road peaked in the four to eight year olds. Males were statistically more likely to sustain a fracture at home and its surroundings than the females. This data is summarized in the table below:

Location	male	female	mean age	2~4yrs	4~6yrs	6~8yrs	8~10yrs	10~12yrs	12~14yrs	Total
	n (%)	n (%)	yrs.	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n
Home	39(62)	19(46)	6	19(86)	17(71)	7(41)	3(27)	5(38)	7(41)	58
School	6(10)	4(10)	9.5	1(5)	1(4)	1(6)	2(18)	2(15)	3(18)	10
Road	11(17)	11(27)	7.8	2(9)	6(25)	5(29)	2(18)	4(31)	3(18)	22
Public Playground	7(11)	7(17)	9.6	0(0)	0(0)	4(24)	4(36)	2(15)	4(24)	14
Total	63(100)	41(100)	7.3	22(100)	24(100)	17(100)	11(100)	13(100)	17(100)	104

TABLE 6.2: LOCATION AT TIME OF INJURY VS SEX AND AGE

Majority of the fractures happened while other children, at 49%, witnessed the event. An adult witnessed only 23% of the events leading to fractures in the sampled patients. 28% of fractures happened while the patient was alone.

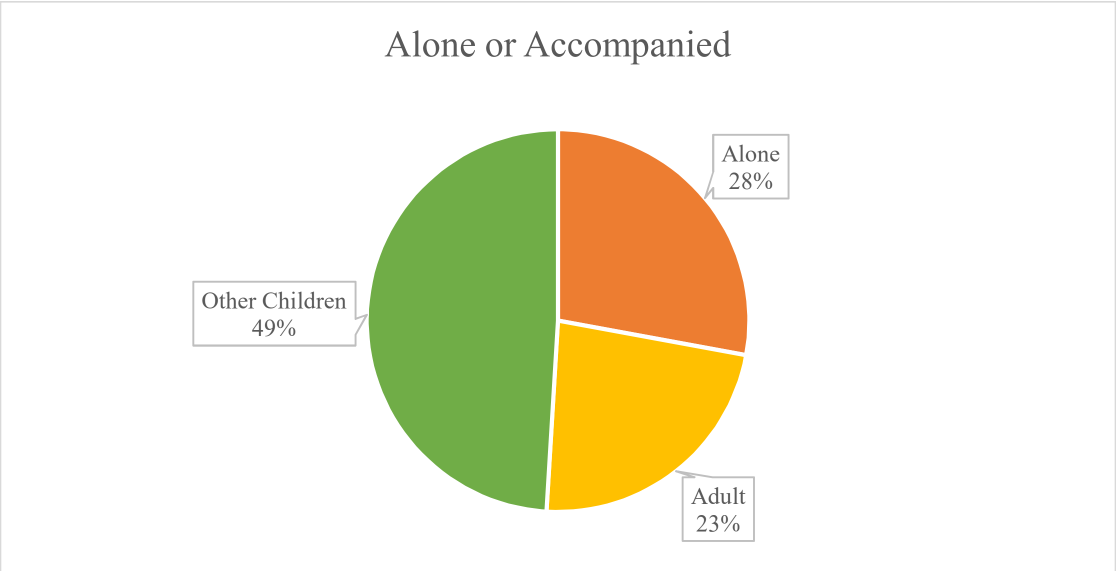

FIGURE 6.4: PATIENT WAS ALONE OR ACCOMPANIED

6.3 Mechanism of Injury

Four mechanisms of injury were identified. These were "falls" at 56%, mean age of 6 years 10 months; "road traffic accidents" at 21%, mean age of 7 years 9 months; "sport injuries" at 12%, mean age of 10 years 9 months and "others" at 11%, mean age of 6 years 10 months in that order.

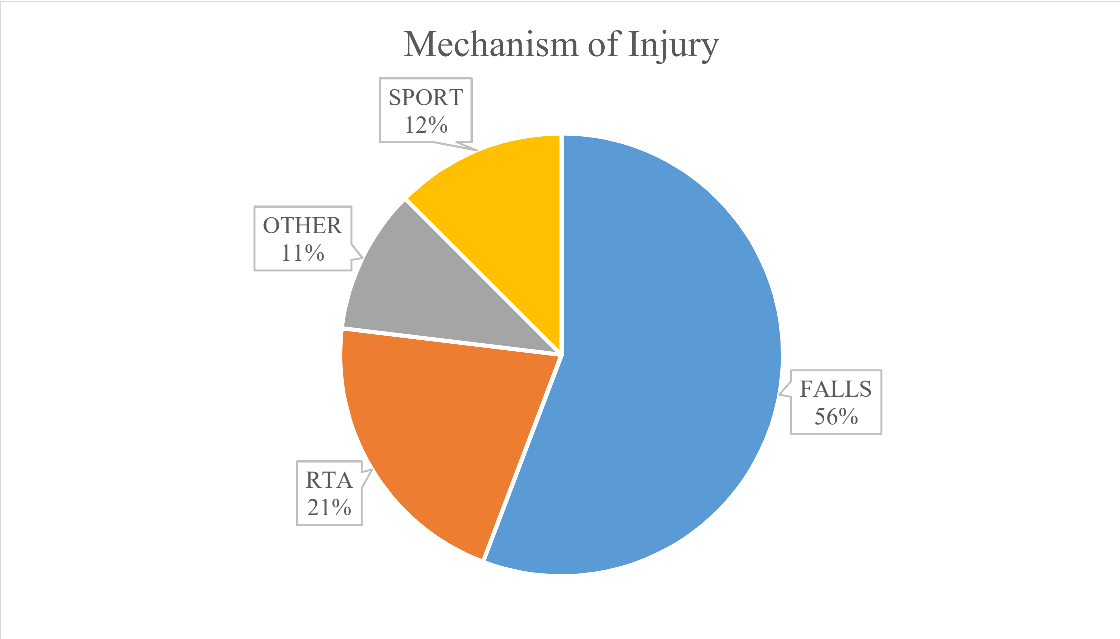

FIGURE 6.5: MECHANISM OF INJURY

The distribution of mechanism of injury by age groups was as below:

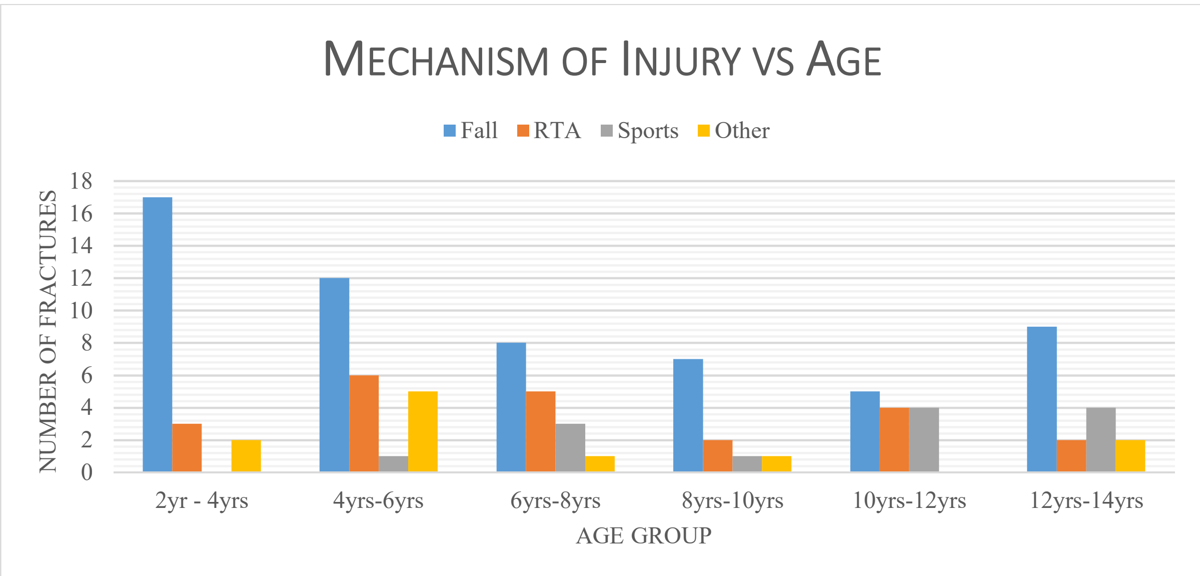

FIGURE 6.6: MECHANISM OF INJURY VS AGE

Males had significantly more fractures that resulted from falls than females. In the rest of the mechanisms of injury, there was no difference noted as shown in Table 6.4 below. *p* value was taken to be significant at values ≤ 0.05.

Mechanism of Injury	**Male:**	**Female**	**p value**
	n (%)	n (%)	
Fall	37(59)	21(51)	0.035649
RTA	10(15)	12(29)	0.669815
Sports	8(13)	5(12)	0.405381
Other	8(13)	3(7)	0.131668

TABLE 6.3: MECHANISM OF INJURY VS SEX

As shown in Table 6.5 below, falls from heights below 1 meter were the main cause of injury both in the "falls" subgroup and as a proportion of all fractures sustained. Majority of these falls were on hard surfaces adding up to 76% of all the falls.

Height of fall	**Hard Landing Surface**	**Soft Landing Surface**	**Total**
0 ~ 1 meter	22	8	30
1 ~ 3 meters	17	2	19
> 3 meters	5	1	6
Totals	44	11	55

TABLE 6.4: FALL VS HEIGHT AND LANDING SURFACE

Road traffic accidents peaked at 4 ~ 8 years of age. In 68% of the road traffic accidents, the patient was a pedestrian, in 18% was a pillion and in 14% was a passenger in a car. Of note is that all patients in the study who were car passengers at the time of accident were not restrained.

Sports injuries peaked at 10 ~ 14 years of age. Majority of the fractures, 62%, occurred in contact sports such as football.

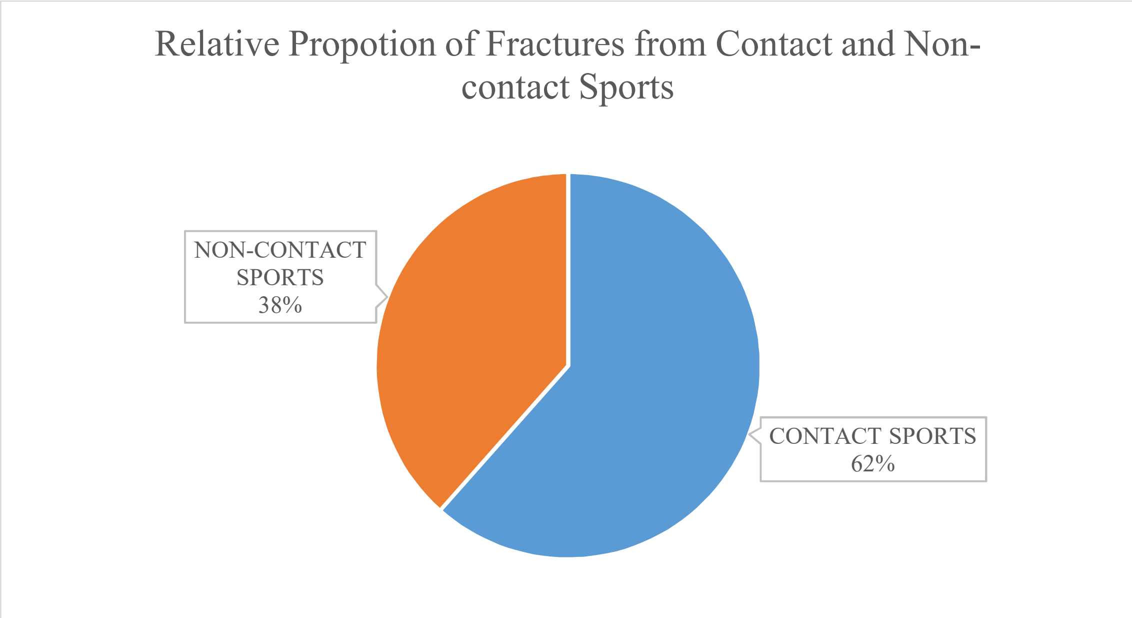

FIGURE 6.7: TYPE OF SPORT CAUSING INJURY

In the “Other” category of mechanism of injury, it was noted that another person falling on, or something heavy like a tire falling on the patient caused the fracture.

6.4 Anatomic Distribution of Fractures

The femur had the highest number of fractures at 33%. The radius at 23% followed. The fibula at 3% was the least fractured bone. Figure 6.8 below illustrates the fracture burden by bone involved.

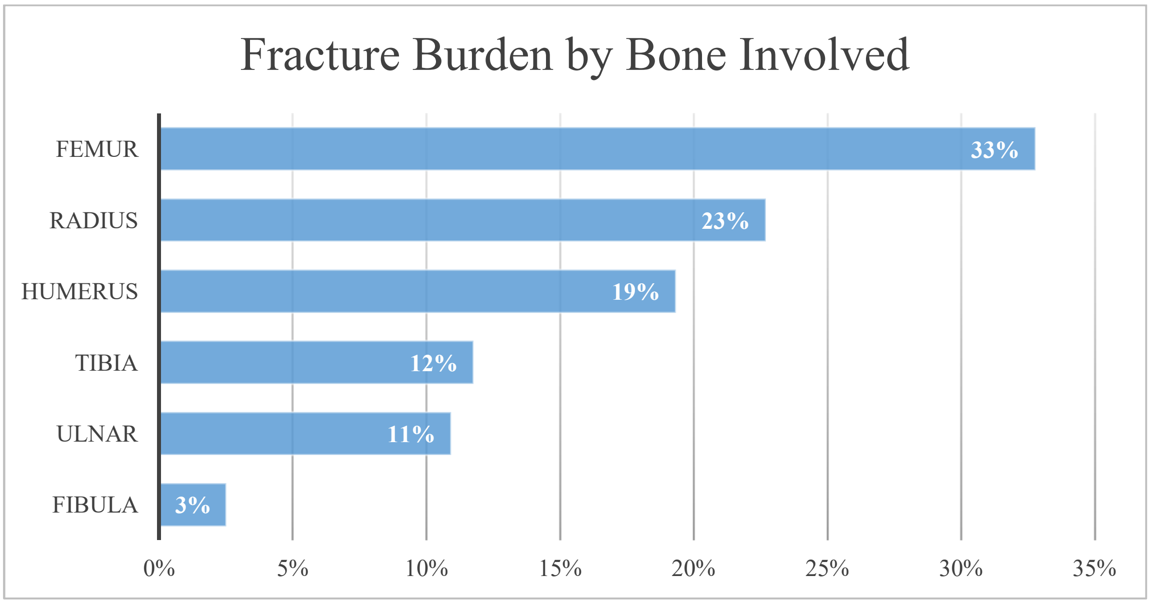

FIGURE 6.8: FRACTURE BURDEN BY BONE INVOLVED

Upper Limb		
Bone	No. of Fractures	%(n=119)
Humerus	23	19%
Radius	27	23%
Ulnar	13	11%
Total	**63**	**53%**

Lower Limb		
Bone	No. of Fractures	%(n=119)
Femur	39	33%
Tibia	14	12%
Fibula	3	3%
Total	**56**	**47%**

TABLE 6.5: FRACTURE BURDEN BY BONE INVOLVED

Majority of the fractures in all the bones surveyed involved the diaphysis at 71%. Fourteen (12%) of the fractures were epiphyseal with the radioulnar complex contributing 64% of these. None of these fractures involved a proximal epiphysis. A summary is presented in the figures below:

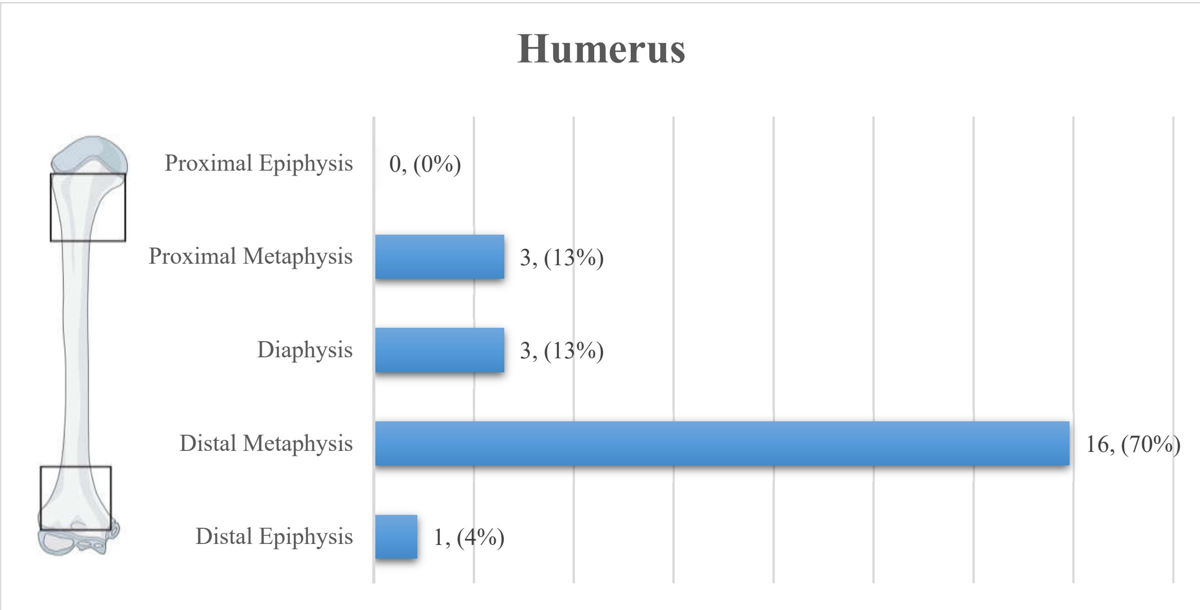

FIGURE 6.9: FRACTURE DISTRIBUTION - HUMERUS

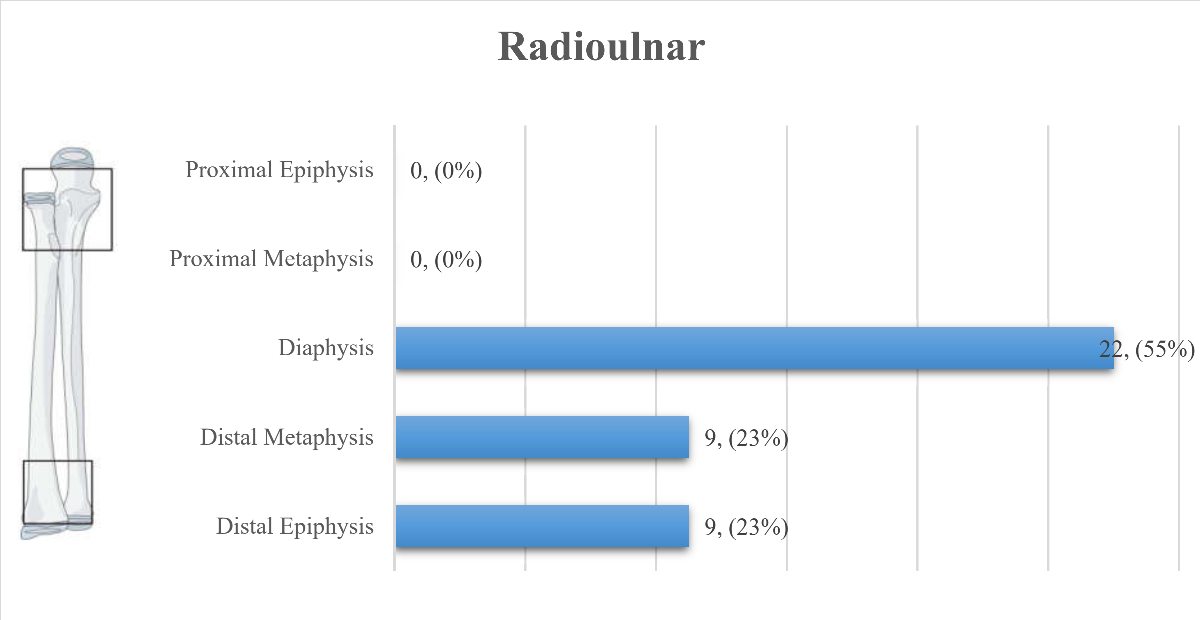

FIGURE 6.10: FRACTURE DISTRIBUTION - RADIOULNAR

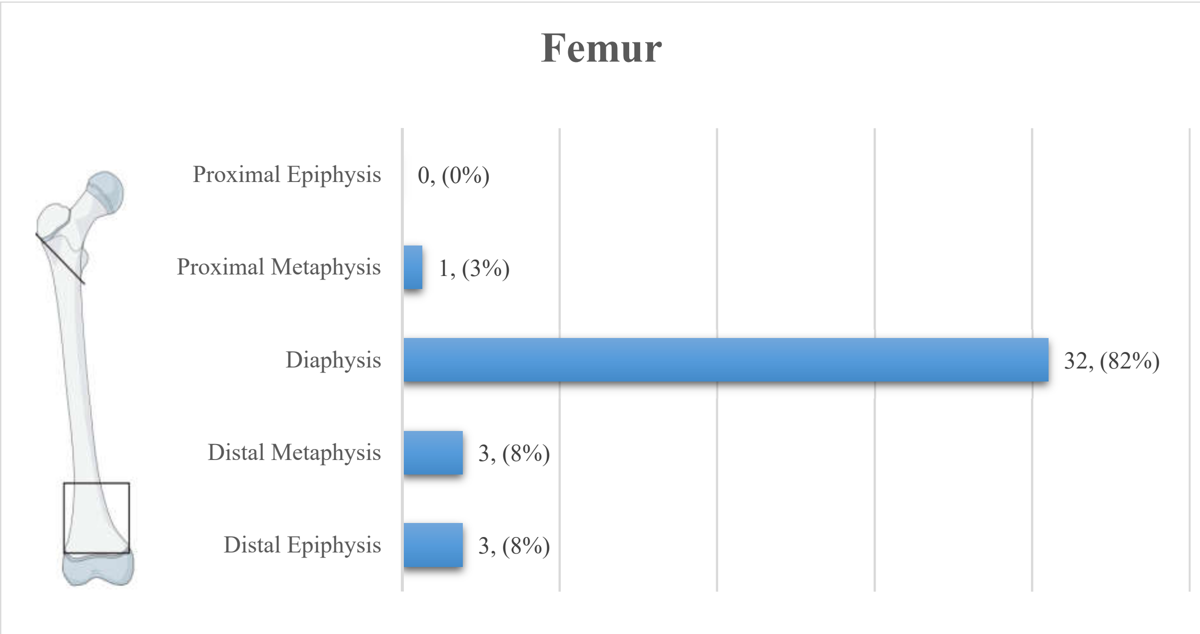

FIGURE 6.11: FRACTURE DISTRIBUTION - FEMUR

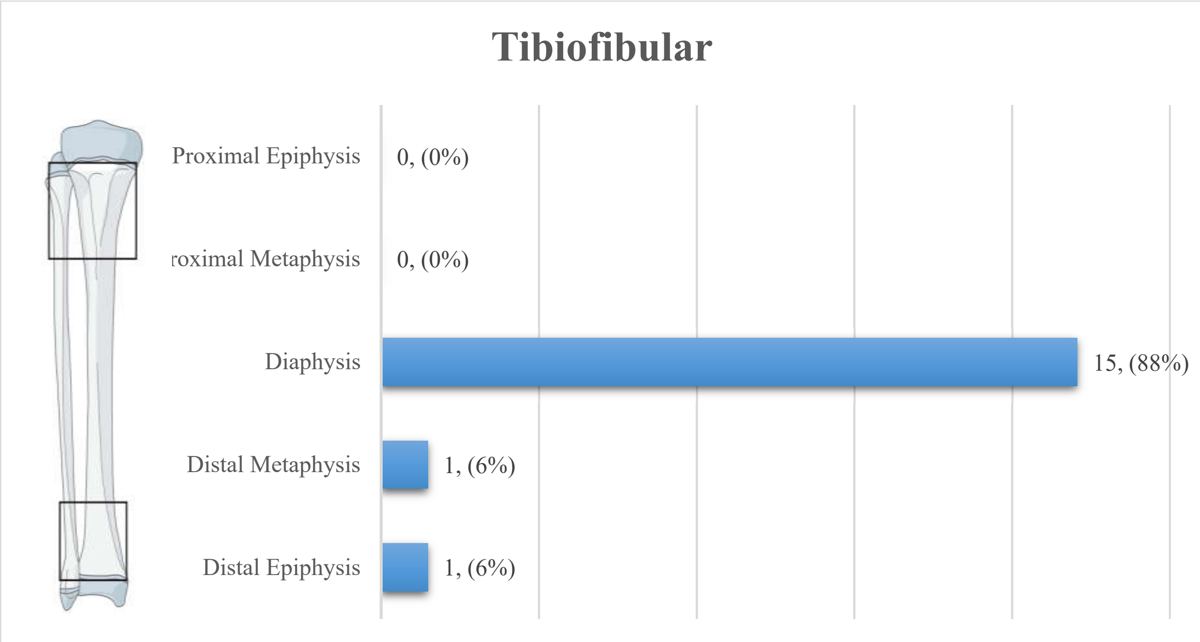

FIGURE 6.12: FRACTURE DISTRIBUTION - TIBIOFIBULAR

6.5 Severity of Injury

Twelve percent of the fractures were comminuted and all involved the lower limb (Femur – 6, 5%, Tibia – 5, 4% and Fibular – 3, 2.5%). Fourteen (12%) fractures involving the growth plates were observed. Four of these were equivalent to Salter Harris I and 10 were equivalent to Salter Harris II fractures.

7. DISCUSSION

The aim of this study was to establish the pattern of long bone fractures in a paediatric population at a tertiary centre in Kenya. Our study was carried out in Kenyatta National Hospital between October 2016 and December 2016. A total of 104 patients were successfully recruited and the results showed that males outnumbered females by nearly 1.5 times (Table 6.1). Other studies have also found that males outnumber females in childhood fractures (19,29,11). The only time females predominated males in our study was in the 10 ~ 12years age group. This age coincides with the pubertal peak height velocity in females, which causes a relative decrease in bone mineral density (17-19).Boys reach their pubertal peak height velocity about two years later and at this point(12 -14 years age group), boys predominate at 76% of all the fractures sustained in that age group. This generalized male predominance is probably due to the experimenting and risk taking behaviour that is more common in males. The mean age of participants in our study was 7 years and 3 months which falls within the ranges that other studies have found (19,11).

The fracture distribution was bimodal in nature with a peak at 4 ~ 6 years and another at 12 ~ 14 years. This is attributed to increased mobility in the younger age group and the relative decrease in bone mineral density and increased sporting activity in the older age group (34,35). Majority of the fractures were as a result of falls on hard surfaces and this could indicate a lack of proper and safe areas for children in our context could have also led to the high number of fractures at 4 ~ 6 years compared to other countries. Louise Rennie found a similar distribution with a peak at 6 ~ 7 years and another at 13 ~ 14 years (54).

Overall, the upper limb was involved in 53% of the fractures. This is in contrast to other studies that have found that the upper limb is more involved (14,31). This can be attributed to the high rates of lower limb fractures amongst the 2 ~ 6 year olds in our study population. Of note is that most femoral fractures are treated by traction or surgery hence higher likelihood for referral to a tertiary hospital for treatment. Up to 6 years of age, the lower limb predominated but after that, the upper limb was more likely to be fractured. The right side of the body was involved in 55% of the cases and this is comparable to what Per-Henrik Randsborg *et al* (10) found.

The femur had the highest number of fractures at 33%. The radius followed at 23%. Studies elsewhere have established the radius as the most fractured bone in childhood with rates of up to 40% of the fractures. Rennie Louise in Edinburg, Britain (54) found fractures of the radius contributed 32.9% while Tandon *et al* (55) in Mumbai, India came up with 22.4%. On further analysis of the radio-ulnar fractures, it was noted that majority of the fractures (55%) occurred in the shaft region. Distally the metaphysis and epiphysis contributed 23% each. It is worthwhile to note this was the largest proportion of epiphyseal fractures to the rest of the bone segment fractures of all the bones studied. The humerus was the third most fractured bone at 19% with majority involving the distal metaphysis (70%). The femur was fractured in 33% of the cases, majority being diaphysis fractures (82%). The proximal segment of the femur was only involved in one case. The fibula was the least fractured bone at 3% and in all cases involved high-energy trauma. This could be due the fact that the tibia carries most of the stress. On analysis of the tibiofibular complex as one bone, it was noted most of the fractures were in the diaphysis segment (88%).

Valerio *et al* (19) in Naples, Italy found that 68.3% of childhood fractures occurred in the home and its surroundings. In our study, 56% of the fractures occurred at the home or its surroundings with a male to female ratio of 2:1 which was statistically significant (p<0.001). Majority of the children in the developing world are baby sat by their elder siblings or unqualified nannies as the parents go to work. 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.

Only 10% of the fractures were sustained at school. These fractures showed a gradual increase from 5% in the 2 – 4 age group to a high of 18% in the 12 – 14 age group. The mean age was 9 year, 6 months with an equal preponderance of both male and females. This could be attributed to better supervision while at play in school. Playgrounds contributed 13% of the fractures sustained. These fractures occurred during sports.

Falls were the main mechanism of injury at 56%.Majority (55%) were from a level below 0.5 meters. These can be classified as slight trauma (56) and mainly resorted in distal humerus fractures and distal radial fractures. Thirty five percent were from a height of between 0.5 and 3 meters (moderate trauma) with more of shaft fractures both of the upper and lower limbs. Ten percent were from a height of > 3 meters, all from falls from balconies, equating to high-energy trauma. This is an indication that our balconies are not child proofed. Landing on a hard surface led to 80% of the fractures in this group, which was statistically significant (p value <0.001). Simple strategies like improving situational awareness amongst caregivers, closer parental attention, child friendly homes and playgrounds, padding of hard surfaces, child safe windows and covered balconies would go a long way in reducing these fractures. A good example where this has succeeded is the "Children can't fly" program in New York, U.S.A. (57).

Road traffic accidents contributed 21% of the fractures, which is higher than the figures (7% to 10%) from other studies in developed countries (4,12,33) (54). Majority of these fractures were in the 4 ~ 6 age group (27%) and involved pedestrians. An explanation for this could be the lack of properly designated pedestrian crossings and walking areas on our roads. Of all the fractures resulting from vehicular accidents where the patient was a passenger, none was restrained. Several interventions have been used elsewhere to reduce road traffic accidents. These include speed controls, traffic restrictions in some areas, banning of traffic near where children play, providing transport to children to and from school and mandatory use of child car seats (58). Public health programs on road safety targeting school going children would also go a long way in reducing these accidents.

The proportion of injuries from sports matched those found elsewhere at 12% (12,23). Sport injuries start to increase from around five years of age when children start participating in organized sports (11).Sport injuries peaked at 10 ~14 years of age. Majority, at 62% were secondary to contact sports like soccer, rugby. This is in keeping with data from elsewhere (2, 12). There was no statistically significant difference between the males and females in fractures related to sporting activity.

We established a unique mechanism of injury in our study. This involved an object or person accidentally falling on the patient and causing a fracture. This mechanism of injury contributed to 10% of the fractures, majority involving the upper limb (75%). These can be reduced by proper selection of toys and culturing safe play habits.

Open fractures constituted 4% of the fractures and involved mainly the tibia. The subcutaneous nature of the tibia can explain this. This is comparable to available data from other places (11,55). All these fractures were from high-energy events i.e. road traffic accidents where the patients were pedestrians. One of the case also had multiple fractures. This low prevalence is in keeping with the patho- anatomy of pediatric fractures (45,41). Twelve percent of fractures were comminuted and involved the lower limb secondary to high-energy events.

Hedstrom *et al* (59) found 14.8% of fractures in children in Switzerland involved the physis. This is comparable to 12% that we established in our study. Of this, 64% involved the distal radial physis and 21% involved the distal femoral physis.

7.1 Limitations

Our study had several limitations. We had no single case of fractures secondary to child abuse. We relied on the information provided by guardians or parents and this could have made it difficult to identify such cases.

The duration of the study also was not long enough to determine the effects of changes in climatic seasons and school/holiday seasons on fractures. The study was carried out in a referral hospital meaning that our data could be biased. In future, a study can be designed to overcome these limitations.

7.2 Conclusion

i) The paediatric long bone fractures show a bimodal type of distribution (peaks at 4 ~ 6 years and 12 ~ 14 years).

ii) Falls (56%) are the common mechanism of injury in paediatric long bone fractures. Fractures secondary to RTAs (21%) in the study sample are higher than those in other studies are.

iii) Majority of paediatric long bone fractures happen in the home and its surroundings (56%).

7.3 Recommendations

- Development of safety guidelines and policies for prevention of childhood injuries at home and its surroundings.
- There is need to better implement existing road traffic policies and also develop others to reduce the fracture burden secondary to road traffic accidents.
- Studies need to be conducted to determine the various factor affecting the pattern of long bone fractures in paediatric population in our setting.
- A national, multicentre study would better determine the pattern of long bone fractures in paediatric population in our setting.

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9. APPENDIX I

KNH – UoN ERC Letter of Approval for the Study

KENYATTA NATIONAL HOSPITAL APPROVED 12 OCT 2016 KNH/UoN-ERC P.O. Box 20723-00202 NRB.

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/402

12th October 2016

Dr. Eric Ng'ang'a Mwangi
Reg. No.H58/60855/2013
Dept. of Orthopaedic
School of Medicine
College of Health Sciences
University of Nairobi

Dear Dr. Ng'ang'a

Revised research proposal: Pattern of Long Bone fractures in a Paediatric Population at Kenyatta National Hospital (P555/07/2016)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above revised proposal. The approval period is from 12th October 2016 – 11th October 2017.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH-UoN ERC before implementation.
c) Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study.
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Protect to discover

Yours sincerely,

PROF M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director, CS, KNH
The Assistant Director, Health Information, KNH
The Chairperson, KNH- UoN ERC
The Dean, School of Medicine,UoN
The Chairperson, Dept.of Orthopaedic, UoN
Supervisors; Dr. Vincent M. Mutiso, Dr.Joseph C. Mwangi

Protect to discover

10. APPENDIX II

Consent to Participate in a Research Study

Principle Investigator: Dr Eric Ng'ang'a Mwangi, Department of Orthopaedics, University of Nairobi

Research Title: Pattern of long bone fractures in a paediatric population at Kenyatta National Hospital

Brief description on the research study:

This study is looking at the various fractures that have occurred in the long bones i.e. bones of the arm, forearm, thigh and leg in your child. This study will also attempt to determine the causes of these fractures, severity of the fractures and the geographical location where the injury occurred. Participation in the study is on a voluntary basis.

What is expected of you and the patient?

Once you accept your child to participate in this study, you will be expected to fill a questionnaire with the help of the principle investigator or with one of the research assistants. Your child will also be examined to further characterize the injuries. A fracture coding form will be filled by the principle investigator or the research assistant using information obtained from the radiographs taken to diagnose the fracture.

You are not expected pay anything to participate in this study. In the unlikely event that your child will be required to be seen again by the investigator, then your transport expenses will be refunded.

Confidentiality

The information you provide will be kept confidentially and will only be used for the purpose of this study. At the end of the study, the questionnaires will be destroyed and no personal identifying information will be included in the results.

No added risks

There are no risks involved in this study.

Benefits from the study

There are no direct benefits from this study but the information obtained will help in developing strategies for preventing fractures in children. It will also assist in improving quality of care in children who have sustained fractures.

Opting out

One is allowed to opt for their child not to participate in this study. One may also choose to withdraw their child from this study at any point in time. Both of these situations will not compromise the treatment your child will receive now or in the future.

Queries

In case of any questions or queries, you can contact the below named:

Dr. Eric Ng'ang'a

Tel.: +254 721 866 001

e-mail: nganga50@gmail.com

OR

Chairman,

UON/KNH ethics and Research Committee,

Tel. 020-2726300 Ext. 44355

Having read and understood the above information and any questions I had having been answered to my understanding, I voluntarily agree to enrol in this study.

Patient's name: ____

Guardian's name ____

Guardian's Signature ____ Date _______________

Ruhusa kushiriki katika utafiti

Mtafiti: Dr. Eric Ng'ang'a Mwangi, Department of Orthopaedics, University of Nairobi

Maelezo kuhusu utafiti huu:

Lengo la utafiti huu ni kubainisha sababu zinazofanya watoto kupata majeraha ya kuvunjika mifupa na jinsi mifupa hiyo huvunjika. Hii itasaidia katika kuweka mipango ya kuzuia majeraha haya, na pia kupangilia mikakati ya kutibu hawa watoto.

Utahitajika kufanya nini?

Ukikubali mtoto wako kushiriki katika utafiti huu, ataonekana na mtafiti ili kubainisha majeraha. Pia utajaza dodoso kwa usaidizi wa mtafiti. Dodoso hili litabainisha Zaidi kuhusu majeraha mtoto wako aliyo nayo.

Mtafiti pia atangalia picha za x-ray ambazo mtoto atakuwa ameshafanyiwa.

Usiri

Taarifa yoyote utakayo tupatia itawekwa kisiri na itatumiwa kwa utafiti huu pekee. Katika matokeo ya utafiti, hakuna chochote kitawekwa ambacho kinaweza kutambulisha wewe au mgonjwa.

Hakuna madhara

Hakuna madhara yoyote kwa afya ya mtoto yanatarajiwa kwa kubali mtoto wako kushiriki huu utafiti

Kukataa kushiriki

Una haki ya kukataa mtoto wako kushiriki huu utafiti. Aidha unaweza kuamua kuachisha mtoto wako kushiriki katika huu utafiti wakati wowote. Haya yote mawili hayataadhiri huduma ambazo atakazozipata hospitalini.

Mawasiliano

Ikiwa una maswali, unaweza wasiliana na:

Dr. Eric Ng'ang'a

Simu: +254 721 866 001

Barua pepe: nganga50@gmail.com

AMA

Mwenyekiti,

UON/KNH ethics and Research Committee,

Simu: 020-2726300 Ext. 44355

Nimesoma maelezo yaliopo hapo juu, na pia maswali yote yamejibiwa. Nimeelewa na nimekubali kushiriki katika utafiti huu..

Jina la mgonjwa: ____

Jina la mzazi/mlezi: ____

Sahihi ya mzazi/mlezi: ___________________________________Tarehe: ______________

Assent Form

My name is Dr. Eric Ng'ang'a. I am doing a research study about broken bones in children. Permission has been granted to undertake this study by the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee.

This research study is a way to learn more about children and injuries they sustain. At least 100 children will be participating in this research study with you. If you decide that you want to be part of this study, you will be asked to describe what happened leading to your injury. You will also be asked if you have had other injuries before. We will also look at your x-ray films to see how the bones are broken. We will show you where the bone is broken. We will also examine the broken area to look for any wounds. This will be done as gently as possible so as to cause as little discomfort to you as possible.

You will not benefit from this study immediately. A benefit means that something good happens to you. We think this study will benefit you and other children in future by helping us come up with ways of preventing injuries like the one you have. It will also help us develop better ways of attending to children with similar injuries to yours.

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 is 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.

________________________________ (Signature/Thumb stamp)_________________(Date)

Kukubali Kushiriki katika Utafiti

Jina langu ni Dkt. Eric Ng'ang'a. Ninafanya utafiti kuhusu watoto wliovunjika mifupa ya miguu na mikono. Utafiti huu utatusadidia kujua jinsi ulivyovunjika. Kuna watoto wengine mia moja hivi ambao wanashiriki katika utafiti huu.

Ukukubali kushiriki katika utafiti huu, utatueleza kuhusu ulivyo vunjika na kama umeshawahi vunjika tena. Aidha tutangalia picha yako ya x-ray ili kubaini vile mifupa imuevunjika. Tutaweza kukuonyesha pale plipo vunjika.

Utafiti huu hutakuwezesha kupata manufaa yoyote saa hii lakini baadaye utanufaishi watoto wengine na wewe kwa kutusaidia kupata njia nzuri za kuzuia majeraha kama uliyoyapata. Pia itatuwezesha kutafuat nji bora za kuhudumia waliojeruhiwa.

Tukimaliza utafiti huu, tutatoa ripoti. Hii ripoti haitakuwa na jina lako aidha kama ulishiriki katika utafiti huu. Unaweza kuamua kutoshiriki sasa ama wakati wowote katika utafiti huu. Hii haitaadhiri matibabu ambayo unayoyapata au utakayoyapata baadaye. Kama umekubali kushiriki, tafadhali tia sahihi hapa chini.

Mimi, ____ nimekubali kushiriki katika huu utafiti,

________________________Sahihi/alama ya kidole gumba________________________tarehe

11. APPENDIX III

Fracture Distribution Questionnaire

Biodata

Hospital No.: **Study No.**:

X-ray No.: **Date of interview:**

Please fill in the following details:

Patient's Details

1. **Age**: ……………Years…………………. Months
2. **Sex**: ☐ Male ☐ Female
3. **Residence**: County………………………Town/village………………………
4. **Date of Injury**: ……. /………/20….

Parent/Guardian's Details

5. **Relation**: …...………………………………………………………….
6. **Phone number**: ………………………………………………………….

Injury Details

7. At the time of injury, was the patient *(tick one)*

   ☐ **Indoors** ☐ **Outdoors**

8. Where did the injury happen?

   ☐ **At home or its surroundings**

   ☐ **At school**

   ☐ **Public playground**

   ☐ **Road**

   ☐ **Other** (specify)**…………………………………**

9. At the time of injury, was the patient

   ☐ **Alone** ☐ **With an adult** ☐ **With other children**

10. Are the fractures?

☐ **Single** ☐ **Multiple**

11. Which bones are fractured and on which side of the body (left or right)?

Bone	**Side** *(right or left)*
1………………………………	**……………………………….**
2………………………………	**……………………………….**
3………………………………	**……………………………….**

12. Are/Is the fracture(s)

☐ **Closed** ☐ **Open**

13. Has the patient ever had fractures previously?

☐ **Yes** ☐ **No**

14. If Yes in (12) above, indicate the bone(s) involved and the approximate month(s) and year(s) it/they happened below:

Bone	**Month/year**
1………………………………	**……………………………….**
2………………………………	**……………………………….**
3………………………………	**……………………………….**

Mechanism of Injury

15. How did the patient sustain the fracture? *(choose one)*

☐ **Fall**

If it was from a fall, was it *(tick one)*:

☐**From same level i.e. ground level**

☐**From a height, Estimated height in meters ………………...**

☐ **On to a hard surface (concrete, stones, bare earth etc.)**

☐ **On to a soft/ padded surface (loose sand, wood chippings etc.)**

☐ **Road traffic accident**

If from a road traffic accident, was the patient a *(tick one):*

☐ **Pedestrian**

☐ **Passenger in a car** If yes was the patient

☐ **Front passenger** ☐ **Back passenger**

☐ **Restrained e.g. seatbelts, child seat, booster seat**

☐ **Cyclist**

☐ **Pillion (passenger on a motorbike)**

☐ **Sport**

If yes, was it a *(tick if yes)*

☐ **Contact sport e.g. football, soccer, rugby**

☐ **Non-contact sport e.g. athletics, swimming,**

☐ **Assault/ child abuse**

☐ **Gunshot**

☐ **Other** *(Specify)***…………………………………………...**

Dodoso kuhusu ulivyovunjika

Nambali ya hospitali.: **Nambali ya utafiti:**

Nambali ya X-ray: **Tarehe ya mahojiano:**

Tafadhali jibu maswali yafuatayo:

Vidokezo kuhusu mgonjwa

1. **Umri**: ……………Miaka…………………. Miezi
2. **Jinsia**: ☐ Kiume ☐Kike
3. **Makao**: Kata/Kaunti……………………Mji/Kijiji……………………
4. **Tarehe uliyoumia**: ……. /………/20….

Vidokezo kuhusu mzazi/mlezi

5. **Uhusiano**: …...……………………………………………………….
6. **Nambali ya simu**: ………………………………………………………….

Maelezo ya ulivyo umia

7. Ulipoumia, ulikuwa *(weka alama jibu moja)*

   ☐ **Ndani ya nyumba** ☐ **Nje ya nyumba**

8. Uliumia ukiwa wapi?

   ☐ **Nyumbani au karibu na nyumbani**

   ☐ **Shuleni**

   ☐ **Uwanja wa kuchezea wa umma**

   ☐ **Barabarani**

   ☐ **Kwingine** (*taja wapi*) **…………………………………**

9. Ulipoumia, ulikuwa

   ☐ **pekee yako** ☐ **na mtu mzima** ☐ **na watoto wengine**

10. Umevunjika?

    ☐ **pahali pamoja** ☐ **Zaidi ya pahali pamoja**

11. Ni wapi palivunjika na ni upande gani wa mwili(kulia au kushoto)?

Mfupa/sehemu ya mwili	**Upande***(kulia au kushoto)*
1……………………………	**……………………………..**
2……………………………	**……………………………..**
3……………………………	**……………………………..**

12. Palipovunjika, mfupa imetoka/ilitoka nje ya ngozi?

☐ **La** ☐ **Ndio**

13. Umesha wahi vunjika tena?

☐ **Ndio** ☐ **La**

14. Kama ndio kwa swali (12), tafadhali jaza hapa chini pahali ulipo vunjika na tarehe uliovunjika:

Mfupa/sehemu ya mwili	**Mwezi/Mwaka**
1………………………………	**……………………………….**
2………………………………	**……………………………….**
3………………………………	**……………………………….**

Uliumia kivipi

15. Ni nini kilichofanya uvunjike? *((weka alama jibu moja)*

☐ **Kuanguka**

Kama ulianguka,

☐**haikuwa kutoka sehemu iliyo juu**

☐**ilikuwa kuto sehemu iliyo juu kama mita ………………...**

☐ **Uliangukia pahali pangumu (sakafu, rami, mawe, changarawe)**

☐ **Uliangukia sehemu iliyo laini (mchanga, vigae vidogo za mbao)**

☒ **Ajali ya barabarani**

Ulikuwa wewe ni *(weka alama jibu moja):*

☐ **Mwenda kwa miguu**

☐ **Abiria**

Kama ndio, ulikuwa

☐ **Umeketi mbele** ☐ **Umeketi nyuma**

☐ **Umevaa kanda za usalama**

☐ **mwendeshaji baiskeli**

☐ **Abiri wa pikipiki**

☐ **Ukicheza**

Kama ndio, ilikuwa mchezo *(weka alama jibu moja)*

☐ **Michezo inayohusu kukaribiana sana kama kandanda, raga**

☐ **Usiohusu kukaribiana kama kukimbia, kuogelea**

☐ **Kupigwa**

☐ **Kupigwa risasii**

☐ **Njia nyingine***(taja)***…………………………………………...**

12. APPENDIX IV

Fracture Coding Form

Study No: **Age** :

Sex : **Date** :

Each fracture is to be coded on a separate leaf.

The coding is to be done only after filling the fracture distribution questionnaire.

The fracture coding is to be done in reference to the AO Paediatric Comprehensive Classification of Long-Bone Fractures (PCCF) leaflet.

Fracture coding table – tick the appropriate box

* For M/7 and E/7 groups, indicate whether involves medial or lateral side by adding “m” or “l” respectively at the end of the

	1	2	3	4	5	6	7	8	9	r/u; t/f	.1	.2
Bone Involved												
Bone Segment												
Paired bone involved												
Epiphysis*												
Metaphysis*#@												
Diaphysis												
Simple/Multifragmentary												

code.

For proximal segment fractures of the femur, add a grade at the end of the code as follows

I. Mid-cervical fractures
II. Basi-cervical fractures
III. Trans-trochanteric

@ For humeral supracondylar, add a grade at the end of the code as follows

I. Non-displaced
II. Partial displacement
III. Complete displacement, segments in contact
IV. Complete displacement with no contact between segments

Final fracture Code ☐

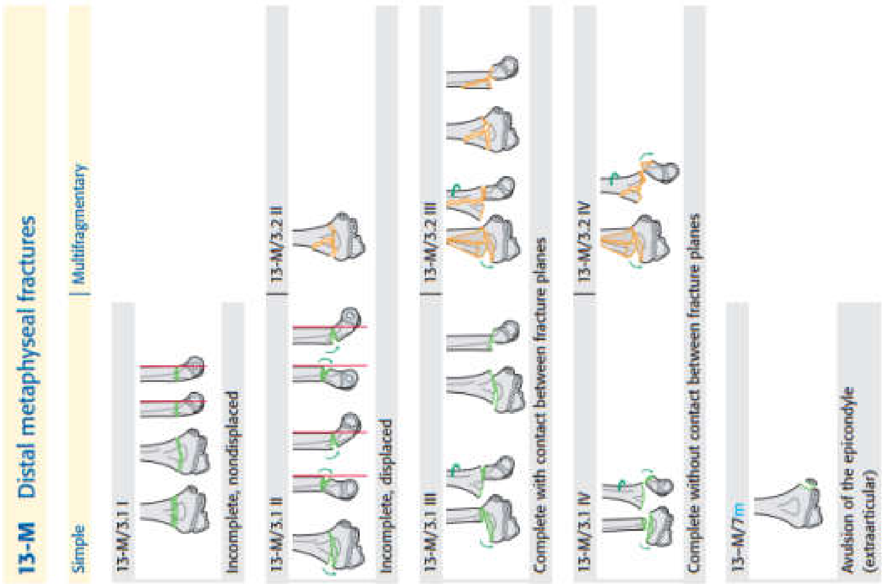
Which side? **Right** ☐ **Left** ☐

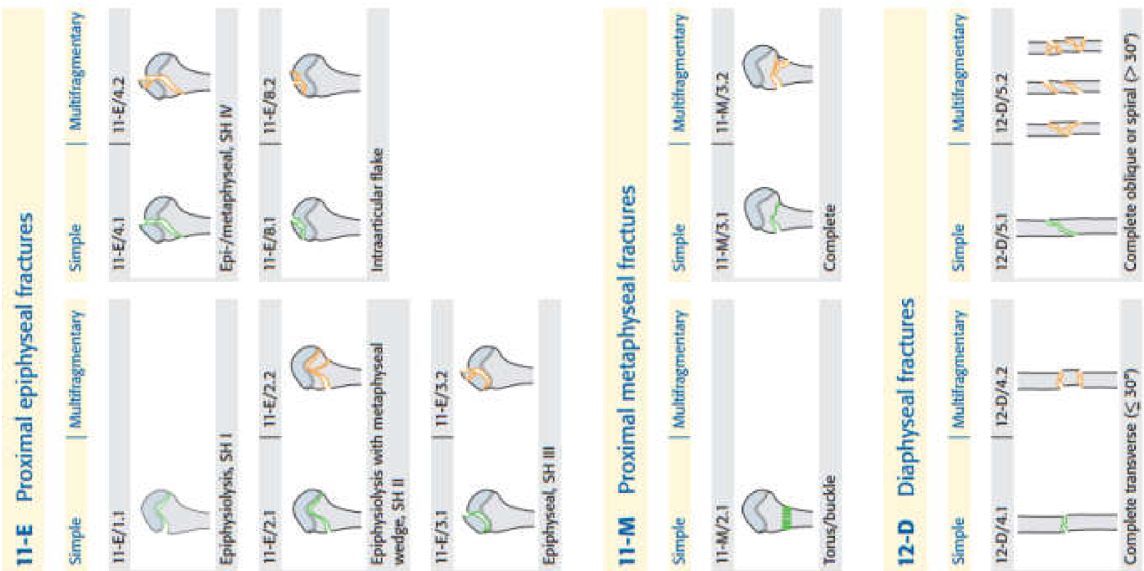
13. APPENDIX V

Classification of specific fractures

Extracted from *Slongo T. et al. AO Paediatric Classification Group (2007) AO Comprehensive Classification of Long-Bone Fractures (PCCF). Copyright © 2010 by AO Foundation, Switzerland.*

1. Humerus





13-E Distal epiphyseal fractures

Simple | Multifragmentary

13-E/1.1

Epiphysiolysis, SH I

13-E/2.1

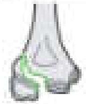
Epiphysiolysis with metaphyseal wedge, SH II

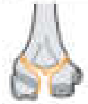
13-E/3.1 | 13-E/3.2

Epiphyseal, SH III

Simple | Multifragmentary

13-E/4.1 | 13-E/4.2





Epi-/metaphyseal, SH IV

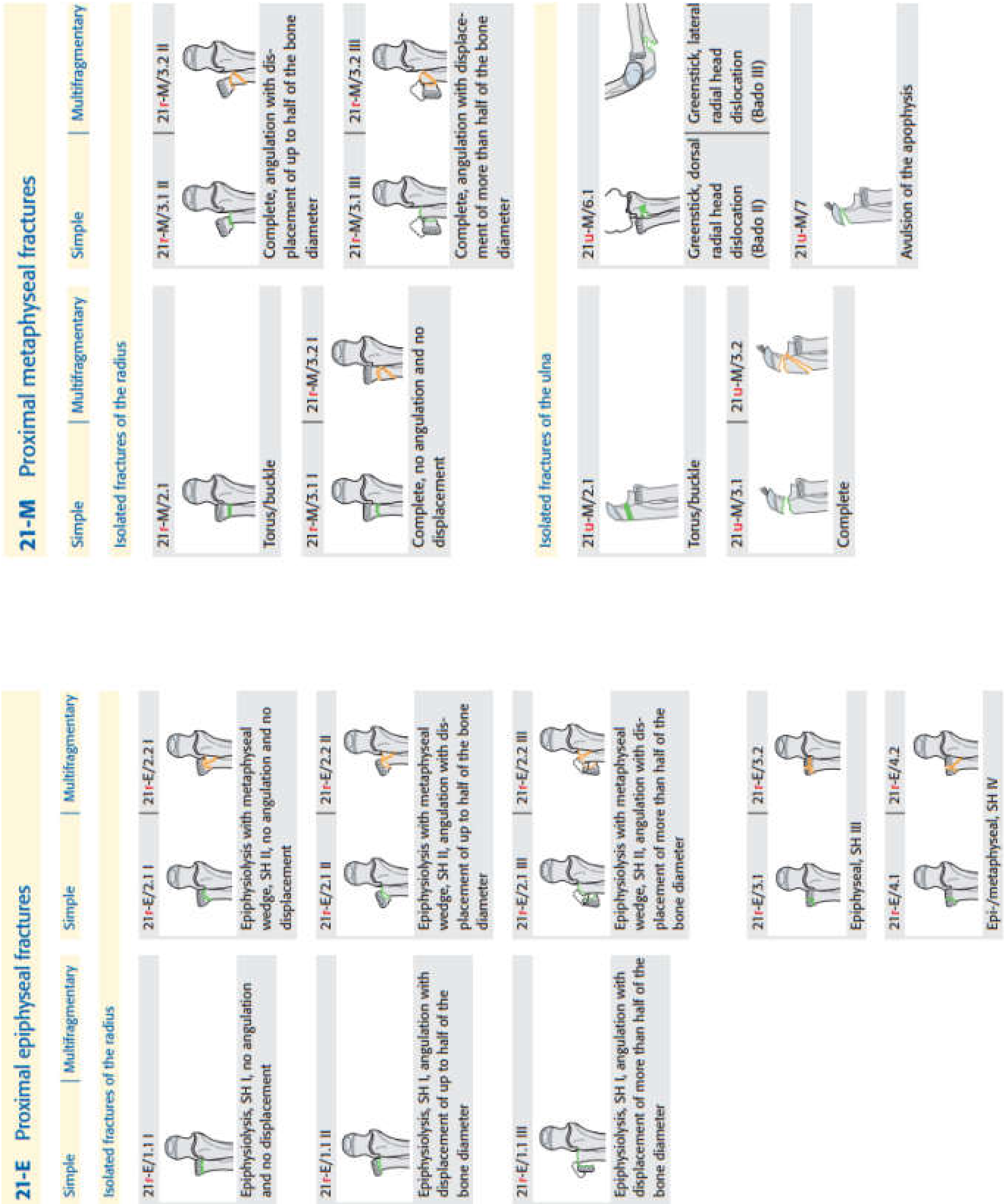
13-E/7

Avulsion of/by the collateral ligament

13-E/8.1 | 13-E/8.2

Intraarticular flake

2. Radius/Ulnar

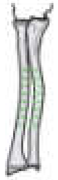


22-D Diaphyseal fractures

Simple | Multifragmentary | Simple | Multifragmentary

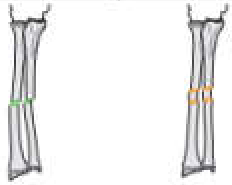
Fractures of both bones

22-D/1.1



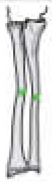
Bowing

22-D/4.1 | 22-D/4.2



Complete transverse (≤ 30°)

22-D/2.1



Greenstick

22-D/5.1 | 22-D/5.2

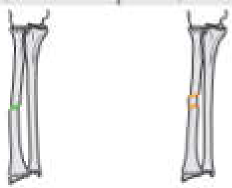
Complete oblique or spiral (> 30°)

Isolated fractures of the radius

22r-D/1.1

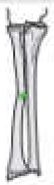
Bowing

22r-D/4.1 | 22r-D/4.2



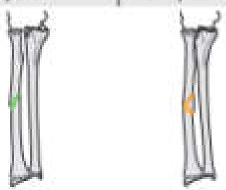
Complete transverse (≤ 30°)

22r-D/2.1



Greenstick

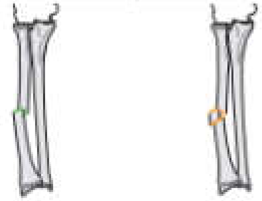
22r-D/5.1 | 22r-D/5.2



Complete oblique or spiral (> 30°)

Simple | Multifragmentary | Simple | Multifragmentary

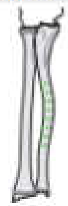
22r-D/7.1 | 22r-D/7.2



Galeazzi

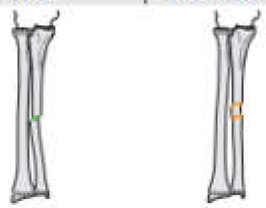
Isolated fractures of the ulna

22u-D/1.1



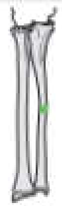
Bowing

22u-D/4.1 | 22u-D/4.2



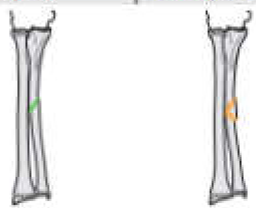
Complete transverse (≤ 30°)

22u-D/2.1



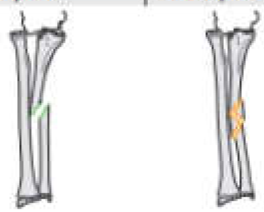
Greenstick

22u-D/5.1 | 22u-D/5.2

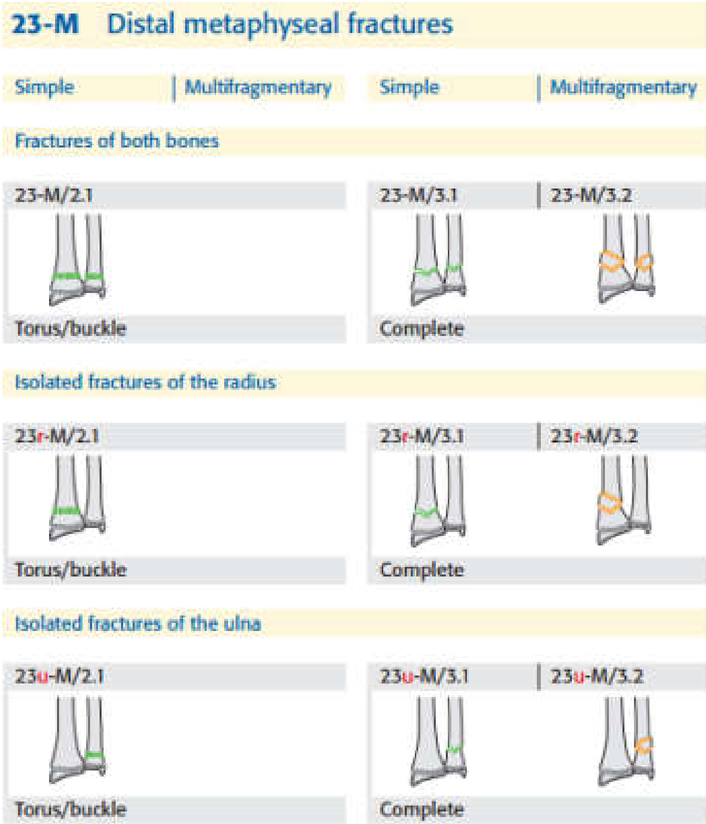


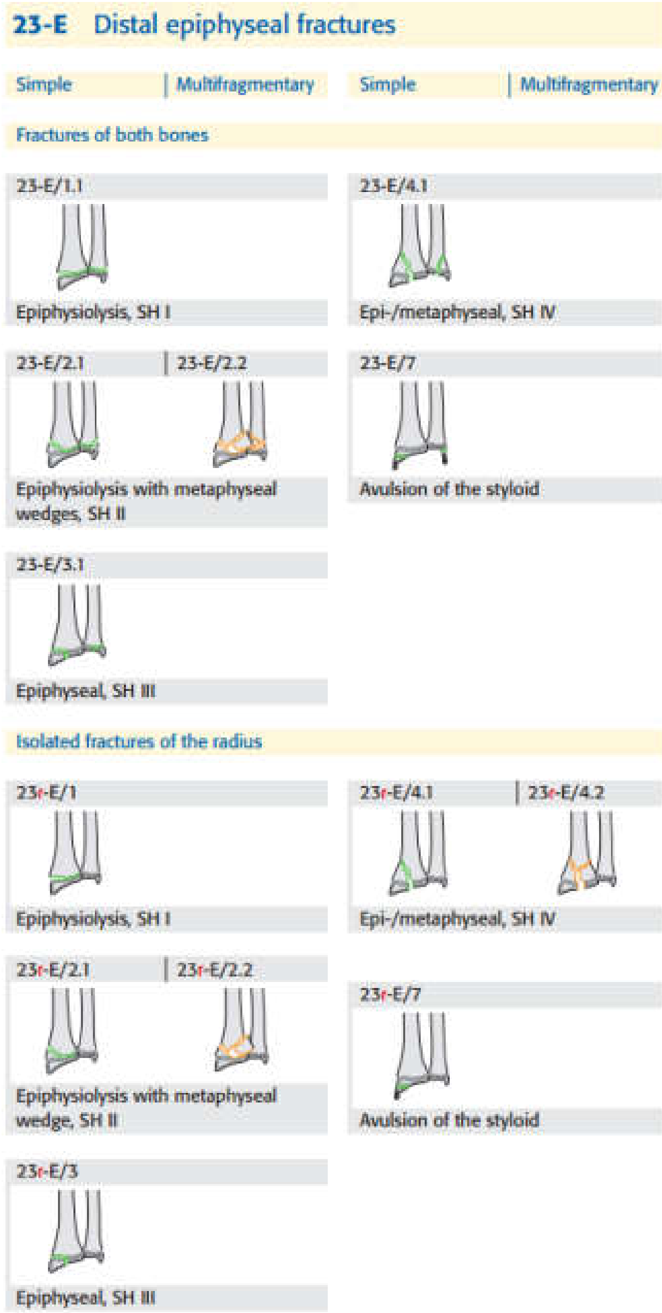
Complete oblique or spiral (> 30°)

22u-D/6.1 | 22u-D/6.2



Monteggia


23-M Distal metaphyseal fractures
Simple
Multifragmentary
Simple
Multifragmentary
Fractures of both bones
23-M/2.1
Torus/buckle
23-M/3.1
23-M/3.2
Complete
Isolated fractures of the radius
23r-M/2.1
Torus/buckle
23r-M/3.1
23r-M/3.2
Complete
Isolated fractures of the ulna
23u-M/2.1
Torus/buckle
23u-M/3.1
23u-M/3.2
Complete

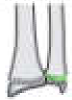

23-E Distal epiphyseal fractures
Simple
Multifragmentary
Simple
Multifragmentary
Fractures of both bones
23-E/1.1
Epiphysiolysis, SH I
23-E/4.1
Epi-/metaphyseal, SH IV
23-E/2.1
23-E/2.2
Epiphysiolysis with metaphyseal wedges, SH II
23-E/7
Avulsion of the styloid
23-E/3.1
Epiphyseal, SH III
Isolated fractures of the radius
23r-E/1
Epiphysiolysis, SH I
23r-E/4.1
23r-E/4.2
Epi-/metaphyseal, SH IV
23r-E/2.1
23r-E/2.2
Epiphysiolysis with metaphyseal wedge, SH II
23r-E/7
Avulsion of the styloid
23r-E/3
Epiphyseal, SH III

Simple | Multifragmentary

Simple | Multifragmentary

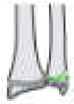
Isolated fractures of the ulna

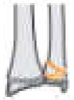
23u-E/1.1



Epiphysiolysis, SH I

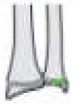
23u-E/2.1 | 23u-E/2.2





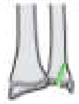
Epiphysiolysis with metaphyseal wedge, SH II

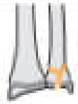
23u-E/3



Epiphyseal, SH III

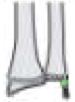
23u-E/4.1 | 23u-E/4.2





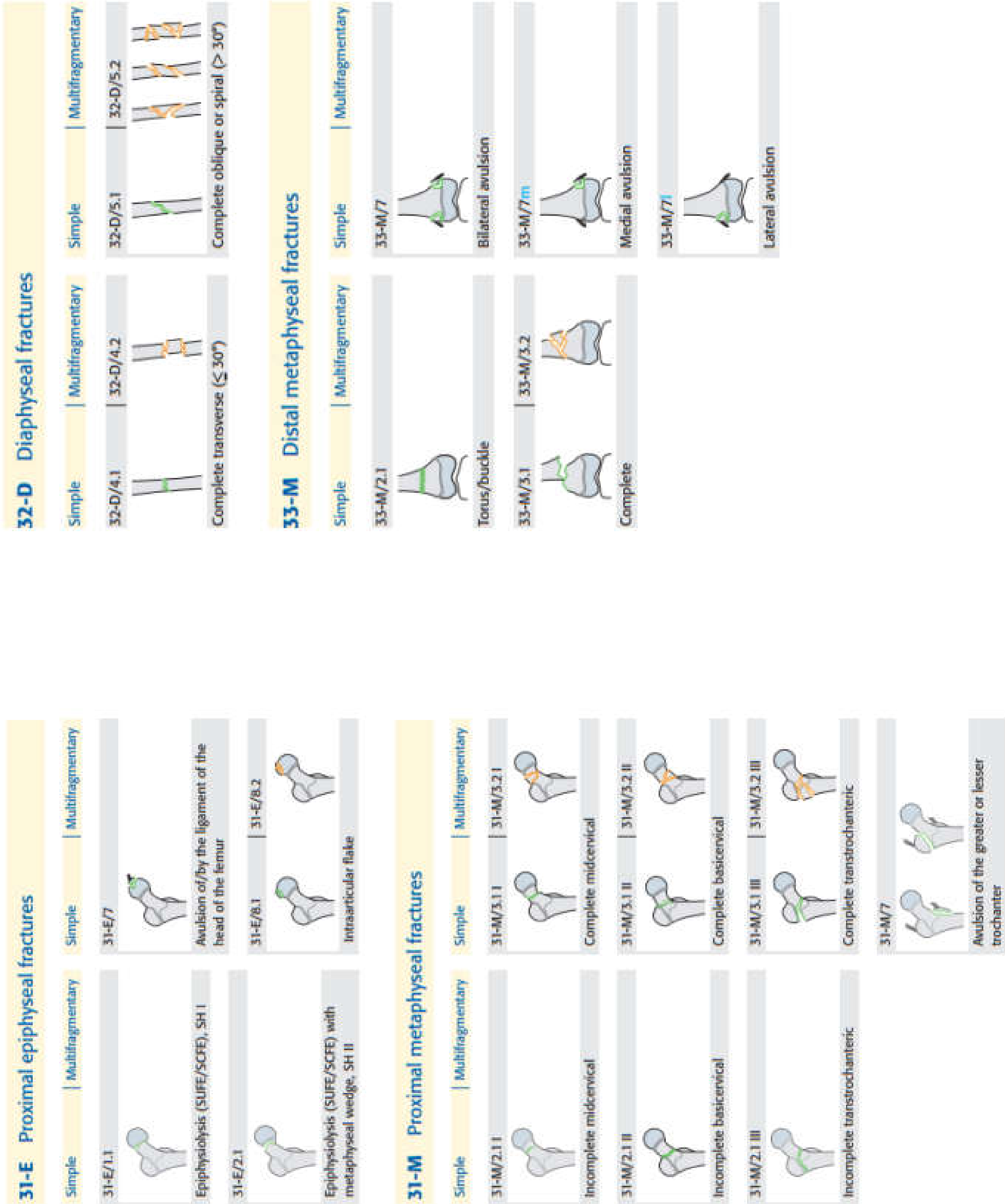
Epi-/metaphyseal, SH IV

23u-E/7

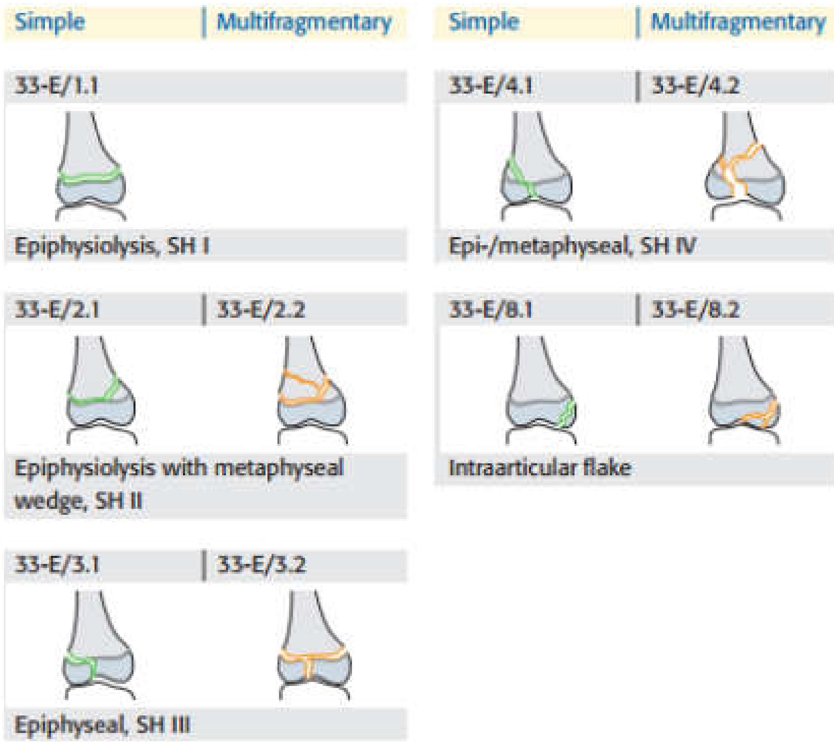


Avulsion of the styloid

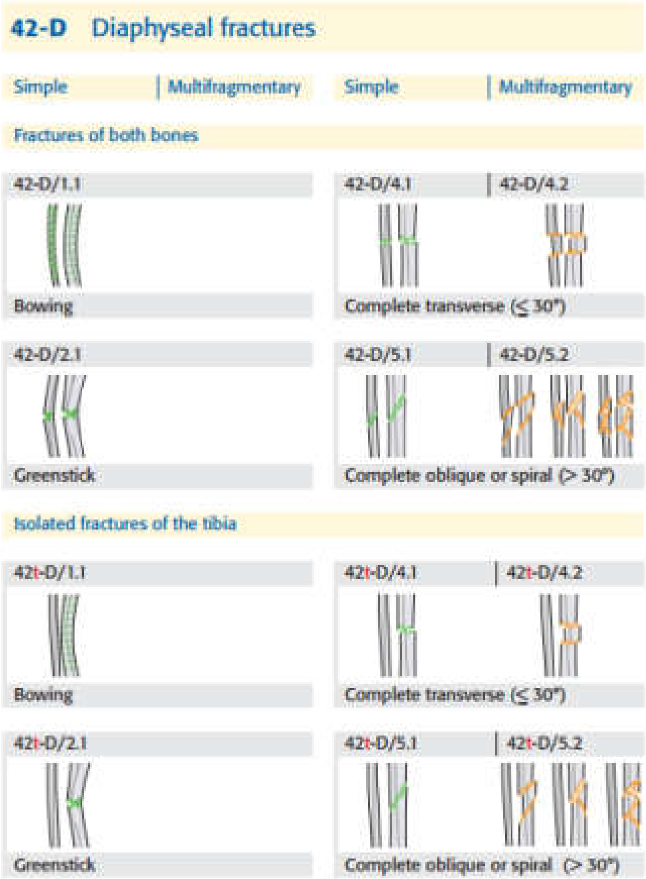
3. Femur

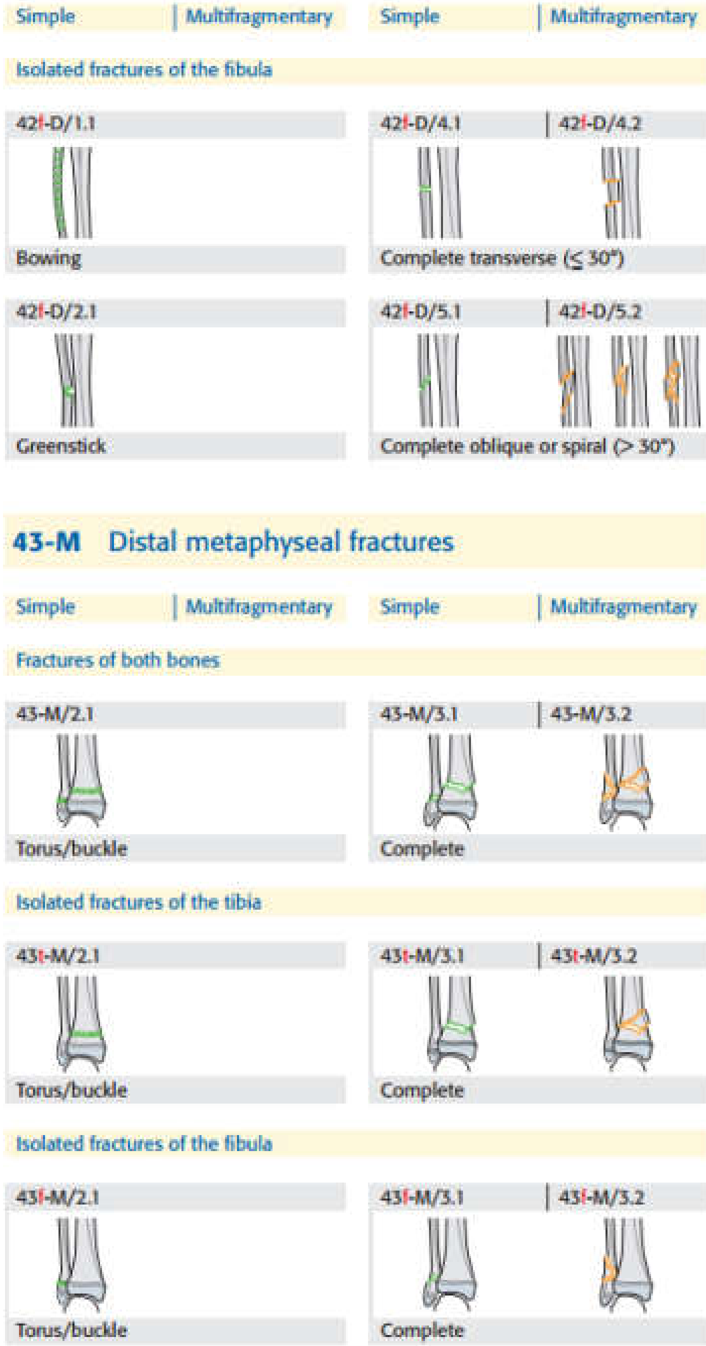

31-E Proximal epiphyseal fractures
Simple
Multifragmentary
31-E/1.1
Epiphysiolysis (SUFE/SCFE), SH I
31-E/2.1
Epiphysiolysis (SUFE/SCFE) with metaphyseal wedge, SH II
31-E/7
Avulsion of/by the ligament of the head of the femur
31-E/8.1
31-E/8.2
Intraarticular flake
31-M Proximal metaphyseal fractures
31-M/2.1 I
Incomplete midcervical
31-M/2.1 II
Incomplete basicervical
31-M/2.1 III
Incomplete transtrochanteric
31-M/3.1 I
31-M/3.2 I
Complete midcervical
31-M/3.1 II
31-M/3.2 II
Complete basicervical
31-M/3.1 III
31-M/3.2 III
Complete transtrochanteric
31-M/7
Avulsion of the greater or lesser trochanter
32-D Diaphyseal fractures
32-D/4.1
32-D/4.2
Complete transverse (≤ 30°)
32-D/5.1
32-D/5.2
Complete oblique or spiral (> 30°)
33-M Distal metaphyseal fractures
33-M/2.1
Torus/buckle
33-M/3.1
33-M/3.2
Complete
33-M/7
Bilateral avulsion
33-M/7m
Medial avulsion
33-M/7l
Lateral avulsion

33-E Distal epiphyseal fractures



4. Tibia/Fibula


42-D Diaphyseal fractures
Simple
Multifragmentary
Simple
Multifragmentary
Fractures of both bones
42-D/1.1
Bowing
42-D/4.1
42-D/4.2
Complete transverse (≲ 30°)
42-D/2.1
Greenstick
42-D/5.1
42-D/5.2
Complete oblique or spiral (> 30°)
Isolated fractures of the tibia
42t-D/1.1
Bowing
42t-D/4.1
42t-D/4.2
Complete transverse (≲ 30°)
42t-D/2.1
Greenstick
42t-D/5.1
42t-D/5.2
Complete oblique or spiral (> 30°)

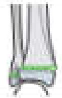

Simple
Multifragmentary
Simple
Multifragmentary
Isolated fractures of the fibula
42f-D/1.1
Bowing
42f-D/4.1
42f-D/4.2
Complete transverse (≲ 30°)
42f-D/2.1
Greenstick
42f-D/5.1
42f-D/5.2
Complete oblique or spiral (> 30°)
43-M Distal metaphyseal fractures
Simple
Multifragmentary
Simple
Multifragmentary
Fractures of both bones
43-M/2.1
Torus/buckle
43-M/3.1
43-M/3.2
Complete
Isolated fractures of the tibia
43t-M/2.1
Torus/buckle
43t-M/3.1
43t-M/3.2
Complete
Isolated fractures of the fibula
43f-M/2.1
Torus/buckle
43f-M/3.1
43f-M/3.2
Complete

43-E Distal epiphyseal fractures

Simple | Multifragmentary | Simple | Multifragmentary

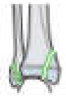
Fractures of both bones

43-E/1.1



Epiphysiolysis, SH I

43-E/4.1

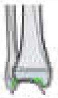


Epi-/metaphyseal, SH IV

43-E/2.1

Epiphysiolysis with metaphyseal wedge, SH II

43-E/8.1



Intraarticular flake

43-E/3.1

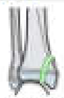
Epiphyseal, SH III

Isolated fracture of the tibia

43t-E/1.1

Epiphysiolysis, SH I

43t-E/4.1 | 43t-E/4.2



Epi-/metaphyseal, SH IV

43t-E/2.1 | 43t-E/2.2

Epiphysiolysis with metaphyseal wedge, SH II

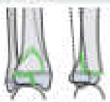
43t-E/5.1

Tillaux (two-plane), SH III

43t-E/3.1

Epiphyseal, SH III

43t-E/6.1



Tri-plane, SH IV

Simple | Multifragmentary | Simple | Multifragmentary

43t-E/8.1

Intraarticular flake

Isolated fractures of the fibula

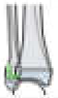
43f-E/1.1

Epiphysiolysis, SH I

43f-E/4.1

Epi-/metaphyseal, SH IV

43f-E/2.1

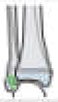


Epiphysiolysis with metaphyseal wedge, SH II

43f-E/7

Avulsion

43f-E/3.1



Epiphyseal, SH III

43f-E/8.1

Intraarticular flake