PATTERN AND MANAGEMENT OF PAEDIATRIC CRANIO-MAXILLOFACIAL TRAUMATIC INJURIES SEEN AT THE KENYATTA NATIONAL HOSPITAL OVER A 6-MONTH PERIOD

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DECLARATION

I certify that this is my original work and has not been presented for a degree or any award in any other institution.

Signature ..... Date ..... Day of ..... 2017.

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DEDICATION

I dedicate this thesis to my parents, Cyrus Ndung'u & Agnes Ndung'u for teaching me the value of education and inspiring me to always aim high in life. I am grateful to my Wife, Carol for her much-needed moral support during my postgraduate training.

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LIST OF ABBREVIATIONS

1. MMF – Maxillomandibular Fixation
2. KNH – Kenyatta National Hospital
3. WHO – World Health Organization
4. ORIF- Open Reduction & Internal fixation
5. CMF- Cranio-maxillofacial

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DEFINITION OF OPERATIONAL TERMS

1) Cranio-maxillofacial injuries- Physical injuries to the soft and hard tissues of the oral cavity, face & head excluding the brain and soft tissue structures in the orbital cavity.
2) Paediatric patient- Any patient below the age of 18 years.
3) Non-surgical treatment- management methods of facial fractures including observation & soft diet, physical therapy, splinting and maxillomandibular fixation that don't involve direct exposure of the fracture.
4) Open reduction and internal fixation- direct exposure and surgical manipulation of fracture fragments and rigid fixation with use of titanium implants or semi-rigid fixation with intraosseous wiring, skeletal wiring (suspension, wire osteosynthesis).

ABSTRACT

Introduction

Trauma is among the leading causes of death in all age groups except those above 60 years, according to the WHO. Noteworthy, trauma patterns and aetiology differ among various age groups and geographical regions. It is estimated that approximately 11.3 % of all paediatric emergency room visits are due to facial trauma. Studies on paediatric cranio-maxillofacial (CMF) trauma in Kenya are few and are presented as part of general CMF trauma.

Objective

The main objective of this study was to prospectively determine the pattern and management of paediatric CMF trauma at the main teaching and referral hospital in Kenya over a 6-month period.

Materials & Methods

This was a cross-sectional descriptive study carried out at Kenyatta National Hospital between April and September 2016. A data collection form was used to document the age, gender, aetiology and pattern of CMF trauma and associated injuries. In addition, management protocols prescribed for these injuries were documented.

Results

Seven hundred and five (705) physically injured children and adolescents presented to KNH during the 6-month study period and among these, 210 (29.8 %) had craniomaxillofacial injuries with a mean age of 7.4 years (SD= 5.6 years). Accidental falls (44 %) were the main cause of CMF injuries followed by motor vehicle crashes (22 %). Interpersonal violence (IPV) had a statistically significant association with the age of the child, mostly affecting older children with a mean age of 13.2 years (SD= 5.3 years);

ANOVA (F=14.34, df=4, $p< 0.0001$). IPV was also more likely to be a cause of CMF in boys than girls ($\chi^2 = 10.485, df=4, p=0.0330$).

Among sixty-six children (31.4%, n=210) who presented with a total of 116 facial fractures, mandibular fractures were the most common with 50 (42.7 %) fractures affecting the mandible. The mandibular condyle was the most likely anatomic region of the mandible to sustain fractures with 32 % of mandibular fractures occurring in this site (n=50). Management of facial fractures was predominantly conservative or through closed reduction (79 %) with 14 patients (21 %, n=66) managed through ORIF. ORIF was more likely to be used in older children (mean age =11.0 years, SD= 5.5) and those with mandibular fractures (50%, n=14) or panfacial fractures (35.7 %, n=14).

Conclusion

Accidental falls were the main cause of paediatric CMF trauma followed by road traffic crashes. Cranio-maxillofacial injuries constituted approximately a third (29.8 %) of all paediatric injuries recorded in this study with the mandible being the most fractured facial bone, with its condylar process being the most fractured region. ORIF for paediatric facial fractures was more likely to be prescribed for older children and in particular those with mandibular fractures or panfacial fractures.

Recommendation

Since we have found that accidental falls and road traffic crashes are probably the leading causes of paediatric cranio-maxillofacial trauma in Kenya, preventive measures to reduce the paediatric trauma burden should focus on reducing the occurrence of falls and road traffic accidents

CHAPTER 1: INTRODUCTION & LITERATURE REVIEW

1.1 INTRODUCTION

Trauma is a rising problem across the world with evidence showing that the rise in the developing world far outnumbers the rise in the developed world. This rise in trauma has been attributed to the steep rise in road traffic crashes in these countries which in turn has been driven, largely, by rapid urbanization and poor road safety measures. According to one WHO publication, nearly 16 000 people die from injuries every day worldwide and for every person who dies of injuries, several thousand injured persons survive and many of these are left with permanent disability. This WHO publication also shows injuries to be the leading cause of mortality and morbidity among children below 6 years of age globally and among the top ten causes in sub-Saharan Africa where infectious diseases take the lead in pediatric mortality data, albeit with gaps in the reporting [1]. The disease burden of paediatric trauma in the developing world has been reported in several publications but few have come from Kenya and the East African region in general.

The traditional view of injuries as "accidents," or random events, has resulted in the historical neglect of this area of public health [2]. During the past few decades, public health officials have recognized that injuries are preventable and therefore have established methods of scientific study for the prevention of injuries. The public health approach to injury prevention involves the four key steps of an epidemiologic approach to any health problem; the first step is to determine the magnitude, scope and characteristics of the problem. The second step is to identify the factors that increase the risk of injury or disability and to determine which factors are potentially modifiable. The third step is to assess what measures can be taken to prevent the problem by using the information acquired in step 2 to design, pilot- test, and evaluate interventions. The final step is to

implement the most promising interventions on a broad scale [2]. This study addresses itself to the first step in this chain, that of characterizing paediatric cranio-maxillofacial injuries in Nairobi, Kenya.

1.2 LITERATURE REVIEW

1.2.1 Epidemiology of paediatric cranio-maxillofacial (CMF) trauma

According to survey data reported by the American National Hospital Ambulatory Medical Care Survey (NHAMCS), an estimated 11.3% of paediatric emergency room visits in the United States of America are due to CMF injuries [3]. Epidemiologic data from various parts of the world show incidence rates of paediatric facial trauma to be between 5% and 20 % [4]. Studies done locally suggest a similar incidence as Kihiko et al. reported that facial injuries constituted approximately 16.5 % of all injuries caused by accidental falls in children below 13 years of age seen over a four-months study period at Kenyatta National Hospital [5]. Although CMF injuries are common in children, facial fractures are rare in children compared to adults. Rowe looked at 1500 facial fractures and found that 5% of them occurred in children younger than 12 years and less than 1% of these fractures occurred in children younger than 6 years with an estimated 1 to 15% of facial fractures occurring in the paediatric population [6]. This low incidence of facial fractures in children compared to adults has been attributed to several factors; the underdeveloped facial skeleton in children, the lack of erupted dentition, malleable nature of bones in children, lack of pneumatization of the paranasal sinuses and protection of the malar region by the prominent buccal fat pad in infants [7]. Furthermore, young children are less often involved in occupational or violence-related accidents that are typical aetiologic agents of adult facial fractures. Soft tissue injuries, although not included in the reporting of most CMF trauma literature, constitute the largest proportion of CMF injuries in the paediatric age

group [8]. Most publications report mandibular fractures as the most common facial fracture in children, but some studies cited herein report a different pattern [3,9–12].

1.2.2 Aetiologic factors

The main causes of paediatric CMF trauma worldwide are road traffic crashes, accidental falls, violence and sports-related accidents with varying contributions from each cause based on geographic region. Eggensperger reported falls as the main aetiologic factor of CMF injuries in Switzerland and similar studies from Europe support this finding [3,8,10]. Motor vehicle crashes are reported to be the leading aetiologic factors in North America, South America, Asia, and Africa [9,11–15]. Sports related CMF injuries constitute a significant proportion of paediatric CMF injuries in Europe than other regions [3]. Falls are reported to be the main cause in children younger than six years whereas road traffic crashes and interpersonal violence are the leading causes among the adolescents [3,16]. Locally, Muriithi et al reported accidental falls to be the leading cause of dentoalveolar injuries among children below the age of 15 years presenting at Kenyatta National Hospital [17]. Paediatric CMF injuries caused by firearms and explosive devices may be a significant proportion in Kenya due to acts of terrorism that have been on the rise recently. Odhiambo et al reported 3.2 % of all firearm injuries presenting at KNH over a two year period affected children below the age of fourteen years [18]. Most of these injuries were as a result of shootings during armed robbery or stray bullets and mainly affected the lower extremities.

1.2.3 Soft tissue injuries

Soft tissue injuries (STIs), whether isolated or in combination with other injuries, are among the most common traumatic CMF injuries encountered in the accident & emergency department [8]. These STIs include bruises, abrasions, bites, lacerations, friction burns, crush injuries, stab wounds, degloving injuries and deep cuts depending on the

mechanism of injury. A summary of the various types of STIs with their respective mechanism of injury is shown in Table 1 below.

Table 1: General classification of soft tissue injuries

Type of force	Type of injury
Sharp, pointed	Stab wound
Blunt	Contusion injury, cut
Extension, twist	Laceration
Shear	Degloving, wound defect, avulsions, abrasion
Combination of forces	Wounds from blows, impaling, bites, and gunshot
Crushing	Traumatic amputation, rupture, crush injury
Thermal	Burns

Few studies have included STIs when reporting on paediatric CMF trauma. In a review of 3385 children treated at a single center in Europe over a period of 10 years, Gassner et al found 1697 (50.1%) children had STIs with or without skeletal injuries [8]. Similarly, Osunde et al found that 70 % of children under the age of 15 years presenting with maxillofacial injuries at a single center in Nigeria had STIs [9].

The management of STIs depends on their severity, special anatomic structures that are injured, presence of fractures, immunization status and the level of wound contamination. In general, soft tissue injuries receive prompt treatment without complications. The high vascularity of CMF structures reduces the risk of infection relative to other anatomic regions, however, delays in treatment of STIs carries a risk of infection [19]. The lower risk of infection allows the surgeon to do minimal debridement and primary closure of facial wounds without increasing the risk of infection compared to wounds in the extremities. It is also important to consider the mechanism of injury as certain injuries, like gunshot

injuries, are associated with significant debris or wound contamination and subsequently require additional debridement and/or antibiotic prophylaxis. A special category of soft tissue injuries are those caused by animal bites especially dogs; they not only carry a higher risk of wound infection and sepsis but also carry the risk of contracting rabies with 100% mortality for established rabies infection [20,21]. Therefore, prophylactic treatment with anti-rabies vaccine should be given without delay to prevent this complication. Early definitive management of soft tissue injuries has been shown to minimize unsightly scarring and reduce the risk of wound sepsis and septicaemia[19, 22, 23]. However, delayed management of lacerations may be justified in the presence of underlying fractures which require surgical intervention [19]. Unnecessary delays may arise due to the unco-operative nature of young children limiting the ability to manage these injuries under local anaesthesia in the acute setting.

1.2.4 Dentoalveolar trauma

Injuries to the teeth and their supporting structures constitute dentoalveolar trauma which is a very common type of injury across all age groups. In all age groups the central incisors are the most prone to injury due to their prominent position on the face [24]. Studies reporting on the occurrence of dentoalveolar trauma in the context of facial injuries are few, with the majority of studies reporting on this topic as an isolated entity. Osunde et al found dentoalveolar injuries to constitute 12.5 % of all pediatric maxillofacial injuries at a single center in northern Nigeria [9]. Noteworthy, was the higher incidence of mandibular fractures at 16.3 % which could be due to underreporting of dentoalveolar injuries. Gassner et al retrospectively reviewed 6000 patients across all age groups treated for CMF injuries at a single center in Austria and found 2874 (47.9 %) patients had dental injuries [25]. Andreasen indicated that with underestimation taken into account, probably every other child had suffered dental trauma at the age of 14 years [26]. Most studies report accidental falls, sports,

interpersonal violence and road traffic crashes as the main causes of dentoalveolar injuries [3,9,25]. Muriithi et al, in a 5-year (1998-2002) retrospective analysis of dental and maxillofacial injuries among children below 15 years of age, treated at Kenyatta National Hospital in Nairobi, Kenya, found dental injuries (80.3 %) to be more common than both soft tissue injuries (29.9 %) and facial fractures (8.3 %) [27].

Multiple classification systems for dentoalveolar injuries exist but the most comprehensive was proposed by Andreasen in 1981, though it lacks the simplicity of the more popular Ellis classification [28]. The Andreasen classification system categorizes dentoalveolar injuries in to four classes with several subclasses; Class A is injuries to the dental hard tissues and the pulp, Class B is injuries to the periodontal tissues, Class C is injuries to the alveolar bone and Class D includes injuries to the gingiva or oral mucosa [28].

Trauma to the dentition in the paediatric patient is usually managed differently depending on whether the injured teeth belong to the deciduous dentition or the permanent dentition. In general, trauma to the deciduous dentition is treated via extraction while injuries to the permanent dentition are managed through dental restorative treatment. Avulsed deciduous teeth are not reimplanted and splinted due to the risk of ankylosis and subsequent interference with eruption of the permanent successor tooth [29].

Luxation injuries to the permanent dentition require splinting of the subluxed teeth to adjacent stable teeth for 3 to 4 weeks [30]. Avulsion injuries to the permanent teeth are generally treated through immediate reimplantation and splinting if the time outside the mouth is not more than two hours [26]. The primary treatment for alveolar bone fractures is non-surgical, consisting of immobilizing the arch segment using an arch bar, wire ligation, or composite supported orthodontic wire extended to stable teeth in the injured arch [31].

1.2.5 Mandibular fractures

The mandible is the most fractured facial bone in children as reported by a vast majority of studies. The incidence of mandibular fractures in children has been shown to be influenced by age with less than 5 % of paediatric mandibular fractures occurring in children less than 6 years of age [3,6,7,11]. The condylar process in children has been shown to be particularly vulnerable with up to 50% of mandibular fractures in children being reported to occur in the condylar region [32]. In younger children (<6 years) these fractures tend to occur in the intracapsular region of the condyle; in older children, they tend to occur in the condylar neck region [33, 34]. Most of the studies report falls and motor vehicle crashes as the main aetiology of mandibular fractures in children younger than 12 years, while sports injuries, interpersonal violence and motor vehicle crashes in that order are the predominant causes among adolescents [3,9,10,27,35–37]. There are differences in the reported contribution of each aetiologic factor between developed and developing countries. Sports injuries seem to be a more significant aetiologic factor in developed countries than in developing countries [3,9,10,36].

The choice of the method of management of mandibular fractures is influenced by several factors namely; the age of the patient, anatomic location, amount of displacement, degree of comminution, presence of other facial fractures, availability of requisite instrumentation and surgeon's preference and experience [4]. The treatment of condylar fractures in both adults and children is controversial with no clear protocol on when to choose one treatment modality among the various treatment options including non-surgical methods, that is; observation, pain management and soft diet, maxillomandibular fixation (MMF) and surgical in the form of open reduction and internal fixation (ORIF). The two issues of concern in paediatric condylar fractures are the risk of temporomandibular joint (TMJ) ankylosis and potential progressive growth disturbances of the face. The intact condylar

unit is essential to the integrity and function of the TMJ apparatus but more importantly it acts as a secondary growth center of the mandible and injuries to the condyle have been reported as the most common cause of temporomandibular joint ankylosis and asymmetrical mandibular growth [38, 39, 40]. A typical case of the sequelae of this type of injury is shown in Figure 1, of a 15-year old girl who presented to our institution with bilateral TMJ ankylosis and a diminutive mandible caused by condylar fractures sustained in her early years of childhood.

Figure 1: 15-year old girl with severe mandibular growth disturbance and bilateral TMJ ankylosis secondary to condylar fractures at an early age. Frontal view, right lateral view, coronal CT scan image of the left TMJ, 3D CT scan view of the left TMJ.

The goals of treating a fractured mandible, therefore, include restoring occlusion and facial form to preinjury function and appearance. In the paediatric patient the presence of underlying tooth buds may complicate ORIF for mandibular fractures. Closed treatment is preferred over ORIF due to the risk of injury to the tooth buds, scarring, risk of facial nerve injury and growth disturbances. In paediatric patients with minimally displaced condylar fractures, physiotherapy and pain management is the treatment of choice. If the occlusion is reproducible, a soft diet for 2 to 3 weeks is indicated. In condylar fractures that are not easily reducible or mandibular asymmetry accompanies a condylar fracture,

MMF may be indicated for 2 weeks followed by physical therapy because longer fixation/ immobilization may result in TMJ ankylosis [41, 42]. The occurrence of fractures to the symphysis, parasymphysis, body and angle of the mandible together with condylar fractures has been associated with a higher rate of TMJ ankylosis in children [43]. The absolute indications for open reduction of condylar fractures are similar to those for adults and include, among others: displacement of the condylar head into the middle cranial fossa, inability to obtain adequate occlusion by closed reduction, lateral extra-capsular condylar displacement and the presence of a foreign body. Relative indications for open reduction of condylar fractures include: severe seizure disorder, mental retardation, severe upper airway obstruction and psychological inability to tolerate MMF [44, 45]. However, due to the enormous remodelling potential of the condylar process in young children and in light of the risks of ORIF mentioned above, few of these fractures are managed surgically [4].

Isolated fractures of the mandibular angle, body and the symphyseal region in the growing patient are typically managed through closed reduction, because these fractures are often easily reduced. In addition, the osteogenic potential of healing bone in children compared with the adult, only 2 to 3 weeks of MMF is required [46]. When MMF is not feasible, an alternative technique is to fabricate a lingual splint from dental models of the patient and use wires to anchor the splint to the dentition with or without circummandibular wiring after fracture reduction. ORIF for angle, symphyseal, or body fractures in the pediatric patient is rarely indicated. In patients with associated condylar fractures, however, internal fixation of the symphyseal fracture has been advocated with the aim of reducing the need for MMF and permitting early resumption of joint function. Therefore, ORIF is limited to patients in whom there is a severely displaced fracture and closed reduction is not feasible or there is an associated condylar fracture. There has been no reported increase in ORIF

of paediatric mandibular fractures with the advent of resorbable plates because the available systems tend to be expensive and most of the aforementioned challenges are still encountered [47, 48].

1.2.6 Paediatric midface fractures

The midface is the anatomic region that spans the distance between the glabella and the occlusal plane. The midface skeleton is composed of several paired bones that may be fractured separately or in a combined fashion due to their articulations with each other. The midface skeleton houses important anatomic structures including the eyes, nasal cavity and paranasal sinuses with important functions. The anatomic pattern and aetiology of paediatric midface fractures differ widely among many studies. Due to the lack of pneumatization of the paranasal sinuses and the protection by a prominent buccal fat pad, midface fractures are rare in the paediatric population with the exception of nasal fractures [4,49].

1.2.6.1 Nasal Fractures

Nasal fractures have been reported as the second most common type of paediatric facial fractures after mandibular fractures [3]. The prominent position of the nose on the face and the thin structure of the nasal bones predisposes them to fractures even with minor force that will not fracture other facial bones [4]. The aetiologic factors of nasal fractures vary with the age of the patient; falls and road traffic crashes are predominant causes in young children below 6 years while interpersonal violence and sports injuries are more significant causes of nasal trauma in adolescents [50]. Nasal fractures have been reported to be more common in boys than girls in the adolescent group and no gender predilection in the younger children which is a reflection of the pattern of aetiologic factors [50]. The true incidence of these injuries tends to be underestimated in most studies due to the fact that they are managed by different surgical specialties with some being managed by ENT surgeons and others by maxillofacial surgeons [10].

Generally, treatment consists usually of closed reduction with nasal packing and splinting after satisfactory reduction of the fracture for stabilization. The treatment is usually done under local anaesthesia in adults and adolescents but sedation or general anaesthesia is required in children [51]. Inadequately treated nasal bone fractures are associated with long-term complications related to midface growth, nasal dorsum and septal deformities which have a negative impact on facial esthetics and occasionally on airway patency [52]. Septal hematomas require urgent evacuation as they carry a risk of septal cartilage necrosis and long-term complications that are very challenging to treat [4].

1.2.6.2 Maxillary fractures

Isolated Le Fort fractures are rare in the paediatric population and are estimated to constitute between 1-10% of all paediatric facial fractures [35]. Midface fractures tend to be a combination of fractures of the various bones that form the midface. For this reason, many studies report them as a single entity or using the term orbito-zygomatico-maxillary fractures reflecting the common pattern of fracture extent frequently seen. Even when reported as a single entity, orbito-zygomatico-maxillary fractures have a lower incidence than mandibular and nasal fractures in children [3,53]. The low incidence of these fractures in children has been attributed to some unique characteristics of the child's maxilla including a higher quantity of cancellous bone, unerupted teeth, and underdeveloped maxillary sinuses. The piriform aperture and zygomatico-maxillary buttress are much thicker structures and the soft tissue contains more adipose tissue in the child than in the adult. Therefore, considerable force is necessary to disrupt the midfacial skeleton in children compared to adults and consequently Le Fort fractures in children are rare and result from high energy impacts [54]. Motor vehicle crashes are the most significant cause of paediatric maxillary fractures due to the high energy impact required to disrupt this anatomic region [11]. Closed reduction and intermaxillary fixation for 2-3 weeks is, most of

the time, the treatment of choice. ORIF is rarely used in young children due to the risk of injury to the tooth buds and interference with midfacial growth but can be considered for adolescents and in panfacial fractures [4].

1.2.6.3 Orbital Fractures

Majority of studies show orbital fractures in children to be rare compared to mandibular and nasal fractures [3,9–11]. However, different patterns have been reported; in a series of 772 facial fractures in children, Grunwaldt et al. reported that orbital fractures were the most common in all age groups (36–45%) at a level one trauma centre in Philadelphia, US [12]. The incidence of orbital fractures has been reported to increase with age and more significant is the distribution of fractures among the four orbital walls that appears to be influenced by the age of the child [11]. The orbital roof is more susceptible to fractures than the other orbital walls in children below the age of 8 years due to their relative underdevelopment and lack of pneumatization of the frontal and ethmoidal sinuses [55]. O-Lee et al reported that orbital roof fractures constitute up to 35 % of paediatric orbital fractures compared to adults where they are rarely encountered and show no gender predilection in paediatrics compared to adults where there is a high male predilection (89-93 %) [56]. Motor vehicle crashes and falls are the commonest aetiologic factors in young children with an increasing contribution from sports and violence as the age increases [57].

Since most growth of the orbits is complete after the age of 7, fractures of the orbit in children 7 years or older should be managed like those in the adult without major concern for growth disturbance [58]. There remains debate about the timing of ORIF with some authors advocating immediate surgery, whereas others advocate waiting until periorbital edema has resolved [56,59]. An ophthalmology consultation is mandatory to rule out globe injury because up to 24% of cases of paediatric orbital trauma have associated injury to the globe [59].

Treatment of paediatric orbital trauma is primarily by conservative management and surgical intervention is warranted only when there is evidence of entrapment, enophthalmos or vertical orbital dystopia [57]. Orbital fractures in children with evidence of muscle entrapment should be treated as a surgical emergency to avoid ischemic necrosis of the extraocular musculature and associated disturbances in eye movements and resultant diplopia [60].

1.2.6.4 Naso-Orbital Ethmoidal (NOE) Fractures

Naso-orbital-ethmoidal (NOE) fractures remain the most complex of all facial fractures to diagnose and treat mainly because of the intricate anatomy and difficult in surgical access for fracture reduction and fixation [4]. Fortunately, NOE fractures are uncommon in children with a reported frequency of 1-8 % [8, 61]. However, as the incidence of high-velocity accidents has increased over the decades, so too has the number of such fractures. Due to the degree of force and the vectors involved, NOE fractures rarely occur as isolated events. Associated injures often include central nervous system injury, cribriform plate fracture, cerebrospinal fluid (CSF) rhinorrhea and fractures of the frontal bone, orbital floor, and middle third of the face, as well as injury to the lacrimal drainage system [61]. Clinical examination may be suggestive with clear fluid discharge that tends to form a double ring when placed on an absorbent paper. A confirmatory test is the presence of β-transferrin presence in the fluid [62]. The prophylactic use of antibiotics and anticonvulsants in patients with CSF leaks to prevent the development of meningitis and seizures though recommended remains controversial [63].

There are several classification systems for NOE fractures but the most widely used is by Markowitz because of its simplicity and clinical utility in surgical management of these injuries. Type 1 fractures have a large central bone fragment without comminution and are easily managed via reduction and fixation of the fragment with miniplates. Type 2

fractures are comminuted fractures but the medial canthal ligament is not detached and are managed via surgical reduction and osteosynthesis while Type 3 fractures are comminuted fractures with detachment of the medial canthal ligament and requires complex canthopexy techniques to re-establish the normal anatomy of the medial canthal/ NOE complex [4].

ORIF is the mainstay of treatment and consideration should be given to the use of resorbable hardware in this region in children due to concerns over interference with growth and hardware migration with the use of metallic implants [4].

1.2.6.5 Zygomatic Complex Fractures

Zygomatic complex fractures include fractures of the zygoma, zygomatico-maxillary complex (ZMC), zygomatico-orbital complexes and the zygomatic arch. These are common fractures especially in adolescents and have been reported to represent up to 41% of all paediatric midface fractures [61]. It has been reported that with increasing age the zygoma becomes more prominent and fractures to this area increase in incidence [7]. Gender predilection has been reported in adolescents with a higher incidence in boys due to the fact that they are more likely to be involved in contact sports and fights than girls [14,61,64]. Since they are often accompanied by orbital fractures, a thorough ophthalmologic examination is warranted supplemented with computed tomography imaging. Reduction of the fractured arch of the zygoma is often the only treatment necessary and, just as in the adult, is performed only if a cosmetic deformity exists or if notable trismus is present [4,61]. Greenstick or minimally displaced arch fractures in the paediatric patient are treated conservatively by observation, but ORIF may be necessary for significantly displaced or comminuted fractures [4]. Intraoral and extraoral approaches are often indicated to stabilize a true zygomaticomaxillary fracture with two-point fixation being adequate for most ZMC fractures in younger children and three-point fixation in adolescents. Facial edema is often

associated with these fractures, which may require a delay in treatment to allow for the edema to resolve. Additionally, care should be taken when placing the hardware for rigid fixation in the zygomatomaxillary buttress region to avoid damaging any underlying tooth buds. Isolated zygomatic arch fractures can be treated via an extraoral (Gilles) or intra-oral (Keen) approaches, usually with no need for rigid fixation. The reduced arch must be protected post-operatively from any trauma or pressure during the initial postoperative period to ensure that the reduced arch does not displace. Growth disturbances rarely occur with this type of fracture [4, 58].

1.2.7 Frontal sinus fractures

The frontal bone is more prone to injury in children due to the prominence and relative larger size of the cranium compared to the face in younger children [7,56]. Frontal sinus fractures in children are rare mainly because of lack of pneumatization of the sinuses in the early years of life. Of the paranasal sinuses, the frontal sinuses are the last to develop and do not fully pneumatize until adolescence [65]. Associated intracranial injuries are more common in paediatric patients with frontal sinus fractures compared with adults. A 2005 study by Whatley et al of 120 paediatric maxillofacial fractures found 11 with frontal sinus fractures and all the 11 patients suffered concomitant orbital fractures, 7 sustained significant intracranial injuries and 4 had CSF leaks [66]. No gender predilection has been reported and the most significant aetiologic factors are falls and motor vehicle crashes [4,65]. Management involves identifying and treating any concomitant intracranial injury in the acute setting and preventing long-term complications such as CSF fistula, meningitis, frontal sinusitis, mucocele and forehead deformities [67]. Conservative management is indicated for paediatric frontal sinus fractures with nondisplaced anterior or posterior table fractures, provided there is no CSF leak. Severely displaced paediatric frontal sinus fractures involving the anterior table require ORIF which involves the use of resorbable

plates or titanium plates that usually require removal after 4-6 months. Posterior table involvement may require cranialization of the frontal sinus similar to management of equivalent injuries in adults. The role of frontal sinus obliteration in the pediatric population is not well established [65, 66]. The role of endoscopic sinus surgery in pediatric frontal sinus fractures with sinus preservation has been advocated as a safe treatment method but long-term follow-up is mandatory due to the rare but serious long-term complications associated with these injuries, including meningitis, frontal sinus mucoceles, cerebral abscesses and osteomyelitis of the frontal bone [63,68].

CHAPTER 2

2.1 STATEMENT OF THE PROBLEM

There is evidence of a rise in the incidence of trauma especially in developing countries which poses a significant public health problem and puts a strain on the healthcare system. CMF trauma has been shown to have significant differences between children and adults in terms of incidence, aetiology, patterns and management. Quantifying the magnitude of paediatric CMF trauma is a first step in formulating policy on prevention and management of these unique injuries. The problem has not been researched adequately, particularly on the African continent, with only a few articles in the literature on this subject matter.

2.2 STUDY JUSTIFICATION

According to WHO, trauma is a leading cause of morbidity and mortality in the paediatric age group world-over, but with a higher proportion in developed countries compared with developing countries where infectious diseases are the major contributors. The main causes of trauma in the paediatric age group have been reported as road traffic injuries, falls, sports related injuries and interpersonal violence with varying contributions from each cause depending on the geographic region and the age of the patient. Studies from different parts of the world show different patterns of CMF trauma in the paediatric age group with respect to the aetiologic factors and the specific anatomic structures injured. There are hardly any studies that have looked at paediatric CMF trauma in Kenya and the East African region. Majority of these studies meant to document the incidence, patterns and management of paediatric CMF injuries in the region are usually part of general CMF trauma and do not give a clear picture of the disease burden in paediatrics.

Management of paediatric CMF trauma also differs from the management of similar injuries in adult patients mostly due to concerns on potential interference with growth of the facial skeleton that are caused by surgical interventions. A study on current

management protocols will help to compare management of these injuries in our country with management in other regions. It will also provide baseline information for future comparative studies on the trends of aetiologic factors, anatomic patterns and management of these injuries.

2.3 Study Objectives

2.3.1 Main objective:

To describe the pattern and management of paediatric cranio-maxillofacial (CMF) trauma at the Kenyatta National Hospital (KNH) in Nairobi between April and September 2016.

2.3.2 Specific objectives:

1) To describe the demographic characteristics of paediatric patients (<18 years) with CMF injuries seen at KNH.
2) To describe the aetiologic factors and anatomical patterns of CMF injuries in paediatric patients seen at KNH.
3) To determine the intervention protocols prescribed for these paediatric CMF injuries at KNH.

2.4 Variables

The variables in this study were categorized in to dependent and independent variables based on the way they were hypothesized to relate with each other. The age and gender of the child has been shown by other authors to affect the contribution from each of the various aetiologic factors and the resultant pattern of injuries sustained, in particular facial fractures. The age of the child and the type of facial fractures sustained have a direct influence on the choice of management.

2.4.1 Independent variables

1. Age
2. Gender

2.4.2 Dependent variables

1. Aetiologic factors.
2. Type of cranio-maxillofacial injury.
3. Management protocol for cranio-maxillofacial injuries.

The relationship between these variables was explored using descriptive and analytical statistics as discussed in chapter 3.

CHAPTER 3: MATERIALS & METHODS

3.1 Study area

Kenyatta National Hospital (KNH) is located along Ngong Road about 3 kilometers from the central business district of Nairobi, the capital city of Kenya (Latitude 1.3011S, Longitude 36.8115E). This tertiary care, teaching and referral hospital has a bed capacity of 1800. The hospital provides services as follows; average annual outpatient attendance is 500,000 visits while average annual inpatient attendance is 70,000 patients [69].

Complex injuries from the entire country and sometimes the East African region are referred to KNH for specialized management. The hospital has both an inpatient and outpatient facility to cater for patients in need of Oral and Maxillofacial surgical care.

3.2 Study population

Paediatric trauma patients (<18 years) seen at Kenyatta National Hospital (KNH) in Nairobi between April and September 2016.

3.3 Study design

This was a hospital-based, descriptive cross-sectional study with the study subjects recruited prospectively.

3.4 Study period

April 2016-September 2016.

3.5 Inclusion criteria

I. Patients below the age of 18 years presenting with cranio-maxillofacial trauma at KNH between April and September 2016.
II. Patients whose parents/ guardians consented to participate in the study.

3.6 Exclusion criteria.

1) Patients whose parents/ guardians declined to give consent.

2) Patients with old injuries (healed).
3) Patients who were managed definitively in other facilities and referred to KNH following complications.

3.7 Sample size determination

Sample size was calculated using the following formula of estimating sample size for a cross-sectional study with a known expected proportion of an attribute in the population study with a precision of 5 % [70].

Sample size $n = \frac{Z_{\alpha}^2 P(1-P)}{d^2}$

Where Z_{α} = Standard normal deviate for a level of confidence of 95 %.

P= Estimated proportion of an attribute in the population.

Estimated proportion of facial fractures in children with cranio-maxillofacial injuries at 30 % by Osunde et al in a similar study done at a teaching hospital in Kano, Nigeria [9].

d= set precision for estimating the proportion=5 %

Therefore, $n = \frac{(1.96)^2 \text{ X } (0.3 \text{ x } 0.7)}{(0.05)^2}$

$n = 217$

The number of paediatric trauma patients with cranio-maxillofacial injuries at KNH (study population) was estimated from a study done by Kihiko et al where 17 % of children below 15 years who sustained injuries from falls had facial injuries [5]. A review of the hospital central registry from previous years' patient attendance, showed the number of paediatric trauma patients attended in the hospital to be approximately 200 patients per month (1200 patients in 6 months). The proportion of patients with CMF injuries seen in six months

was estimated to be 204 (17 % of 1200). This was used to adjust the sample size for a finite population.

$$n = \frac{noN}{no + (N - 1)}$$

$$n = \frac{217 \times 204}{217 + (204 - 1)}$$

$$n = 105\ patients$$

Where *n*= sample size corrected for finite population,

n_0= sample size without finite population correction, (calculated from the first formula) and

N= study population.

Therefore, a minimum of 105 children with cranio-maxillofacial injuries were required to adequately power the study.

3.8 Sampling technique

A convenient sampling technique (non-probability sampling) was utilized to recruit study subjects, with all patients who met the study criteria being included.

3.9 Ethical considerations

Ethical clearance to carry out the study was granted by the KNH/UON Research Ethics and standards committee before commencement of the study. (ERC protocol P3/01/2016-Appendix 1). Informed consent was sought from all parents or guardians of the study subjects with an additional assent for all children above 8 years of age. Confidentiality was maintained throughout the study by removing any patient identifiers from the data collected. The study participants benefitted from participation through efforts by the principle investigator to expedite their definitive management by the appropriate medical/surgical specialists. The principle investigator (a senior house officer) also

assisted the junior house officers in management of minor injuries (STIs and dentoalveolar injuries) which was an added benefit to the participating children.

3.10 Data collection

The principal investigator and his research assistant interviewed the parents/guardians using a data collection form (Appendix 2) followed by physical examination and interpretation of available radiographs (CT scans and OPGs). This was done in the Accident & Emergency department or outpatient clinic as well as in the wards. The research assistant was a clinical officer stationed at the A&E department as a triage officer with training on diagnosis of common injuries presenting at the department. Her role was to identify all paediatric patients presenting with traumatic injuries and notify the principal investigator who was a senior house officer in the department of Oral & Maxillofacial Surgery with adequate training in diagnosis and management of CMF injuries. The principal investigator reviewed all patients with CMF injuries after they were flagged by his assistant to ensure all injuries were captured in the data collection sheet consistently and accurately. Additionally, all CT scan images were correlated with the radiologists' reports to ensure reliability of the results. The classification of CMF fractures in the questionnaire followed that universally accepted classification systems to ensure validity; dental injuries were classified according to the Ellis classification and facial fractures according to the AO classification [71,72].

The patient's sociodemographic data such as age, gender, medical history, and residence were obtained. The cause of injury/mechanism of injury, initial treatment/ management protocols and other injuries sustained were recorded.

The inpatients were then followed up in the wards and outpatients in the clinic to document the management of the cranio-maxillofacial injuries.

The emergency management of patients by the attending doctors preceded data collection.

3.11 Statistical analysis

Data was entered and analyzed using SPSS version 23.

Descriptive statistics (mean with standard deviation, median with interquartile range) were used in conjunction with graphical (pie charts and bar graphs) and tabular representation of the data for exploratory purposes.

The following associations between study variables were tested for statistical significance:

1) Association between gender and aetiology of CMF injury was tested using chi square test of goodness of fit test (with both as categorical variables).
2) Association between age and type of CMF injury was tested using ANOVA (with age as a continuous variable and type of injury as categorical variable).
3) Association between age and aetiology of CMF injury was tested using ANOVA (with age as a continuous variable and type of injury as a categorical variable).
4) Association between gender and type of CMF injury was tested using chi square goodness of fit test.

CHAPTER 4: RESULTS

4.1 General Paediatric Trauma

A total of seven hundred and five (705) injured children presented to KNH over the six-months study period, between April and September 2016. The median age was 7 years (IQR= 2.5-12.0). There were 439 boys (62 %) and 266 girls (38 %).

The distribution of the patients according to the site and type of injury is shown in Fig. 2.

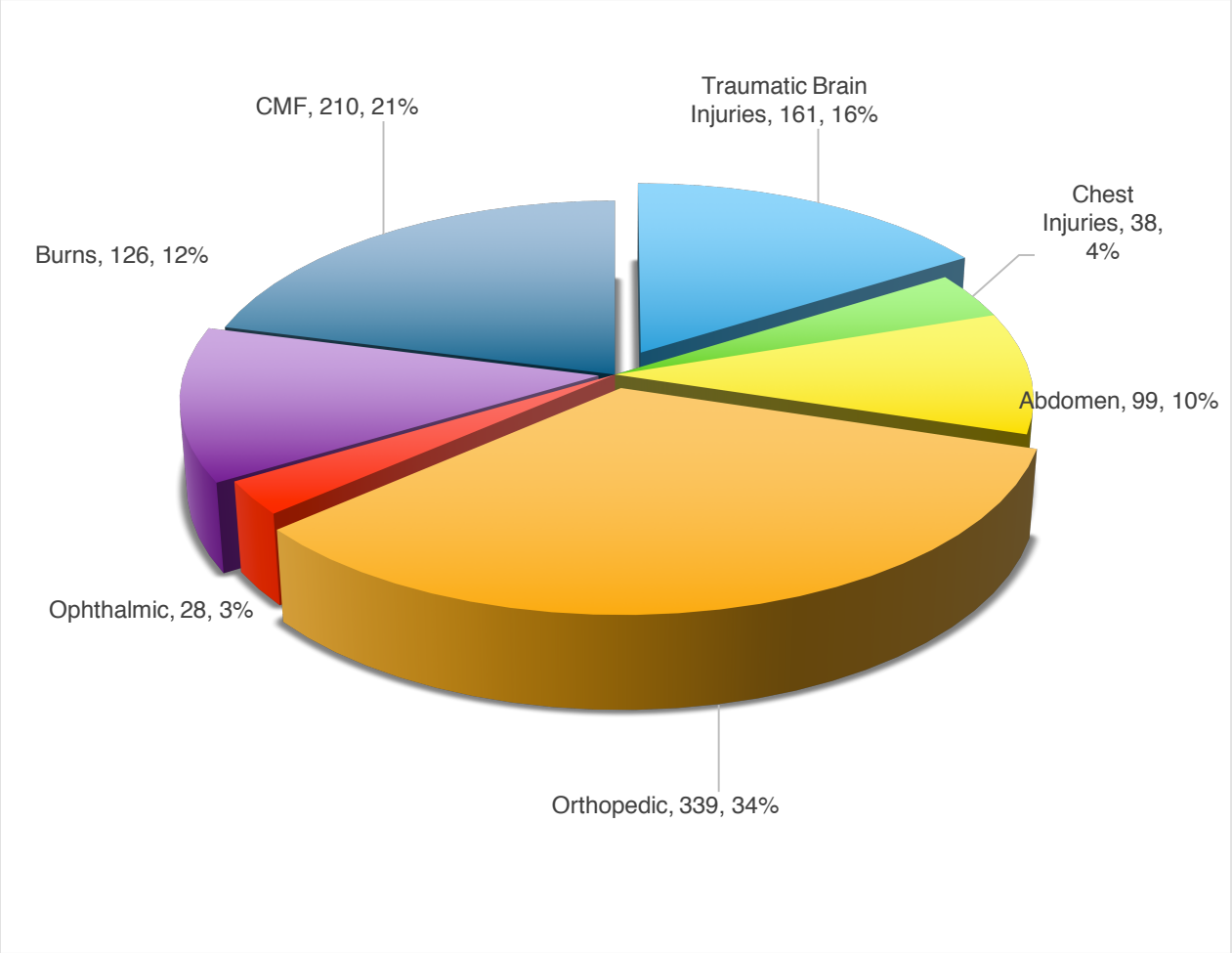

Figure 2: Occurrence of the various types of paediatric trauma.

Orthopedic injuries, being the most common type of injury seen, were recorded in 339 children representing 48.1 % of all the children seen over the 6-month study period.

Cranio-Maxillofacial injuries were seen in 210 children representing 29.8 % of the study population. The incidence of CMF trauma was closely mirrored by that of traumatic brain injury with approximately 23% of children presenting with head injury of varying severity.

4.1.1 Aetiology of Paediatric Trauma

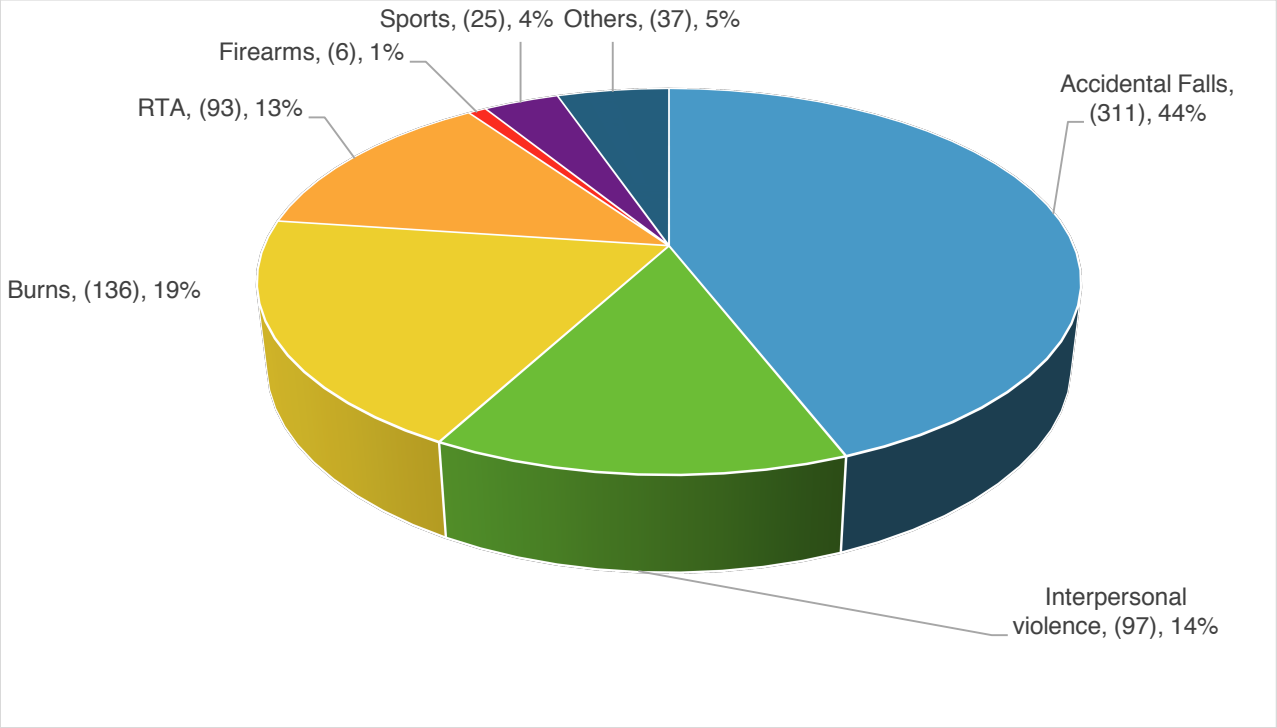

Figure 3: Distribution of paediatric trauma cases by aetiologic factors.

The causes of injuries for 705 children seen over the 6-month study period are as shown in Fig. 3. Accidental falls were the predominant cause of paediatric trauma accounting for 44 % of all injuries. Injuries through road traffic crashes were the third largest group, contributing 13 % of all paediatric injuries whereas burn injuries had an incidence of 19 %.

4.2 Craniomaxillofacial (CMF) injuries

CMF injuries constituted approximately 28.9 % or nearly a third of all injuries seen in the 705 children who were studied. The distribution of CMF injuries according to socio-demographic features was analyzed using non-parametric tests and presented graphically using charts as follows.

4.2.1 Age distribution of children with CMF injuries

The age range of the patients with CMF injuries was between 3 months to 17.9 years (mean= 7.4 SD 5.6, median = 5yrs, IQR= 2.8 - 12.0). The age group most affected was that below 6 years of age with 118 patients (56.2 %) falling under this age group (Figure 4).

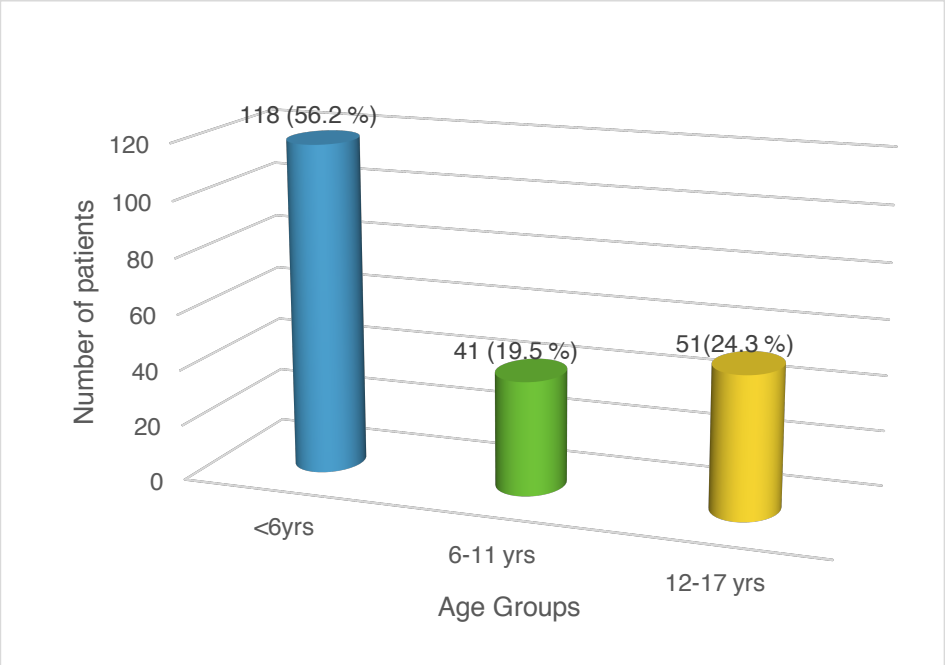

Figure 4: Distribution of children with CMF injuries by age categories.

4.2.2 Gender distribution of children with CMF injuries

There were 146 (69.5 %) boys and 64 (30.5 %) girls who sustained CMF injuries during the study period giving a boys to girls ratio of 2.2: 1.

4.2.3 Aetiologic factors of CMF injuries

Accidental falls were the most frequent cause of paediatric craniomaxillofacial injuries with 91 cases (44 %) reported followed by motor vehicle crashes, which were the cause of injury to 45 patients (22 %). Interpersonal violence was the aetiologic factor in 30 patients representing 14 % of injured children. The distribution of children with CMF injuries according to the aetiologic factors among the 210 patients is shown in Fig. 5.

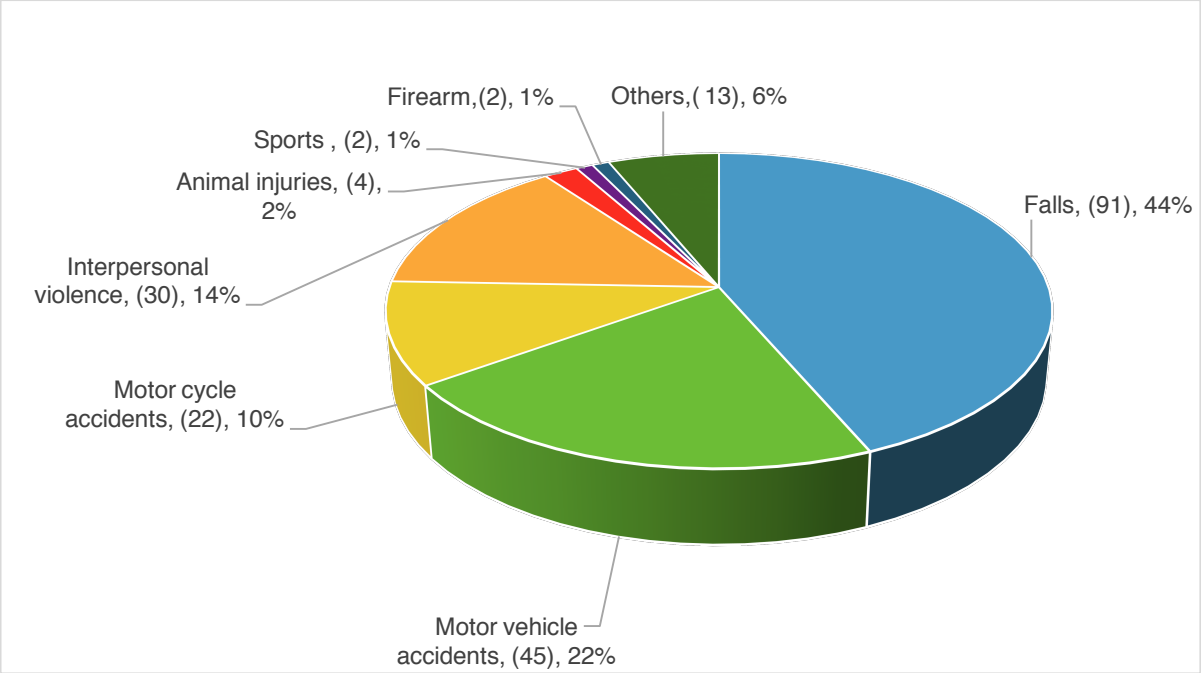

Figure 5: Distribution of children with CMF injuries by aetiologic factor (n=210).

4.2.4 Distribution of CMF injuries by type and anatomic site

Soft tissue injuries were the most prevalent CMF injuries recorded in the study population with 151 out of 210 patients (71.9 %) sustaining one or more STIs (Figure 6).

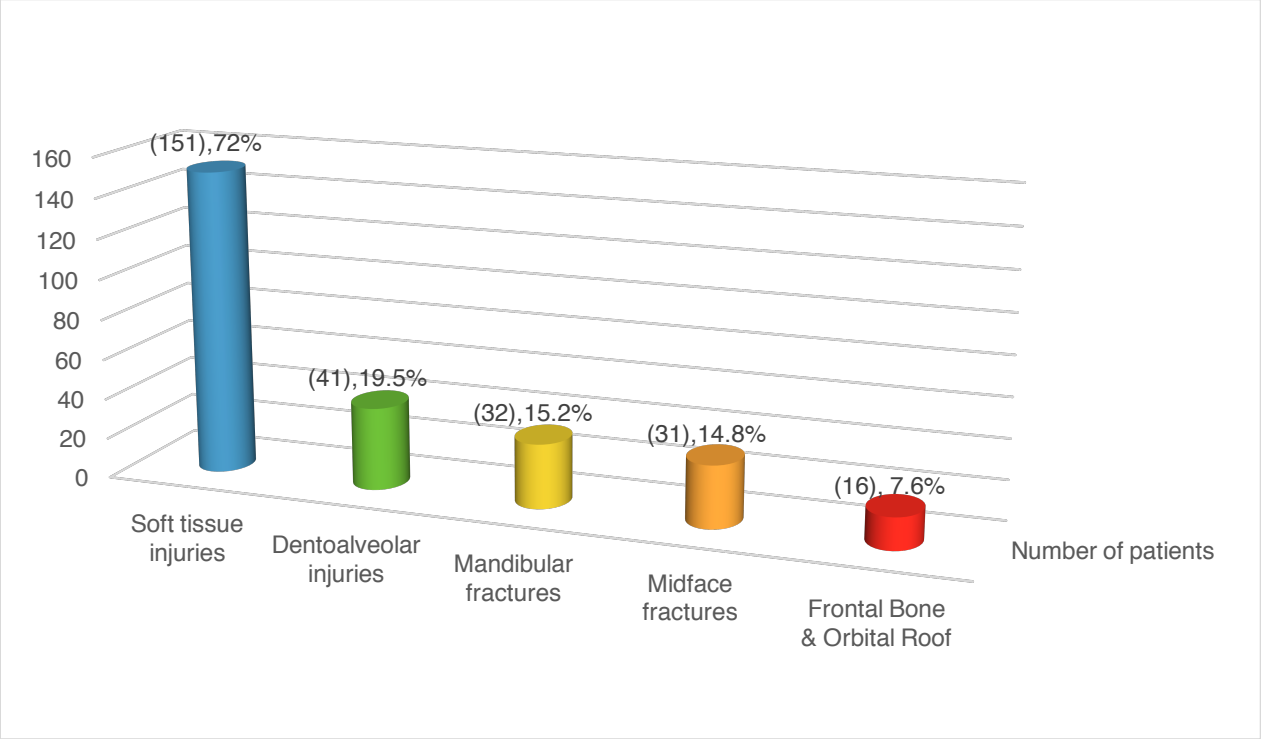

Figure 6: Distribution of patients by type of CMF injury (n=210).

2.2.5 Occurrence of soft tissue injuries

Soft tissue injuries were the most common injuries to the CMF region recorded in the study. Most injuries were lacerations affecting the facial skin and the scalp as shown in Table 2. Degloving injuries affected three children and were the result of road traffic crashes. Four cases of animal bites were recorded with one child aged 3 years succumbing to hypovolemic shock secondary to severe hemorrhage. Table 3 summarizes the types of STIs recorded.

Table 2: Distribution of children with CMF soft tissue injuries (n=151).

Soft tissue injury (STI) (*n= 151)*	Number of injuries	% of total number of patients with STIs
Non-specialized skin of the face	67	43.8
Scalp	44	28.6
Lip	31	20.3
Eyelid	20	13.1
Tongue	13	8.5
Globe (ocular)	7	4.6
Nose	7	4.6
Pinna of the Ear (Auricle)	3	2.0
Parotid duct	2	1.3
Facial nerve	2	1.0
Lacrimal apparatus	1	0.7

Table 3: Distribution of STIs by type

Type of STI	Number of injuries	% of total STIs
Lacerations & cuts	136	90.1
Degloving injury	3	2
Stab wounds	3	2
Animal bites	4	2.6
Gunshot & ballistic	3	2
Ruptured viscera (globe)	2	1.3
Total	151	100

There was fairly equal distribution of STIs among the various age groups although with a slightly high frequency among the 3-6-year-olds. Accidental falls were the leading cause of STIs among children age six years and below while motor vehicle crashes and interpersonal violence were the leading causes among the 7-11-year-olds and 12-17-year-olds respectively (Table 4).

Table 4: Age and gender distribution of children with STIs

Age Group	Gender		Predominant cause of STI for the age group (%)
	Male	Female	
1-2 yrs	21	16	Falls (57%)
3-6 yrs	38	18	Falls (55.2%)
7-11 yrs	19	7	MVC (35%)
12-17 yrs	27	5	IPV (43.8%)

4.2.6 Skeletal injuries in the CMF region

66 patients (31.4 %) out of the 210 patients presented with a total of 116 CMF fractures. Mandibular fractures were the most common category with 50 fractures (43.1 %) followed by midface fractures (46 fractures, 39.7%). The distribution of the various types of midface fractures (maxillary, nasal, NOE, zygomatic and orbital) are shown in Figure 7. Twenty frontal bone/sinus fractures were recorded representing 17.2 % of all CMF fractures.

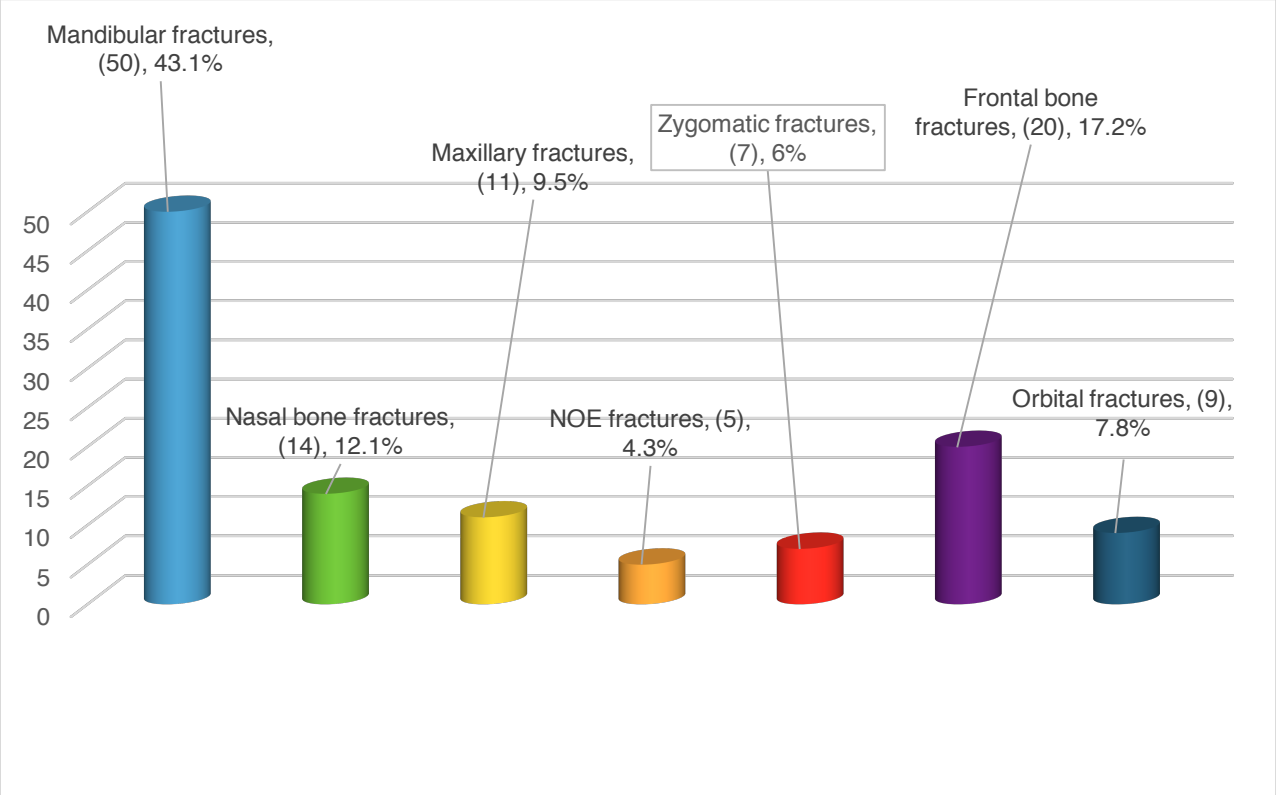

Figure 7: Distribution of CMF fractures by anatomic site (fractured bone) (n=116).

4.2.7 Pattern of mandibular fractures

Amongst children with mandibular fractures, the condylar process was the most common fracture site, with 16 (32 %) condylar fractures recorded (Figure 8). Bilateral condylar fractures were seen in 4 patients while unilateral condylar fractures occurred in 8 patients.

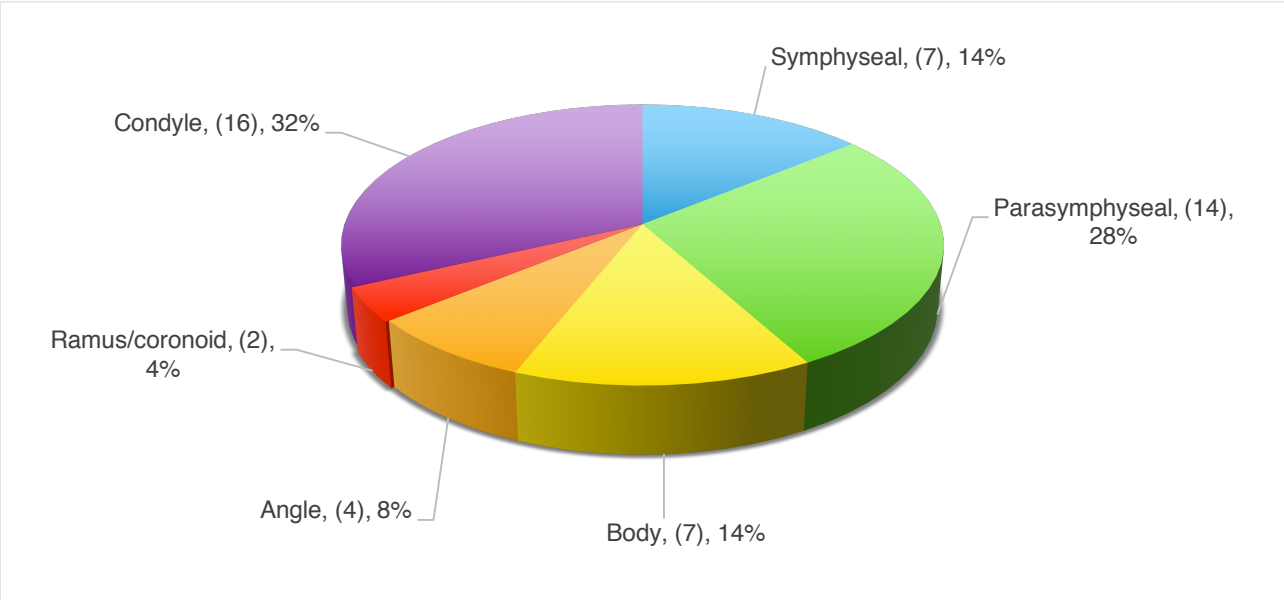

Figure 8: Occurrence of mandibular fractures by anatomic site (n=50).

4.2.8 Occurrence of dentoalveolar injuries

Fourty-one (19.5 %) out of two hundred and ten children and adolescents presented with dentoalveolar injuries constituting the largest group of patients with maxillofacial hard tissue injuries. Twenty-eight children (68.3 %) with dentoalveolar injuries were boys and thirteen (31.7 %) were girls. Luxation injuries were the most common type of dentoalveolar injury followed by crown fractures (Table 5). The main cause of dentoalveolar injuries was accidental falls with a contribution of 56.1 % (Table 6).

Table 5: Distribution of children with dentoalveolar injuries by type of injury (n=65).

Dentoalveolar injuries	Number of children with each particular injury*
Luxation injuries	32
Crown fractures	15
Avulsion	10
Alveolar bone fractures	6
Root fractures	2

Table 6: Aetiology of dentoalveolar injuries (n=41)

Aetiology	No. of children	% of children with dentoalveolar injuries
Motor vehicle crash	7	17.1
Motor cycle crash	4	9.8
Falls	23	56.1
IPV	5	12.2
Others	2	4.9
Total	41	100

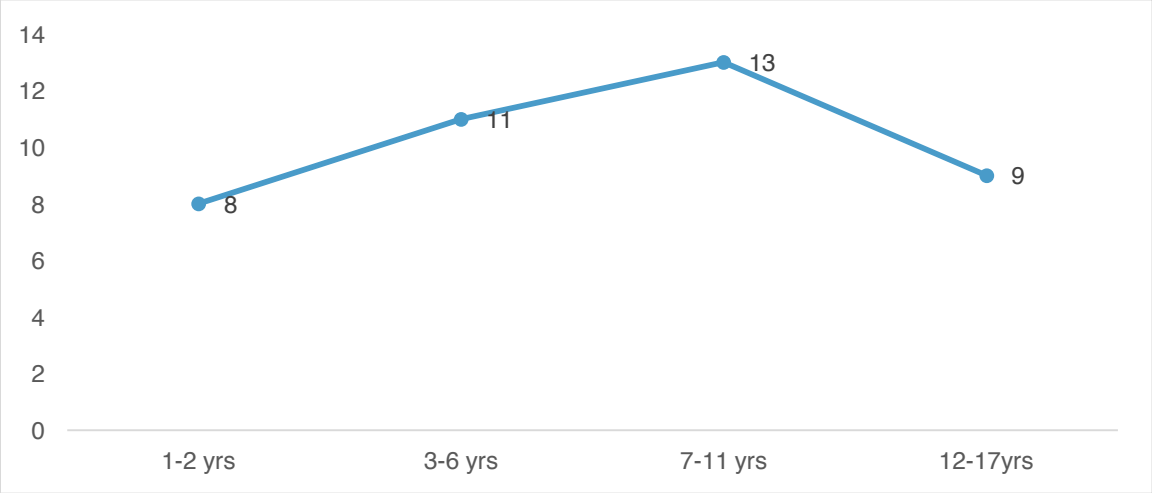

Figure 9: Line graph showing the trend of occurrence of dentoalveolar injuries with the age of the child (n=41).

Dentoalveolar injuries had a trend of increase with age from children aged two years and below with a peak in those between seven and twelve years followed by a steep decline in children between thirteen and seventeen years (Figure 9). The aetiologic factors also varied with age; with falls being the predominant cause in children below 12 years and road traffic crashes causing the majority of injuries in children between the age of 13 years and 17 years.

4.2.9 Pattern of midface fractures

A total of 31 children (47%) among the 66 children with facial fractures had midface fractures. 46 different midface fractures were recorded representing 39.7 % of all paediatric facial fractures.

Table 7: Distribution of midface fractures among 31 patients.

Type of fracture	No. of fractures	% of total midface fractures (n=46)
Nasal	14	30.4
Maxillary	11	23.9
Zygomatic	7	15.2
NOE	5	10.9
Orbital	9	19.6
Total	46	100

Maxillary fractures showed a bimodal distribution pattern with a peak in children aged 6 years and below and those between 13 years and 17 years and all children with maxillary fractures were boys. Orbital fractures predominantly affected the roof than any other wall (Table 8).

Table 8: Distribution of orbital fractures by affected wall

Orbital wall	Number of fractures	% of total orbital fractures
Roof	4	44.4
Lateral wall	2	22.2
Floor	2	22.2
Medial wall	1	11.1
Total	9	100

4.2.10 Occurrence of Frontal bone/ sinus fractures

Twenty frontal bone/sinus fractures were seen in sixteen (16) patients representing 16.2 % of all CMF fractures. There were 5 patients with isolated anterior table fracture, 4 patients with both anterior and posterior table fractures and no isolated posterior table fractures. CSF rhinorrhea were seen in all 4 patients with posterior table fractures and all of them closed spontaneously within a few days after the injury. Fractures of the frontal bone in young children with no pneumatized frontal sinus were seen in seven (7) patients mainly presenting as depressed skull fractures accompanied by concussion or minor intracranial bleeding except two patients who had intracranial bleeding and brain oedema necessitating decompressive craniectomy.

Table 9: Distribution of children by type of frontal bone fracture (n=20).

Frontal bone fractures (*n=20)*	**Number of fractures**	**% of frontal bone fractures**
Anterior table fractures	9	45
Posterior table fractures	4	20
Non-specified frontal bone fractures (No pneumatized frontal sinus)	7	35
Total	20	100

Twenty (20) fractures of the frontal bone were seen in 16 patients with 4 patients presenting with both anterior and posterior table fractures.

4.3 CMF injuries and socio-demographic factors

4.3.1 Association between age of the patient and type of CMF skeletal injury

The mean ages of patients with each type of CMF skeletal injury were compared using One-Way Analysis of Variance (ANOVA) test and no significant differences were observed (Table 10). The *α-level of significance* was set at 0.05.

Table 10: Summary of ANOVA results for association between type of CMF injury and the mean age of the patients (210)

Type of CMF injury	*n*	M	SD	Df	F	*p*
All CMF injuries	210	7.41	5.65	4	1.21339	0.3049
Mandibular fractures	32	8.17	5.97			
Midface fractures	31	9.11	5.73			
Frontal bone	16	5.65	5.69			
Dentoalveolar injuries	41	7.92	5.06			

The F-ratio value was 1.21339 with a *p-value* of 0.304924. The result is not significant at $p < .05$.

4.3.2 Association between the gender of the patients and type of CMF injury

There were 146 males and 64 females seen at KNH with CMF injuries during the study period. The distribution of patients by gender and type of CMF injury sustained was analyzed using the *Chi square goodness of fit* test and there was no statistically significant association at an α level of 0.05 ($\chi 2 = 3.98$, $df=4$, $p=0.4087$) (Table 11).

Table 11: Summary of Chi-square results for association between CMF injuries and gender (n=210).

	Gender		**χ^2 Goodness of fit test**
Type of Injury	Male (%)	Female (%)	
	(n=146)	(n=64)	$\chi^2 = 3.98$
Soft tissue injuries	105(71.9)	46(71.8)	$df=4$
Mandibular fractures	26(17.8)	6(9.4)	$p=0.4087$
Midface fractures	25(17.1)	6(9.4)	
Frontal bone fractures	12(8.2)	4(6.3)	
Dentoalveolar injuries	28(19.2)	13(20.3)	

4.3.3 Association between the age of the patients and aetiologic factors of CMF injuries

The mean ages of children who had CMF injuries caused by the four main aetiologic factors were compared using ANOVA test. The age of child had a statistically significant association with the aetiologic factors, with the mean age of children injured through IPV being significantly higher than that of all the other mean ages, as shown by the summary of the ANOVA test below.

Table 12: Table 8: Summary of results for ANOVA test for the association between the main aetiologic factors and the mean age of patients (n=210).

Aetiological factor	*n*	M	SD	Df	F	*p*
Motor vehicle crashes	45	8.22	5.44	4	14.34	<0.0001
Motor cycle crashes	22	7.78	5.22			
Accidental falls	91	4.94	4.31			
IPV	30	13.25	5.32			
All CMF injuries	210	7.41	5.65			

A post hoc analysis (*Tukey HSD test)* showed a statistically significant difference between the mean age of patients with injuries caused by IPV (n=30) with the mean age of all other categories (n=210) showing that IPV was more common among the older children/ adolescents than the younger children. Although the mean age for patients with injuries caused by accidental falls was lower than any other group, it was not statistically significantly different from the mean age of all patients combined.

4.3.4 Association between the gender of the patients and aetiologic factors of CMF injuries.

Chi square Goodness of fit test was used to test the null hypothesis that the gender of the patient had no association with the aetiology of CMF injuries with an α level of significance set at 0.05.

IPV was the only aetiologic factor that showed statistically significant association with the gender of the child, affecting boys more than girls ($X^2=10.485$, $df=4$, $p=0.0330$).

Table 13: Summary of Chi-square results for association between the main aetiologic factors with the gender of the patients (n=210).

Aetiologic factor	**Male**	**Female**	**Total**
Motor vehicle crashes	26	19	**45**
	31.29	*13.71*	
	(0.89)	(2.04)	
Motor cycle crashes	12	10	**22**
	15.30	*6.70*	
	(0.71)	(1.62)	
Falls	65	25	**90**
	62.57	*27.43*	
	(0.09)	(0.22)	
IPV	28	4	**32**
	22.25	*9.75*	
	(1.49)	(3.39)	
Others	15	6	**21**
	14.60	*6.40*	
	(0.01)	(0.03)	
	146	**64**	**210**

$\chi^2 = 10.485$, df = 4, χ^2/df = 2.62, P ($\chi^2 > 10.485$) = 0.0330

Expected values are shown in italics, individual chi-square values are shown in parentheses.

4.3.5 Association between CMF injuries and other injuries

Children with isolated CMF injuries were more common than those who suffered polytrauma. There were differences in the percentages of patients with different types of CMF injuries who presented with concomitant non-CMF injuries (Table 14). Frontal bone fractures had the highest association with non-CMF injuries; 31.3 % of patients with frontal bone fractures had traumatic brain injury. There were no patients with concomitant CMF injuries and abdominal injuries.

Table 14: Proportions of patients with particular CMF injury and concomitant injuries (Poly-trauma patients).

	Traumatic Brain Injury	**Chest injuries**	**Orthopedic injuries**	**Ophthalmic injuries**
CMF Soft tissue injuries (n=151)	30 (19.9)	4(2.6)	13(8.6)	8(5.3)
Frontal bone fractures (n=16)	**5(31.3)**	0	1(6.3)	1(6.3)
Dentoalveolar injuries (n=41)	0	1(2.4)	2(4.9)	0
Mandibular fractures (n=32)	2(6.3)	1(3.1)	2(6.3)	0
Midface fractures (n=31)	4(12.9)	0	3(9.7)	2(6.5)

Figures in brackets represent the percentage number of patients with a particular type of CMF injury who had a particular concomitant non-maxillofacial injury.

4.4 Management of paediatric cranio-maxillofacial injuries

Soft tissue injuries were mostly minor and were managed by primary closure. Only 2 STIs were severe enough to require advanced treatment in the form of a split thickness skin graft for one injury and the other one a full thickness skin graft. Delayed primary closure of minor soft tissue injuries was high with unnecessary delays in management caused by the uncooperative nature of young children without any form of sedation.

Special soft tissue injuries included one injury to the facial nerve caused by shrapnel from an explosive device while the other injury was severance of the parotid duct caused by a motor vehicle crash. Both injuries were accompanied by facial fractures requiring ORIF and these soft tissue injuries were repaired during the same operation for fracture management.

A total of 66 patients had facial fractures, 24 had pure mandibular fractures, 20 had pure midface fractures, 10 had pure frontal bone fractures with one 2-year old patient having panfacial fractures and the remaining 11 patients having fractures in two of the above categories. A majority of the fractures (49 %) were managed conservatively through observation, analgesia, soft diet and physiotherapy. Fig.10 summarizes the various interventions prescribed for management of the facial fractures.

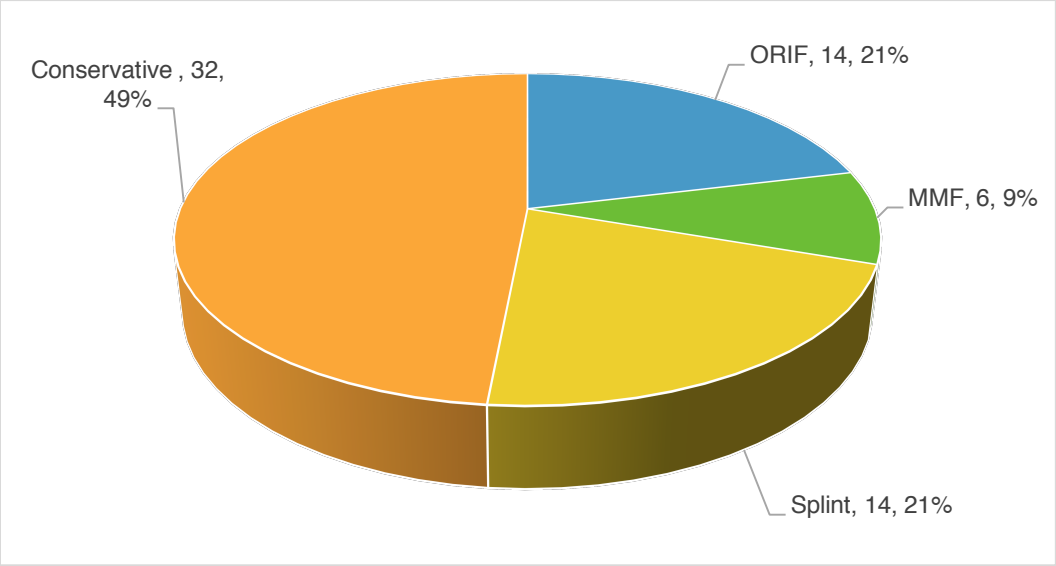

Figure 10: Distribution of patients with CMF fractures by the management prescribed (n=66).

Fourteen patients (21 %) out of sixty-six patients with facial fractures underwent ORIF for fracture management. Table 15 summarizes the important characteristics of these 14 patients.

Majority of facial fractures (49 %) were managed conservatively with observation, soft diet and analgesia. 21 % of CMF fractures were managed through ORIF and a similar percentage through splinting with an arch bar, with MMF prescribed for 9 % of patients with CMF fractures. Out of the 14 patients managed surgically, seven of them (50 %) had a mandibular fracture with 5(35.7 %) of these patients having panfacial fractures. Seven (50 %) of these patients sustained their injuries through high energy impacts in the form of motor vehicle crashes. The mean age of the patients managed surgically was 11.04 years and a standard deviation of 5.49 years, compared with that of the patients managed non-surgically with a mean age of 7.13 years, SD 5.53 years.

Table 15: Clinical details of children with CMF fractures managed through ORIF (n=14).

Age (Years)	Gender	Aetiology	CMF Fracture(s)	Type of fixation
11	Male	Shrapnel injury	Mandibular body (comminuted) Parasymphyseal (bilateral)	Rigid fixation (Titanium)
15	Male	MVC	Symphyseal Le Fort I, palatal split	Rigid fixation (Titanium)
9	Male	MVC	NOE Type III	Semi-rigid fixation (Stainless steel wire Canthopexy)
17	Male	MVC	Frontal sinus (Anterior & posterior tables), NOE Type I	Cranialization (Titanium mesh cranioplasty)
17.6	Male	MVC	Panfacial (Mandibular body & angle, Le Fort II, ZMC, Orbital roof	Rigid fixation (Titanium)
4	Male	Fall	Mandibular (Symphyseal & bilateral condylar), Le Fort II	Semi-rigid fixation (circummandibular wiring)
2	Male	MVC	Mandibular (Body, Condyle), Le Fort II, ZMC	Rigid fixation (Titanium)

13	Male	Firearm	Mandibular (Angle, Ramus & Condylar), Le Fort I	Rigid fixation (Titanium)
16	Male	IPV	Le Fort II, Zygomatic arch	Rigid Fixation (Titanium)
17	Male	IPV	Le Forte II, Orbital floor, Nasal	Rigid fixation (Titanium)
8	Male	MVC	Frontal Bone, Ruptured globe, epidural hematoma	Craniectomy (Titanium mesh cranioplasty)
5	Male	IPV	Mandibular (Parasymphysis, bilateral, condylar)	Rigid fixation (Titanium)
5	Female	MVC	ZMC, Frontal sinus, Orbital roof & Lateral wall, NOE Type II	Rigid fixation (Titanium)
15	Male	IPV	Mandibular (Parasymphysis)	Rigid fixation (Titanium)

CHAPTER 5: DISCUSSION

This study looked at all CMF injuries in patients below the age of 18 years who presented at a tertiary referral and teaching hospital over a period of 6 months. Craniomaxillofacial injuries constituted about 30 % of all paediatric injuries seen, second in incidence after orthopedic injuries which accounted for almost half of all paediatric trauma patients seen during the study period. Other studies have reported the proportion of cranio-maxillofacial injuries among children to be between 5% and 20 % [5,11]. The slightly higher proportion of CMF injuries in this study is mostly likely due to inclusion of minor injuries seen at the accident & emergency department and outpatient clinics that are often not captured by surveying only hospital-admitted patients as reported in other comparable studies [11,73].

5.1 Epidemiology of paediatric CMF injuries

5.1.1 Aetiology of paediatric CMF injuries

Among patients with CMF injuries, the mean age was 7.4 years (SD 5.6 years) and 56.2 % of them were below 6 years. The predominant cause of injury among children aged 6 years and below was accidental falls from a height or falls during play. Children in this age group are usually very active and therefore prone to injuries especially due to accidental falls and include toddlers still learning to walk.

Boys are more likely to sustain injuries compared to girls due to their more aggressive nature [3]. In this study, boys were more than twice likely to sustain craniomaxillofacial injuries than girls; 62% of the patients were boys and 32 % were girls. This finding is similar to those reported by other authors; *Muriithi et al* reported boys were twice more likely to present with dentoalveolar injuries compared to girls in a study done at Kenyatta National Hospital in Kenya while *Eggensperger et al* reported 60 % of paediatric facial fractures affected boys, in Switzerland and similar findings have been reported by *Osunde et al* in Nigeria and *Imahara et al* in United States [3,9,11,17].

The most common cause of CMF injuries among children in this study was accidental falls contributing to nearly 50 %, which is similar to findings by some authors [3,53]. Other similar studies have reported motor vehicle crashes to be the leading cause of paediatric facial trauma [9,11]. Although most studies from developing countries suggest that road traffic accidents are the leading cause, this study found accidental falls as the largest contributing aetiologic factor, highlighting possible underreporting of minor injuries caused by accidental falls from comparative studies [9,74.] Road traffic crashes due to motor vehicles and motor cycles contributed a combined 31.6 % of CMF injuries among children in this study. Studies from Europe have reported different findings with road traffic crashes contributing less casualties behind falls and assaults while American studies have reported assaults and motor vehicle accidents as the leading causes of paediatric facial trauma [3,11,12,53]. These differences are likely due to the type of centers where the studies were carried out, inclusion or exclusion of outpatients and actual differences brought about by more rigorous enforcement of road safety measures in European countries [3,11,53].

In this study motor cycle crashes caused a third of road traffic –related injuries with the remaining two-thirds caused by motor vehicle crashes. Higher rates have been reported from India where Verma et al reported motorcycle injuries contributed more cases of road traffic injuries than motor vehicle crashes in a review of one hundred children with maxillofacial injuries [16]. Motor cycle transport has in recent times become a common means of transport in Kenya and has become a significant contributor to injuries affecting children as passengers or pedestrians and teenagers as riders, passengers or pedestrians. Studies from Europe show bicycle accidents cause more injuries in children than motor cycle accidents [8,53]. This difference is due to geographical differences in preference and popularity of various modes of transport. In this study, sports injuries were reported as the cause of CMF injuries in only 1 % of the children presenting at this referral hospital. Sports injuries were only reported among the 12-17 olds category contributing 3.9 % CMF injuries in this age group. Studies from developed countries report a bigger contribution from sports injuries than in

developing countries which could be due to higher involvement of adolescents in contact sports and risky sporting activities such as ice skating and skiing in Europe and North America [3,53].

5.1.2 Pattern of paediatric CMF injuries

Soft tissue injuries were the most common CMF injuries seen in this study 72% of the patients having one or more STI with or without fractures. Studies that have included soft tissue injuries in their analysis have reported a similarly high incidence of between 50-75 % [8,9]. Most studies have reported mandibular fractures as the commonest paediatric facial injury mainly because they omitted soft tissue and dentoalveolar injuries from their studies [15, 16]. This fact was highlighted by *Gassner et al* who reported that these injuries tend to be excluded from majority of studies on paediatric facial trauma [1]. Excluding soft tissue and dentoalveolar injuries, the results of this study shows similar results as reported by other authors, with mandibular fractures representing about 50 % of paediatric facial fractures in this study [9,11,53].

Dentoalveolar injuries constituted the largest proportion of maxillofacial hard tissue injuries in our study. Similar findings have been reported from the few studies that have included dentoalveolar trauma when reporting on craniomaxillofacial trauma in children [8,25]. These injuries are usually treated in outpatient clinics and thus are underreported or omitted by studies that are done at tertiary referral centers.

Mandibular fractures were the most common facial bone fractures constituting almost half of all facial fractures. The highest number of mandibular fractures affected the condylar process at 32%, which is similar to patterns reported from other studies that have shown that up to 50 % of paediatric mandibular fractures involve the condyle [14, 30, 16, 29, 26]. The head of the condyle in children is mainly composed of cancellous bone and little cortical bone and thus prone to fracture when an impact is transmitted from the symphyseal region of the mandible [7].

Midface trauma was less common than mandibular trauma with a combined incidence of 38.4 % among paediatric facial fractures seen in this study. Nasal fractures were the commonest midface

fracture and third overall after mandibular and frontal bone fractures. This finding is similar to other reports in the literature that put nasal fractures as the commonest midface fracture in children and second commonest facial fracture after mandibular fractures [3,9,11,61.] Nasal and maxillary fractures were most common among children less than 6 years while mandibular fractures occurred in higher frequency among teenagers. This trend of facial fractures in children shifting from the upper facial skeleton to the lower facial skeleton with age has been related to the development of the face with the lower face increasing in prominence as the child grows and therefore becoming more prone to injury [7]. Maxillary fractures showed a bimodal frequency with a peak in 0-2-year-olds and another peak among the 12-18 year olds. Paediatric maxillary fractures have been associated with high energy trauma and are therefore seen relatively more common in patients injured through road traffic crashes than other causes [3]. In this study, they were mainly caused by accidental falls in the younger children and assaults and road traffic crashes in the adolescent age group.

A total of 9 orbital fractures were reported in this study representing approximately 7.7 % of all facial fractures seen during the study period. Generally, a low incidence of orbital fractures in children has been reported in the literature with a range of 5-35 % except for a study done by *Grunwaldt* that reported orbital fractures to be the commonest paediatric facial fracture [3,11,12,37]. The orbital roof was the most fractured orbital wall in this study with nearly half of the orbital fractures affecting the roof. The orbital roof has been reported as the most fractured orbital wall in children compared to adults where the orbital floor is the most fractured orbital wall [55,56]. A possible explanation that has been advanced in the literature is the prominence of the upper face coupled with lack of pneumatization of the paranasal sinuses in the young child with most orbital roof fractures propagating from the frontal bone [56]. The pneumatized frontal sinus act as a crumple zone limiting propagation of frontal sinus fractures to the orbital roof in adults while the pneumatized ethmoidal and maxillary sinuses cause the medial wall and the floor of the orbit to thin and therefore more prone to fractures in adults [55]. *Grunwaldt et al* found that all children with isolated orbital roof fractures were younger than 7 years

old, and the authors of previous reports of orbital fractures in children found that up to 35% of cases involved the orbital roof [12,55,60].

Frontal bone fractures constituted about a 16 % of all cranio-maxillofacial fractures in this study, an incidence that's within the range reported by other studies of between 2.9 % and 35 % [4]. The mean age of these patients was lower than the mean age of patients with midface and mandibular fractures although not statistically significant. This is similar to other reports in the literature of a higher incidence of frontal bone fractures among children less than 6 years due to the cranium to face ratio that diminishes from a high of 8:1 at birth to the adult ratio of 2.5:1 [7]. This type of injury was associated with a higher proportion of head injury compared with the other facial fractures. Similar findings were reported by Whatley et al in a 2005 study with 7 out of 11 children with frontal bone fractures presenting with significant intracranial injuries [20].

5.2 Management of paediatric CMF injuries

The management of facial fractures in children presents unique challenges mainly due to concerns of growth disturbance and the risk of injury to the dentition when surgical management is undertaken. In this study majority of the fractures were managed conservatively or through closed reduction, with 21 % of children with CMF fractures being managed through ORIF. Similar studies have reported low rates of surgical management of paediatric CMF fractures [9,10]. The choice of closed reduction versus ORIF in the management of paediatric facial fractures depends on the type of fracture, age of the child and severity of injury [4]. In this study majority of patients who were managed through ORIF had mandibular fractures, panfacial fractures and mainly in their teenage. Closed reduction has been shown to be the mainstay of management of paediatric facial fractures with good outcomes although there is no consensus on actual management choice [4,6,55].

The choice of the modality of management of condylar fractures in children and adults remains controversial with several studies showing good outcomes following closed reduction and few suggesting superior outcomes with ORIF [41,43,75,76]. Fractures of the mandibular condylar head in

children carries a significant risk of temporomandibular joint ankylosis. Early mobilization is important in preventing this complication and therefore maxillomandibular should not be applied for longer than 2 weeks in children with condylar head fractures [4,41,75,77]. The concurrent occurrence of symphyseal and parasymphyseal fractures together with condylar fractures in the same patient (guardsman fracture) was seen in five patients representing about 16.7 % of all mandibular fractures in this study. Restoring the normal occlusion in this type of fractures may be extremely challenging and have been shown to carry a higher risk of TMJ ankylosis [43]. In adult patients with concomitant mandibular symphysis and condylar fractures, a case for ORIF of the symphyseal fracture followed by MMF has been made in order to avoid the need for fixation of the condylar fracture(s) with good outcomes. *Dongmei* and *Ellis* have suggested a similar approach in paediatric patients suggesting lower incidence of ankylosis when this approach is used [43]. Similarly, *Nørholt* et al followed 55 paediatric patients with condylar fractures managed conservatively for a median period of 10 years and found no cases of TMJ ankylosis but found growth disturbances and facial asymmetry increased with the age of the child at the time of trauma, questioning the efficacy of conservative management of condylar fractures in older children [45]. In this study, monomandibular fixation with an arch bar with or without circummandibular wiring was used to manage this type of injury in the younger children (below 12 years of age) while intermaxillary fixation was favored in the adolescents. Long-term follow-up of this cohort of patients with additional patients will contribute to better understanding of the incidence of TMJ ankylosis caused by paediatric condylar fractures.

In this study, majority of midface fractures were managed non-surgically with ORIF being prescribed for midface fractures in the setting of panfacial fractures. The only isolated midface fracture that was managed surgically was NOE type II in a 9-year old child. Management of NOE type II and type III fractures is surgical since there are no reliable non-surgical techniques of addressing them [4].

Management of frontal bone fractures generally follows the principles of creating a "safe sinus" that are practiced in adult patients [66]. In this study two patients aged 6 and 8 years with severely comminuted frontal bone fractures and intracerebral hemorrhage and signs of increased intracranial pressure (ICP) underwent decompressive craniectomy, due to excessive brain oedema, and followed later by titanium mesh cranioplasty. Other injuries to the frontal bone were managed conservatively with all 4 cases of CSF leaks sealing spontaneously. The preservation of cranial bone in the anterior abdominal wall as recommended by other authors was not possible due to lack of adequate abdominal wall thickness in these children which predisposes them to extrusion or intraabdominal migration of the preserved bone. Secondary reconstruction of these cranial defects in children are best managed using rib grafts in children due to concerns of growth interference when titanium mesh is used [4]. Long-term follow –up of these patients is necessary as complications of frontal sinus fractures have been shown to present decades later after the trauma incident [66].

5.3 CONCLUSION

1. Craniomaxillofacial injuries constituted approximately a third of all paediatric injuries recorded in this study.

2. Accidental falls were the predominant cause of paediatric trauma, mainly affecting children below 6 years of age. Road traffic crashes were the second commonest cause and were more likely to be associated with more severe injuries necessitating surgical management of facial fractures.

3. Soft tissue injuries were the predominant craniomaxillofacial injury encountered in injured paediatric patients.

4. The mandible was the most fractured facial bone and almost half of these fractures affected the condylar process.

5. The management of paediatric facial fractures was influenced by the age of the child with ORIF being prescribed for older children more than younger children with similar injuries.

5.4 RECOMMENDATIONS

1. The pattern of paediatric craniomaxillofacial injuries in Kenya does not differ significantly with reports from other countries although comparison of studies is difficult due to differing study methods.
2. Accidental falls and road traffic crashes are the leading causes of paediatric craniomaxillofacial trauma in Kenya. Therefore, preventive measures to reduce the paediatric trauma burden should focus on reducing the occurrence of falls and road traffic accidents.
3. Long-term follow-up of paediatric craniomaxillofacial trauma patients is required to validate current treatment protocols.

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APPENDICES

Appendix 1: Institutional Ethics & Research Committee Approval

KENYATTA NATIONAL HOSPITAL APPROVED 04 APR 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/118

4th April, 2016

Dr. George Muiruri Ndung'u
Dept. of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine
School of Dental Sciences
College of Health Sciences
University of Nairobi

Dear Dr. Ndung'u,

Revised Research Proposal: Patterns and Management of Paediatric Maxillofacial Trauma in Selected Referral Hospitals in Nairobi (P3/01/2016)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH-UoN ERC) has reviewed and **approved** your above proposal. The approval period is from 4th April 2016 – 4th April 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**

Appendix 2: Consent/ Assent

Part I: Consent Information (English)

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

Introduction and purpose

I am Dr. George Ndung'u, a postgraduate student at the University of Nairobi, Department of Oral and Maxillofacial Surgery. I am inviting you to participate in a study I am conducting. The purpose of this study is to determine Incidence, pattern and management of maxillofacial injuries in children and adolescents at KNH.

Study Benefits

- The findings of this study may not be of immediate/direct benefit to you or your child but in the long run it may help in coming up with policies aimed at preventing similar injuries and in appropriate management of similar injuries.
- The questions you will be asked and subsequent examination is part of routine diagnosis of your injuries. Please take note that refusal to participate in this study will not in any way affect the quality of treatment offered to your child.
- Participating in this study will not result in a financial benefit. You will however not incur any extra financial cost because of participating in this study.
- This study will provide data for health planning and development of prevention programs aimed at the reduction of pediatric maxillofacial injuries

Inconvenience, risks and right of withdrawal

- You may experience inconvenience due to being asked many questions.
- Your involvement is purely voluntary. At any point during the study you are free to withdraw temporarily or permanently.

- There are no dangers or risks associated with participating in the study.

Duration

The history taking by the investigator will take approximately 30 minutes. This will involve asking questions relating to your child's injury, examination of the entire body including the face and other injured sites.

CONFIDENTIALITY

- Privacy and confidentiality of the patient participating in this study shall be maintained. No name shall be written on the questionnaire and all the data obtained shall be securely stored.
- Like all scientific information, we will seek to share our findings with other people undertaking similar studies. We may therefore publish our findings in scientific journals or present them in scientific meetings. No information that can identify you or your child will be used in such publications and meetings.

INVESTIGATORS

In the event that you need any further information in relation to this study please contact the following;

I. Principal investigator. Dr. George Ndung'u'u at phone number 0714791901.

II. Lead supervisor Dr. Walter Odhiambo at The University of Nairobi Dental Hospital P.O Box 30197 Nairobi.

III. Chairman UON/KNH, Research, Ethics and Standards Committee on 020-2726300 ext. 44355.

Part II: Consent Information (Kiswahili)

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

MAELEZO KUHUSU IDHINI

Lengo

Kwa majina naitwa DR GEORGE NDUNG'U, mwanafunzi katika chuo kikuu cha Nairobi, Idara ya upasuaji wa mdomo, uso na fuu la kichwa (Oral and Maxillofacial surgery). Nakualika kushiriki katika utafiti huu unaolenga kupata habari kuhusu Matukio Na Muundo Na Matibabu ya Majeruha Ya Maxillofacial Kati ya Watoto Katika Hospitali ya Kenyatta National Hospital.

Faida ya utafiti

- Huenda matokeo ya utafiti huu yasikufaidi wewe kibinafsi wala mtoto wako lakini habari tutakayopata itasaidia kupata njia nzuri zaidi za kuzuia na kutibu majeraha haya.
- Maswali utakayoulizwa pamoja na ukaguzi utakaofanyiwa mtoto wako ni kawaida na itasaidia kuelewa majeraha ya mwanao na pia itatumika kuyapanga matibabu yake.
- Kukosa kushiriki hakutadhuru matibabu yake vyovyote vile.
- Hutapata malipo ya kifedha kwa kushiriki. Pia, hutahitaji kakulipa chochote kwa kushiriki.
- Habari tu takayopata pia itasaidia kuweka mikakati muafaka ili kuzuia na kupunguza majeraha kati ya watoto.

Madhara na hatari zinazokusudiwa, kushiriki kwa hiari na kujiondoa katika utafiti:

- Kushiriki kwako kutakuhitaji kujibu maswali mengi na kufanyiwa ukaguzi wa majeraha.

- Kushiriki kwako ni kwa hiari yako.

• Uko huru kukataa kushiriki ama kujiondoa katika utafiti huu wakati wowote ule.

• Hakuna hatari zinazokusudiwa kwa kushiriki katika utafiti huu.

Muda utakaotumia

Mahojiano na ukaguzi na mtafiti itachukua dakika thelathini.

USIRI WA MAHOJIANO

• Usiri wa mgonjwa anayehusishwa utatiliwa maanani. Jina lolote halitaandikwa kwenye nakala ya maswali na majibu yote yatakayokusanywa yatawekwa kwa njia salama
Kama habari zingine za kisayansi, tutataka matokeo ya utafiti huu yajulikane na wanasayansi wengine wanaofanya tafiti kama hizi. Kwa hivyo tutachapisha matokeo yetu kwenye vitabu vya sayansi na kutangaza matokeo haya katika mikutano ya kisayansi.
Maelezo kuhusu nafsi yako hayatajumuishwa katika ripoti ya utafiti huu na hivyo hayatajumuishwa katika vitabu na mikutano hizi za kisayansi. Nafsi yako na mwanao itabakia siri.

Ikiwa utakuwa na maswali ama jambo Lolote ungependelea kujua kuhusiana na haki zako kama mshiriki katika utafiti huu, jisikie huru kuwasiliana na;

1. DR GEORGE NDUNG'U: Nambari ya simu 0714791901
2. DR WALTER ODHIAMBO SLP 30197 Nairobi
3. Kamati inayochanganua maswala ya utafiti ya hospitali kuu ya Kenyatta na chuo kikuu cha Nairobi kupitia Sanduku la posta: 20723 Nairobi, Nambari ya simu: 726300-9

Part III: Consent Form (English)

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

My name is Dr. George Ndung'u from the University of Nairobi undertaking a Masters in Dental Sciences. I am conducting a study on the pattern and management of maxillofacial injuries in children and adolescents at KNH.

Methodology: investigator prescribed clinical record forms.

The results obtained will be presented to the University as well as the Ministry of Health enabling them therefore to provide information, which will aid in development of policies relating to prevention and appropriate management of such injuries.

No harm shall be inflicted on your child. Participation is completely voluntary and you are free to withdraw from the study at any point and that would not affect treatment in any way.

I .....have been explained to the purpose and conditions of my child's involvement in the study.

I agree to the above and give consent to be included in the study.

Name.....

Sign /thumb print of parent/guardian……

Date.....

INVESTIGATOR

GEORGE NDUNG'U

Signature.....

For further information, /enquiries or complaints please contact

I. Principal investigator. Dr. GEORGE NDUNG'U at phone number 0714791901

II. Lead supervisor. Dr. WALTER ODHIAMBO at The University of Nairobi Dental Hospital P.O Box 30197 Nairobi

III. Chairman UON/KNH, Research, Ethics and Standards Committee on 020-2726300 ext. 44355

Part IV: Consent form (Kiswahili)

FOMU YA MGONJWA KUKUBALI KUSHIRIKI KATIKA UTAFITI

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

Mimi, DR. GEORGE NDUNG'U, mwanafunzi katika chuo kikuu cha Nairobi. Ninafanya utafiti katika chuo kikuu cha Nairobi unaochunguza Matukio Na Muundo Na Matibabu ya Majeruha Ya Maxillofacial Kati ya Watoto Katika Hospitali Kuu ya Kenyatta. Nitakuhoji kuhusu kuumia uso na sehemu nyingine na nitaandika yale utakayosema kwa shughuli za utafiti huu. Pia mgonjwa atapigwa picha kwa minajili ya utafiti huu.
Uelewe kwamba hakuna malipo ya kushiriki na habari yote utakayopeana itawekwa siri. Unaweza kujiondoa wakati wowote katika utafiti huu, na hali hiyo haitaathiri matibabu ya mgonjwa kwa vyovyote vile.

Jina lako na wala la mgonjwa halita andikwa pahali popote katika makaratasi ya utafiti ila nambari ya utafiti tu.

Mimi..... (majina kamili kwa herufi kubwa)

nimeelewa maelezo yote ambayo nimepewa. Nimekubali kushiriki katika huu utafiti kama mzazi wa .... kwa hiari yangu.

JINA LA MZAZI/ MLINZI.....

Sahihi/kidole gumba.....Tarehe .....

MTAFITI

NDUNG'U GEORGE MURIRURI

Sahihi.....

Kwa maelezo zaidi/maswali au malalamishi unaweza kuwasiliana na;

I. Mtafiti Mkuu. DR GEORGE NDUNG'U Kwa simu ya Rununu 0714791901

II. Kiongozi Msimamizi. DR. WALTER ODHIAMBO, Chuo Kikuu Cha Nairobi SLP 30197 Nairobi

III. Mwenye kiti kamati ya Chuo Kikuu cha Nairobi na Hospitali Kuu ya Kenyatta, maadili na kamati ya utafiti, kwa nambari ya simu; 020-2726300 ext 44355

Part V: Assent information/ Form (English)

(For subjects between 7 years to 18 years of age)

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

1. My name is Dr. GEORGE NDUNG'U from the University of Nairobi.
2. We are asking you to take part in a research study because we are trying to learn more about injuries to the face among children in Nairobi.
3. If you agree to be in this study I will use your medical records to obtain information about you the injuries that you have and the planned treatment. If necessary I will examine you and look at your X-rays (radiographs). This will not hurt at all and will not interfere or delay your treatment unnecessarily.
4. There are no risks to you if you participate in this study.
5. There are no direct benefits to you for participating in this study. However, the information we learn from this study may help prevent similar injuries occurring in other children and also in providing care to those who get injured.
6. Please talk this over with your parents before you decide whether or not to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.
7. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you don't want to participate or even if you change your mind later and want to stop.
8. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me [0714791901] or ask me next

time. (You may call me at any time to ask questions about your disease or treatment.)

9. Signing your name at the bottom means that you agree to be in this study. Your doctors will continue to treat you whether or not you participate in this study. You and your parents will be given a copy of this form after you have signed it.

_____ _____

Name of Subject Date

_____ _____

Parent/Guardian signature Date

Part VI: Assent Information/ Form (Kiswahili)

IDHINI YA WOTOTO KATI YA UMRI WA MIAKA SABA HADI KUMI NA NANE

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

1. Jina langu ni DR GEORGE NDUNG'U kutoka chuo kikuu cha Nairobi.
2. Tunakusihi kushiriki katika utafiti wa majerahi ya fuu la kichwa na uso kati ya watoto jijini Nairobi ili tuweze kuyaelewa kwa kina.
3. Ukikubali kushiriki kwa utafiti huu, nitatumia recodi zako za hospitali kupata maelezo ya kibinafsi yako na majeraha uliyo nayo na matibabu inayopangwa na madaktari wako. Kisha nitakagua picha zako za eksirei kubaini majeraha uliyonayo. Ikihitajika, nitakuchunguza kubaini majeraha uliyo nayo. Hii haitasababisha maumivu yeyote na wala haitachelewesha kuhudumiwa.
4. Hakuna hatari yeyote kwako utakapo shiriki kwenye utafiti huu.

5. Hakuna faida itakuja kwako ukishiriki kwenye utafiti huu. Hata hivyo, matokeo yake inaweza tumika kuzuia na kubaini njia mwafaka za kutibu majeraha kama haya kwa watoto wengine.
6. Tafadhali ongea na wazazi wako kuhusu kushiriki kwako kwa huu utafiti. Pia tutauliza wazazi wako idhini ya kushiriki kwako katika utafiti huu. Hata kama wazazi wako watakubali kushiriki kwako, unaweza kataa kushiriki.
7. Kama hautaki kushiriki katika utafiti huu, sio lazima. Kushiriki ni kwa hiari yako na ukikataa kushiriki hakuna mtu atakasirishwa na uamuzi wako.
8. Unaweza uliza maswali kuhusu utafiti huu kutoka kwangu. Pia unaweza wasiliana nami kupitia simu ya rununu (0714791901) iwapo una maswali ya ziada kuhusu utafiti huu. Madaktari wako wataendelea kukuhudumia iwapo utaamua kushiriki au kutoshiriki kwa huu utafiti.
9. Kutia sahihi kwa hii fomu kunamaanisha umekubali kushiriki kwenye huu utafiti. Wewe na mzazi wako mtapewa nakala ya fomu hii ukitia sahihi kama thibitisho lako kushiriki kwa utafiti huu.

_____ _____

Jina lako Tarehe

_____ _____

Jina la Mzazi Tarehe

Appendix 3: Data collection form

Title of Study: *Patterns and Management of Pediatric Maxillofacial Injuries at a Tertiary Referral Hospital in Kenya*

Part I: Patterns of pediatric maxillofacial injuries

Serial number.....

Date..... .....

Hospital Code.....

Department/Ward/Clinic code.....

PERSONAL DATA:

1. Initials . . . . . .
2. Age . . . .
3. Gender . . . .
4. County of Residence . . . . . .

CAUSE OF INJURY (Tick only one appropriately)

1. Motor vehicle accident
2. Motor cycle accident
3. Falls
4. Assault
5. Interpersonal violence
6. Child abuse
7. Sports injuries
8. Firearm injuries
9. Animal injuries
10. Other cause

Specify. . . . . ..

ATLS PRIMARY SURVEY AND MANAGEMENT (Indicate any positive findings)

1 Airway & cervical spine control . . . . . .

. . . . . .

. . . . . .

. ..

2 Breathing . . . . . .

. . . . . .

. . . .

3 Circulation . . . . . .

. . . . . .

. . . .

4 Disability (neurological) . . . . . .

. . . . . .

. . . . . .

. ..

5 Exposure & environment. . . . . .

. . . .

ATLS SECONDARY SURVEY AND MANAGEMENT (Indicate any specific injuries noted)

a) . . . . . .

b) . . . . . .

c) . . . . . .

d) . . . . . .

e) . . . . . .

f) . . . . . .

g) . . . . . .

h) . . . . . .

i) . . . . . .

j) . . . . . .

MAXILLOFACIAL INJURIES (tick any injury noted)

1. Soft tissue injuries
    a. Ocular (Globe)
    b. Scalp
    c. Facial skin
    d. Parotid duct
    e. Tongue
    f. facial nerve
    g. Lip injuries
    h. Eyelid
    i. Lacrimal apparatus
    j. Ear
    k. Nose
2. Mandibular fractures
    a. Symphyseal
    b. Parasymphyseal
        i. Right
        ii. Left
    c. Body

i. Right

ii. Left

d. Angle

i. Right

ii. Left

e. Ramus

i. Right

ii. Left

f. Coronoid process

i. Right

ii. Left

g. Condyle

i. Right

ii. Left

3. Maxillary fractures

a. Le Forte I

b. Le Forte II

c. Le Forte III

d. Palatal spilt

4. Naso-orbital ethmoidal fractures (Markowitz classification)

a. Type I

b. Type II

c. Type III

5. Nasal bone fractures

6. Zygomatic fractures
    a. ZMC “tripod fractures”
    b. Isolated Arch fracture
7. Orbital fractures
    a. Orbital floor
    b. Medial wall
    c. Lateral wall
    d. Orbital roof
8. Frontal bone fractures
    a. Anterior table fracture
    b. Posterior table fracture
    c. NFOT injury
    d. Dural tear/CSF leak
9. Dental trauma (Indicate tooth using FDI system)
    a. Crown fracture
    b. Root fracture
    c. Subluxation
    d. Intrusion
    e. Extrusion
    f. Avulsion
10. Alveolar fractures/ Dentoalveolar fractures

Part II: Management and early outcomes of pediatric maxillofacial injuries.

1. Soft tissue injuries (Indicate treatment method(s) used)
    a. Primary closure
    b. Delayed primary closure
    c. Skin grafting
    d. Flap
        i. Local
        ii. Regional
        iii. Distant/free flap
2. Mandibular fractures
    a. Soft diet/ observation
    b. Splint
    c. Intermaxillary fixation
    d. ORIF
3. Maxillary fractures
    a. Soft diet/ observation
    b. Intermaxillary fixation
    c. ORIF
4. Nasal fractures
    a. Observation
    b. Splinting
    c. ORIF
5. NOE fractures
    a. Conservative
    b. ORIF

6. Orbital fractures
    a. Conservative
    b. ORIF
        i. Bone grafts
        ii. Alloplastic reconstruction
7. Zygomatic fractures
    a. Conservative
    b. ORIF
8. Frontal bone fractures
    a. Conservative
    b. Cranialization
    c. ORIF
9. Dental trauma (Indicate tooth using FDI system)
    a. Restorative
    b. Extraction
    c. Splinting
10. Alveolar fractures
    a. Observation/ soft diet
    b. Splint

Early outcomes/ complications of maxillofacial injuries

1. Infection/Osteomyelitis
2. Malocclusion/Malunion
3. Non-union & delayed union
4. TMJ hypomobility
5. Death

6. Others

Specify . . . .

. . . .

. . . .