AN ANALYSIS OF THE PATTERN OF ORBITAL FRACTURES AT TWO REFERRAL TEACHING INSTITUTIONS IN NAIROBI

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DECLARATION

This is my original work and has not, to my knowledge, been presented for degree at any other university.

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DEDICATION

To all the victims of orbital fractures and their relatives whose lives have been affected in one way or the other.

To my parents, sisters and brothers.

To my lectures and fellow residents who inspired me in preparing this work.

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"How far we climb up a mountain does not only depend on our efforts but it also depends on those who give us a push along the way." I would like to acknowledge the tireless effort of my great and inspirational teachers: Prof Mark L. Chindia, Dr. Walter A. Odhiambo, and Dr. Kennedy Koech, for their indispensable support throughout this study. I am also greatly indebted to the following:

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LIST OF ABRREVIATIONS

1. BDS.. Bachelor of Dental Surgery
2. Cc .... cubic centimeters
3. Cm.. centimeters
4. CT .... Computed Tomography
5. Dept..Department
6. EOMM ....Extra-Ocular Muscle Motility
7. Etc .... Et cetera
8. IPV………………………………………………………………….interpersonal violence
9. KNH...Kenyatta National Hospital
10. LE...Left Eye
11. mJ……………………………………………………………………….……..millijoule
12. mm…………………………………………………………………...………millimeters
13. MCCs…………………………………………………………….....motor cycle crashes
14. MVC……………………………………………………………..motor vehicle crashes
15. MRI……………………………...………………..……..Magnetic Resonance Imaging
16. NOE……………………………………………………….……..Naso-Orbital-Ethmoid
17. OMFS…………………………………………Oral and Maxillofacial Surgery/Surgeon
18. P(L/DL)LA……………………………………..………………..poly-L/DL-lactic Acid
19. PDS…………………………….……………………………………...Polydioxanone
20. PGA……………………………………………………………...……Polyglycolic Acid
21. PLLA……………………………………………………..………Poly-L-Lactic Acid
22. RE…………………………………………………………………………..Right Eye

23. RTCs……………………………………………………………………Road Traffic Crashes

24. SCH…………………………………………………………...subconjuctival haemorrhage

25. SDS………………………………………………………..,…..School of Dental Sciences

26. STIs……………………………………………………………………Soft Tissue Injuries

27. UON…………………………………………………………....University of Nairobi

28. UNDH……………………………………………...University of Nairobi Dental Hospital

29. USS………………………………………………………………….Ultrasound Scan

30. VF……………………………………………………………………..….Visual Field

31. ZF………………………………………………………………Zygomatic-Frontal Suture

32. ZM…………………………………………………………...Zygomatic-Maxillary Suture

33. ZMC……………………………………………………..Zygomatico-Maxillary-Complex

34. ZT…………………………………………………………Zygomatic-Temporal Suture

ABSTRACT

Background of the study

Orbital fracture is a common injury accompanying mid-face trauma. The incidence of isolated orbital fractures ranges from 4 to 16% of facial fractures. Combined with other injuries including those of the zygomatico-maxillary-complex (ZMC) and those of the naso-orbito-ethmoidal (NOE) complex, they account for 30 to 55% of all facial fractures. Orbital trauma can result in significant functional and cosmetic defects and hence can be significantly disabling. The modal age of 20-40 years leads to reduced productivity and loss of manpower. Patients with fractures involving the orbit often present with concomitant injuries of the eyeball and/or the surrounding extra-ocular structures. Misdiagnosis or delayed diagnosis may result in debilitating complications such as blindness, diplopia, permanent paresthesia, malocclusion and facial disfigurement.

Material and Methods

A descriptive prospective hospital-based study was carried out to determine the demographics, aetiology, clinico-radiological features and management modalities among patients presenting with orbital fractures (n=60) at the University of Nairobi Dental Hospital (UNDH) and Kenyatta National Referral Hospital (KNH) in Nairobi, Kenya**.** A specially designed data collection tool which was tested and calibrated was completed for all patients with confirmed orbital fractures. All data were coded and entered into the statistical package for social sciences (SPSS) software version 20 for analysis.

Results

Sixty patients (52 male, 8 females; $p<0.05$) with confirmed orbital fractures on CT scan were recruited into the study. Orbital fractures occurred most frequently in the 21-40-year old age group (80%, $p<0.05$). The self-employed group was the most affected occupational group (40%) whilst the least affected was the formally employed group (3.3%). The distribution of orbital fractures according to occupation was statistically significant *($X^2=23.500$, $p=0.000$).*The principal aetiological factor was motor cycle crashes (MCCs) at 30 % particularly riders (21.6%) followed by interpersonal violence (IPV) at 23.3%, public vehicle crushes (PVCs) at 20%, private vehicle crushes (PVCs) at 10%, injury from flying objects at 10% and falls at 8.3%. All the cases of IPV were male (n=14, p=0.071) particularly of the 20-30-yr old age (n=8) group. Clinical features noted included peri-orbital oedema, subconjuctival haemorrhage (SCH), step deformity on the rim, peri-orbital ecchymosis, trismus, eyelid laceration and avulsion, paresthesia, malar collapse and telecanthus, blindness, diplopia and entrapment of extra-ocular muscles, enophthalmos, vertical dystopia, exophthalmos and eyelid ptosis. The most commonly affected anatomical site was the floor (75%) followed by the lateral wall (71.7%), infra-orbital rim (66.7%), zygomatico-frontal suture (63.3%), medial wall (46.7%) and orbital roof (25%). Notably, 65% had zygomatic arch fractures whilst 51.7% had ZMC fractures. In this study 5 patients had pure blow-out orbital fractures whilst 55 patients had impure fractures. There were more fractures involving the left orbit (n=28) than the right (n=14). Bilateral orbital fractures were seen in 18 patients. Indirect CT scan findings included haemosinus (air-fluid level) in 47 patients, tissue emphysema, teardrop and pneumocephalus. The relationship between haemosinus and orbital fractures was statistically significant ($p<0.05$). More of the patients were managed conservatively (60%).

Conclusion

The present study has reaffirmed that RTCs, especially motor cycle crashes and IPV are the leading cause of orbital injuries most commonly in the young males in their third and fourth decades of life. Evidently, haemosinus as demonstrated on CT scanning together with peri-orbital oedema and SCH constitute the clinical features most consistent with orbital fractures, most of which were the impure variants. The left side was more affected than the right whilst the floor and the lateral wall being the commonest sites of orbital fractures. Impure variants particularly zygomatico-maxillary-complex fractures are by far more common than the pure variant. Depending on the severity of the injury, orbital fractures can be managed either surgically or conservatively.

CHAPTER 1

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

1.1.1. Background

Orbital fracture is a common injury accompanying mid-face trauma. The incidence of isolated orbital fractures ranges from 4 to 16% of facial skeletal injuries[1]. In combination with those of the zygomatico-maxillary (ZMC) and naso-orbito-ethmoid (NOE) complexes, they account for 30 to 55% of facial injuries[1]. Orbital trauma can result in significant functional and cosmetic defects and hence can be significantly disabling[2]. Patients with fractures involving the orbit often present with concomitant injuries of the eyeball and/or the surrounding extra-ocular structures. Orbital floor fractures have been associated with a 40% risk of ophthalmic complications[3]. Blindness following facial bone fractures has been reported to occur in between 0.67 to 9% of the orbital wall fractures [1, 2, 4, 5]. Interestingly, the rate of missed diagnosis of orbital fractures is very high [5]. In a study by Liu Jun (2002), 42.6% of orbital fractures were missed[6]. In another study conducted by Ashar (1998) to assess the frequency of blindness associated with maxillofacial trauma, it was concluded that early diagnosis of the exact nature of the ophthalmic injury and treatment were important and the involvement of the ophthalmologist was mandatory[7].

1.1.2. Relevant Surgical Anatomy of the Orbit

The orbit is made up of seven bones. The orbital shape varies with age, gender and race and between individuals but the volume is usually 29–30 cm3 with the eyeball occupying 7cc of the orbital volume [1, 8,9,10]. Important vital neurovascular structures are transmitted through the orbital foramina and fissures. These include structures such as the optic, oculomotor, trochlear, ophthalmic and abducent nerves in addition to the ophthalmic veins and artery. These structures are vulnerable to injury following trauma. Medial to the infra-orbital foramen the floor is about

0.27 to 0.5mm whilst the lamina papyracea is about 0.2 to 0.4mm. The lesser wing of the sphenoid bone is about 3 mm thick. The floor and the medial wall are, therefore, the thinnest portions of the orbit. This makes the medial wall and floor the most common sites of orbital fractures[1]. The medial walls are parallel in the sagittal plane and the lateral walls form a 90º angle with each other [11,12].There is evidence of inter-racial morphometric variations of the orbital anatomy hence the possibility of differences in the pattern of orbital fractures among different races[5]. In a retrospective review of computed tomography (CT) scans and demographics in an unselected cohort of 152 patients with orbital blowout fractures, it was shown that most blowout fractures involve the orbital floor in Caucasians and Asians, whereas in Afro-Caribbeans the most common site for fracture was the medial wall[13].

1.2.Literature Review

1.2.1. Classification of Orbital Fractures

Orbital fracture classification systems vary widely and may even be confusing, which makes comparisons between studies difficult[9, 14]. For the purposes of this study orbital fractures were classified into [9, 15]:

- Pure/ Simple fractures
  - Blow out fractures
    - Medial wall
    - Floor: trap door, tear drop
    - Lateral wall
    - Roof
    - Any combination(s) of the medial, lateral, floor and roof
  - Blow-in fractures

- Impure/Complex fractures
    - Orbital rim fractures
        - Tripod (Zygomatico-Maxillary Complex) or Tetrapod
        - Lefort II
        - Lefort III
        - Naso-Orbito-Ethmoid (NOE) complex
        - Simple orbital rim fractures

1.2.2. Socio-Demographic presentation of orbital fractures

Most authors agree that by far the most commonly affected age group is the 20-40 years with an 80% plus male predominance[1, 8, 14, 16]. In a retrospective analysis of 132 patients with orbital fracture, 84% males were affected vis-a-vis 16% females. In this study the most affected age group was the 31-40-year-old age range (24.2%), followed by the age groups of 21-30 years (22%) and 11-20 years (22%) [16].

1.2.3. Etiology and Mechanisms of Orbital Fractures

1.2.3.1. Etiology

The commonest causes of facial fractures are motor vehicle crashes (MVCs), assaults, falls and sports injuries [17-21]. In a Swedish retrospective study investigating the injuries before the introduction of the seatbelt law in 1975, the main cause of zygomatico-orbital injuries was MVCs [22]. However, similar more recent studies have established assault (stoning, fists, kicks) as the commonest cause of orbital fractures[20, 21, 23]. Airbags, paradoxically, have been reported to cause ocular injuries and less frequently orbital fractures. In their study Lehto et al. (2003) reported a 2.5% frequency of ocular injuries but a low risk of severe eye injury from airbags (0.4%) [24]. The etiology of orbital fractures varies according to geographic region and occupation. In war zones and mining regions, the predominant etiology includes high velocity missiles, bomb-blasts and gunshots. Sports, particularly boxing, cricket, rugby and soccer are associated with a high risk of orbital fractures[25]. In a review of ten papers on orbital trauma, Jatania (2012) broadly divided the etiology of orbital fractures into five main categories including MVCs, assaults, industrial accidents, sports and others (Table 1.1)[1]. Evidently MVCs constituted by far the commonest cause of orbital fractures and assault being the second.

Table 1.1: Etiology of Orbital Fractures

First author	N	Motor Vehicle Accident %	Assault %	Industrial Accident %	Sports %	Other %
Abbas	772	24	1	0	0	75
Al-Qurainy	363	12	50	19	12	0
Amrith	104	32	13	20	10	20
Cook	365	40	31	0	0	29
Covington	243	80	5	0	0	15
Crumley	324	71	17	7	4	5
Gwny	567	35	37	5	9	18
Jayamanne	135	3	73	12	0	3
Lim	839	39	43	3	0	15
Luce	1 020	65	35	0	0	0

1.2.3.2. Mechanisms of blow-out Orbital Fractures

Three accepted mechanisms of **blow-out** orbital fractures have so far been described [15, 21, 26, 27] which include:

1. **Hydraulic or "retropulsion" theory (Smith & Regan) [15, 21] :** An anterior force causes an increase in intra-orbital pressure resulting in the orbital wall giving way. The thinnest parts of the orbital wall are the ones at the greatest risk of fracture including the medial wall and the floor medial to the infra-orbital fissure (Fig 1:1). It has been shown that a 0.8–1 ml increase of bony orbital volume corresponds to 1 mm on the Hertel exopthalmometer. Accordingly, an increase in the bony orbital volume of 1.5–2 ml will cause clinically evident enophthalmos (≥ 2 mm) [28]. Enophthalmos may be temporarily concealed and compensated for by a hematoma and oedema. Likewise, exophthalmos may result from a reduced orbital volume or a swelling of the intra-orbital soft tissues or a combination of the two factors. A 'sunken eye' in the acute stage may be caused by the so-called 'retraction syndrome', an entrapment of the inferior rectus muscle causing the superior rectus muscle to exert a strong inward pull on the eye bulb as a reaction to the entrapped antagonist [9,12, 28, 29]. Diplopia may be caused by displacement of the eye globe, as the two eyes are no longer in line with the same visual axis [30].
2. **Buckling or "Bone Conduction" theory:** Forces on the orbital rim are transmitted along the longitudinal axis of the orbital wall. This causes buckling particularly in the thinnest parts of the orbit.
3. **Globe to wall theory:** This involves the direct impact of the globe onto the orbital wall.

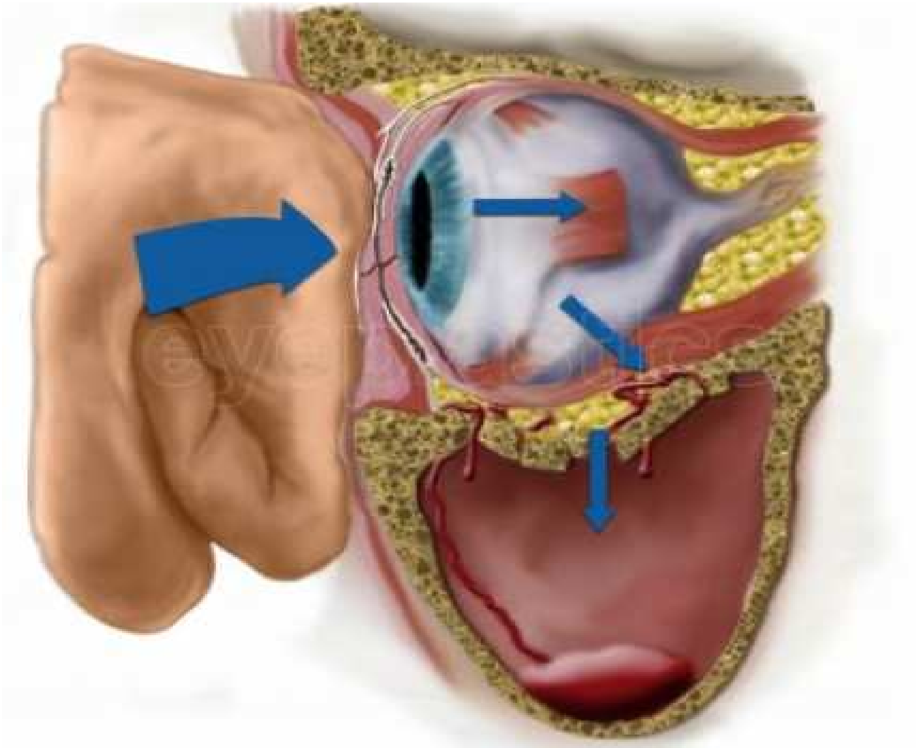


Figure 1.1: Illustration of the Hydraulic Theory (http://www.eyeplastics.com)

In essence, the maxillary and ethmoidal sinuses serve as air bags or shock absorbers to protect direct injury to the eyeball and orbital contents. This explains why globe rupture is relatively uncommon in orbit fracture[1]. In a cadaveric study, Rhee et al. (2002) found that a force greater than 4900 mJ led to orbital floor fracture with herniation of the orbital contents whereas a force greater than 6860 mJ resulted in a combined orbital floor and medial wall fracture[27]. These results imply that increasing force to the eyeball leads to increasing damage to the orbital walls beginning with the orbital floor ("hydraulic theory") [27].

1.2.4. Clinical presentation of orbital fractures

Mark et al. (1999) conducted a study to evaluate ocular injuries concomitant with orbital fractures. They concluded that the ocular sequelae of midfacial fractures ranged from non-vision threatening injuries to vision-threatening injuries. It was also noted that pure orbital fractures were twice as common as impure orbital fractures. Of note is that some ophthalmic injuries may be apparent; However, other potentially blinding complications can easily be missed unless they are actively sought[31]. The loss of vision associated with missed potentially dangerous clinical features can attract serious litigations. It is, therefore, mandatory for the Oral and Maxillofacial surgeon to be well conversant with the clinical features of orbital fractures[32]. In fact, Khan etal in their study demonstrated the need for a mandatory ophthalmological review to minimize unwarranted complications. In their study, 89% of their patients went through a thorough ophthalmological review[33].

Ansari et al. (2005) in a review of 2503 cases of facial fractures at an Iranian Maxillofacial Unit, demonstrated that 550 (22%) had orbital wall fractures. Of the 550; 83 (3.31%) had minor ocular and extra-ocular signs and symptoms whilst 39 (1.56%) had severe injuries and blindness. Laterally directed forces were the main cause of blindness. These laterally directed forces were noted to cause tripod, lateral orbit and Le Fort III level fractures[34].

Tan Başer et al. (2011) reported that the ocular findings that accompany orbital fractures are periorbital ecchymosis (87.0%), periorbital paresthesia (33.3%), diplopia (12.96%), restricted eye movements (11.1%), and enophthalmos (7.4%) [35]. Of note from this study and the one by Ten Chen (2005) is that peri-ocular petechiae and oedema were present in almost all patients presenting with orbital fractures[5]. The exception is the “white eye syndrome” or the “orbital floor trap door” phenomenon common in the paediatric and adolescent age groups [36]. It is a characteristic feature of the young elastic skeleton [37, 38, 39]. Orbital soft tissue/the inferior rectus muscle becomes tightly entrapped in the fracture leading to ischaemia and if not treated in time, fibrosis and permanent diplopia may develop. The symptoms and signs in the acute stage of an 'orbital floor trap door' fracture can be misleading and are often mistaken for those of cerebral concussion. The patient suffers from pain and nausea and sometimes from vomiting, bradycardia and syncope (oculocardiac reflex) [37]. In these cases, acute surgery to release the entrapped tissue is urgent if serious complications such as permanent diplopia are to be prevented.

1.2.5. Other common ocular manifestations of orbital wall trauma

Of interest is that fractures of the orbital lateral wall usually lead to backward, downward and outward displacement of the zygomatic bone. Consequently, the orbital cavity enlarges and diplopia develops. In a 5-year retrospective study by Lateef et al. (2011), limitation of mandibular movement occurred in 41% of patients with ZMC fractures and was shown to result from mechanical impinging of the zygomatic arch on the coronoid process of the mandible. Of note is that diplopia was observed in 14.5% of patients in this study [40]. Al-Qurainy et al. (1991) reported diplopia in 19.8% of patients with mid-face fractures and found that zygomatic fractures were a principal risk factor in the development of diplopia [41]. In addition, if the fracture is near the superior orbital fissure, the oculomotor nerve may be injured, which will bring about external ophthalmoplegia and possible diplopia [42]. The orbital apex and Superior Orbital fissure syndromes have also been reported. For unknown reasons, Teng Chen (2009) demonstrated that the left eye was more commonly injured than the right eye[5].

1.2.6. Radiological findings

The generally recommended imaging modalities for orbital trauma include plain radiographs (Waters and Caldwell views), CT scans (coronal, sagittal and axial slices), Ultrasound scan (USS), MRI and Cine MRI for dynamic evaluation [11, 43, 44]. CT scan is generally considered the gold standard for diagnosis of orbital fractures[5]. When it comes to bone resolution, CT scan remains superior to plain radiographs, USS and MRI images. MRI is, however, better for soft tissue resolution. In a study by Ten Chen (2009) the missed diagnosis rate of cranial CT scan was 26.3%, and that for plain X-ray was 47.4%[5]. This also showed that despite being the gold standard, fractures can still be concealed on the CT scan. Comparing the diagnostic value of US with that of CT scan, Jank et al. (2004) showed that there were no statistically significant differences, provided a skilled and experienced operator performed the US examination [44]. Direct CT Scan findings include fracture position, size of the defect and status of the optic canal. Indirect signs include, soft tissue swelling, muscle entrapment, air fluid level (hemorrhage) and tissue emphysema [45].

Table 1.2: Radiological Pattern of Orbital Wall Fractures (Jank et al, 2003 [46])

LOCATION OF FRACTURE	N	%
Medial	1	0.2
Lateral	4	0.9
Floor	357	84.2
Medial/Lateral	2	0.5
Medial/ Floor	29	6.8
Lateral/ Floor	26	6.1
Medial/ Lateral/ Floor	5	1.2

From their study, Jank et al. (2003) showed that the floor was by far the commonest site of orbital wall fractures (Table 2.2). Also evident from this study was that the medial wall and orbital floor fractures were the most commonly found combination [46]. According to their findings, the least common isolated fracture was the medial wall injury. Isolated lateral wall fractures are relatively uncommon perhaps because of the thickness of the bone [47].

Bilateral orbital fractures account for approximately 2 to 6% of all orbital fracture cases [48]. In their study, Roh et al. (2014) noted that the medial wall with nasal bone fractures to have been the most common type of bilateral fracture. The nose is the most frequently injured part of the face because of its central prominent positioning and thin cartilaginous skeleton [49]. It is, therefore, thought that the impact on the nasal bones is transmitted to the thin medial walls bilaterally. However, depending on the striking angle and the magnitude of the force, fractures of the zygoma, maxilla and frontal bone, which are thicker and harder than the nasal bones, tend to occur unilaterally [50, 51]. In another study Cağatay et al. (2011) found that the commonest combination was that of the floor and the lateral wall (37.5%) [16].

A study by Tong et al. (2000) found that 22.6% of patients with orbital fractures sustained isolated (pure) and 77.4% sustained non-isolated (impure) types of fracture [52]. The results of this studies were comparable to a 2-year retrospective study by Khan et al. (2004)[33]. Both studies confirm the general perception that impure orbital fractures are much more common than isolated fractures. In both studies, ZMC fractures accounted for most impure forms of orbital fractures. Burm et al. (1999) indicated in their study that the facial fractures most frequently associated with orbital fractures were nasal bone fractures followed by zygomatic and mandibular fractures [53]. Gacto et al. (2009) also determined that the most frequently accompanying facial fracture was the zygomatic fracture [54].

Martello and Vasconez (1997) who studied 621 patients with systemic injuries associated with orbital trauma, determined that extremity and pelvic traumas (33%) occurred most frequently, followed by chest (7%) and intra-abdominal injuries (5%) [55]. Gewalli et al. (2003) reported soft tissue trauma in 34%, extremity and pelvic in 25%, and chest in 9% of the patients [56]. In their study, Roh et al. (2014) found that 23.8% of the patients with orbital fractures had systemic injuries. These included life-threatening problems, such as brain hemorrhage, spinal injury, internal organ damage, shock secondary to excessive bleeding and unconsciousness [49].

1.2.7. Management

Management of orbital wall fractures varies from conservative approaches to surgical intervention depending on the nature of the injury. The literature indicates that the choice of open surgery in orbital fractures should be dependent on the finding of enophthalmos and reduced globe motility, whereas a conservative approach should be used only in patients with discrete clinical symptoms. Clinical findings are the major indicator for open surgery, followed by radiologic investigation [46, 57, 58]. Indications for surgery can be summarized as: enophthalmos of 2mm or more, area of orbital floor fracture 1.9cm^2 or more, greater than 50% of the floor involved, diplopia for more than 2 weeks, deteriorating visual acuity, retained foreign body, paraesthesia, telecanthus, vertical dystopia, trismus, malar collapse, non-resolving oculocardiac reflex and entrapment of muscles (trapdoor, tear-drop) [46, 58].

Various types of materials for repair of orbital fractures have so far been described. In a review of 55 articles, Gunarajah and Samman (2013) demonstrated that over 19 different materials are used depending on the surgeon’s preference as well as the clinical condition [59]. Table 1:3 summarizes some of the implant materials available in the market.

Table 1.3: Type of Implant Material (Gunarajah et al., 2013 [59] and Kontio et al. 2009 [20])

TYPE OF IMPLANT MATERIAL	EXAMPLE
Autogenous materials	• Bone-calvarium, iliac crest, scapular, rib • Cartilage • Temporalis fascia • Dura • dermis
Allogeneic materials	• Irradiated fascia lata • Lyophilized dura mater • Lyophilized cartilage
Alloplastic materials	**Nonresorbable** • Titanium mesh • Vitallium • Bioactive glass • Silicone • Teflon • Porous polyethylene sheet • BAG plate • Hydroxyapatite sheet **Resorbable** • PLLA plate • P(L/DL)LA 70/30 plate • PLLA/PGA sheet • Polyglycolic acid membrane • PDS sheet • Polyglactin-910 mesh • Polyglactin-910/PDS sheet • Periosteum-polymer complex
Xenograft materials	• Collagen membrane
Others	• Suture suspension

Gunarajah and Samman. Repair of Orbital Floor Blowout Fractures. Journal of Oral and Maxillofacial Surgery 2013; 71: 550-570.

1.2.8. Fixation points and surgical approaches

A lot has been said about 1-, 2- and 3-point fixation techniques in ZMC fractures; and it is now widely accepted that 3 point fixation has the highest stability [60, 61, 62, 63, 64]. Davidson et al (1990) analyzed different combinations of miniplate fixation for stabilizing the fractured zygoma in human skulls. This experimental study found that the three-point fixation at the fronto-zygomatic suture; inferior orbital rim and zygomatico-maxillary buttress conferred maximum stability against forces matching physiological stresses [18]. Unlike the 1-point and 2-point fixation in which there are a few scars left, concern has been raised about the multiple scars that result from the 3-point fixation. However, if the incisions are properly made using the option of transconjunctival incision for the orbital rim (which leaves no obvious scar), upper eyebrow incision for the FZ suture (minimal scar that can be hidden under the eyebrow) and intraoral buccal sulcus incision (no visible scar), the 3-point fixation can give better esthetic results[60]. Despite these apparent advantages, three-point fixation is associated with more extensive periosteal stripping, extreme retraction of bone edges and the requirement of expert assistance for application of miniplates across the zygomatico-maxillary buttress. In addition, longer operative time, the presence of more hardware and increase in the cost of surgery are some disadvantages of the 3-point fixation approaches [60]. However, in the light of the literature review, it was found that irrespective of the approach taken for reduction, good results can be achieved by ensuring that zygomatic bone fractures are properly reduced and adequately stabilized at least on three points [60].

1.3. Statement problem and Justification

Due to the continuing proliferation of IPV, RTCs, sport related and firearm injuries, Kenyan health professionals are faced with increasing victims with orbital fractures. The diagnosis and management of orbital fractures poses a challenge that can be appropriately tackled if there is improved understanding of their pattern of presentation in the Kenyan population. There are hardly any local studies on the pattern of orbital fractures. As such it is not sufficient to only rely on data from other regions. In fact, racial variation in orbital morphometry could result in differences in the pattern of orbital fractures.

The rate of misdiagnosis of orbital fractures has been shown to be very high. Misdiagnosis of orbital fractures may result in severe complications such as blindness, diplopia, permanent paresthesia, malocclusion and facial disfigurement. These complications can significantly reduce the quality of life. Knowledge of the early complications can help clinicians know what to expect and hence come up with strategies on how to pre-empt and prevent avoidable mishaps. The findings from this study will not only aid in the diagnosis of orbital injuries but will also aid in establishing the magnitude of this problem and contribute to better understanding and in the formulation of management protocols for these injuries. Preventative strategies can also be developed, thereby reducing the morbidity and mortality associated with orbital fractures.

1.4.Objectives

1.4.1. Broad Objective

To determine the aetiology, clinical features, radiological features and the modalities of management of orbital fractures at the UNDH and KNH.

1.4.2. Specific objective

To determine

1.1. Patient demographics associated with orbital fractures,

1.2. Aetiology factors associated with orbital fractures

1.3. Clinico-radiologic features of orbital fractures among patients presenting at the KNH and UNDH.

1.4. Immediate and definitive management modalities of orbital fractures among patients presenting at the KNH and UNDH.

1.5. To identify any relationship between etiology, clinical features and radiologic pattern.

CHAPTER 2

2. Material and Methodology

2.1. Study area

The study was conducted at two referral institutions in Nairobi; Kenyatta National Hospital (KNH) and the University of Nairobi Dental Hospital (UNDH). KNH is the oldest and biggest hospital in Kenya. It has 50 wards, 22 out-patient clinics, 24 theatres (16 specialised) and Accident & Emergency Department. It has a bed capacity of 1800. It covers an area of 45.7 hectares and within the KNH complex are College of Health Sciences (University of Nairobi); the Kenya Medical Training College; Kenya Medical Research Institute and National Laboratory Service (Ministry of Health). (KNH, 2013). The UNDH is the largest and oldest dental training institute in Nairobi, Kenya. It is one of the schools under the University of Nairobi, College of Health Sciences and its mandate is to train both undergraduate and postgraduate students.

2.2. Study population: All patients who presented with orbital fractures at the UNDH and KNH Maxillofacial/Ophthalmology departments were included in the study.

2.3. Study Design: A 5-month descriptive prospective hospital based study commencing on 1st of July 2014 up to 30th of November 2014

2.4. Study instrument: A structured and pre-tested questionnaire was used.

2.5.Variables

Table 2.1: Variables

Independent variables	
Demographic variables	Age group, gender, occupation
Etiological factors	MCCs, IPV, Public VCs, Private VCs, hit by blunt objects, falls.
Dependent variables	
Clinical features:	Diplopia, enophthalmos, infra-orbital paeresthesia, periorbital ecchymosis, visual field, eyelid lacerations, visual acuity, pupils, dysmotility, globe position, trismus, facial wounds, scalp wounds etc.
Radiological features	Anatomical site of fracture i.e. floor, medial wall, roof, lateral wall, Le Fort fractures, ZMC, NOE, trap-door, indirect findings
Management:	Whether conservative, surgical management, type of graft or implant used, incisions used

2.6.Inclusion criteria:

All patients with confirmed orbital fractures (On CT scan) presenting at the KNH and the UNDH during the study period who consented to be recruited and to participate in the study.

2.7.Exclusion criteria:

- Patients with confusion and diminished autonomy.
- Patients who declined to give the consent to participate in the study.
- Patient with confirmed orbital fractures without CT scans.

2.8.Sampling method

All patients presenting at the UNDH and KNH with orbital fractures from the first of July 2014 to the 30th of November 2014 were included in the study. A convenience sampling method was, therefore, used to select participants into the study.

2.9.Sample Size

Sixty patients with confirmed orbital fractures on CT scan were included into the study. The following sample size determination formula for incidence studies for an unknown population proportion (Corlien, 2003) [65] was used to estimate the proportion of population the study size as follows:

$$\text{Sample Size} = \frac{Z^2 P\,(1-P)}{D^2}$$

n=desired sample size when n>10,000

Z = standard error corresponding to 95% confidence level ($p<0.05=1.96$)

d = degree of accuracy (0.05)

P= proportion of target population estimated to have orbital fractures.

From the study by Jitania (2012), orbital fractures constitute approximately 4 to 16% of craniomaxillofacial fractures[1]

$$\text{Therefore } n= \frac{1{,}96^2 \times 0.04\,(1-0.04)}{0.05^2}$$

= 59 (4% 0f the CranioMaxillofacial fractures constitutes orbital trauma[1])

2.10. Data collection:

Data collection was done through interviewing of the patients with orbital fractures where possible. Where the condition of the patient did not permit an interview, relatives or attendants of the patient were interviewed. Medical records and case sheets were referred to whenever necessary to collect additional information.

Procedure: Using a specially designed chart (see Appendix I), data collection included the evaluation of:

- Patient demographic data
- Associated aetiological factors
- Clinical assessment by the principal investigator;
  - Ocular and peri-ocular findings
  - Concomitant systemic soft tissue involvement
- CT scan findings
  - Pattern of orbital fractures
  - Concomitant craniomaxillofacial and systemic fractures
  - Indirect CT scan findings
- Treatment offered

2.11. Limitations and challenges of the study

- Not all patients with orbital fractures could afford CT scans. However, any patient without CT scans was excluded from the study
- Acute stages: periorbital oedema made it difficult to do a thorough examination of the eye.

- For head injury patients, clinical parameters like vision, diplopia, EOMM, visual field, paraesthesia, mouth opening could not be assessed because of the limited cooperation from the patient.

2.12. Minimizing errors and biases

All data collection was conducted by the principal investigator. The investigator was appropriately calibrated before and during the study in the following ways:

- Pretesting of the questionnaire and clinical examination chart to minimize intra-examiner variations in data collection.
- Training and retraining of the principal investigator by the supervisors. Special emphasis was paid on calibrating the investigator on standard protocols for eye examination and interpreting head and neck CT Scans.
- Every sixth patient was re-examined by the supervisors.
- Whenever deemed necessary the principal investigator consulted an assigned specialist oral and maxillofacial radiologist and/or a consultant ophthalmologist.

The study population was restricted to only those who met the inclusion criteria. Patients in whom oedema may have made it difficult do a thorough examination were re-examined after the oedema had subsided.

2.13. Data management and analysis

All data were coded and entered into the statistical package for social sciences (SPSS) software version 20 for analysis. Categorical data and significance of differences was determined using the Pearson's chi-square test and/or Fisher's exact tests. The results were presented in the form of tables and graphs.

2.14. Validation

The quality assurance of all the findings was achieved by calibrating and standardizing the principal investigator. Every sixth study participant was re-examined by the supervisors on a different occasion in order to obtain a measure of the consistency in the study findings. To minimize on false positives or false negatives of the CT scan findings, the PI was closely assisted by the supervisors.

2.15. Ethical considerations

On the 16th of June 2014, the Ethics and Research committee of the Kenyatta National Hospital and University of Nairobi approved the proposal of the study. Strict ethical values of patient confidentiality were maintained by the use of codes for each patient instead of their names. Informed consent was signed by every patient to declare voluntary participation before recruitment into the study.

CHAPTER 3

3. RESULTS

3.1. Etio-Socio-demographics

During the 5-month study period, 60 patients (52 males and 8 females, ratio of 6.5:1) were seen and treated for orbital fractures at KNH and UDH. A non-parametric binomial test elicited a statistically significant difference in gender distribution between males and females *($p<0.05$).* Orbital fractures occurred most frequently in the 21-30- (40%) and 31-40-year-old (40%) age groups (Fig. 3.1). The difference in the distribution of orbital fractures according to age was statistically significant ($X^2=41.167$, $df=4$, $p<0.05$). None of the patients was above the age of 50 years and the least affected age group was the 0-10-year-old cohort.

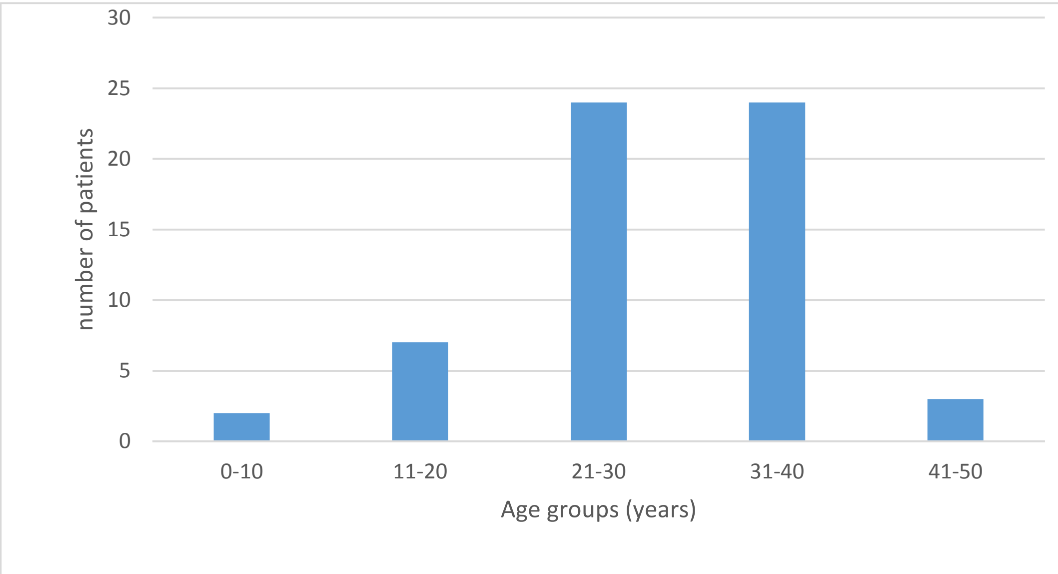
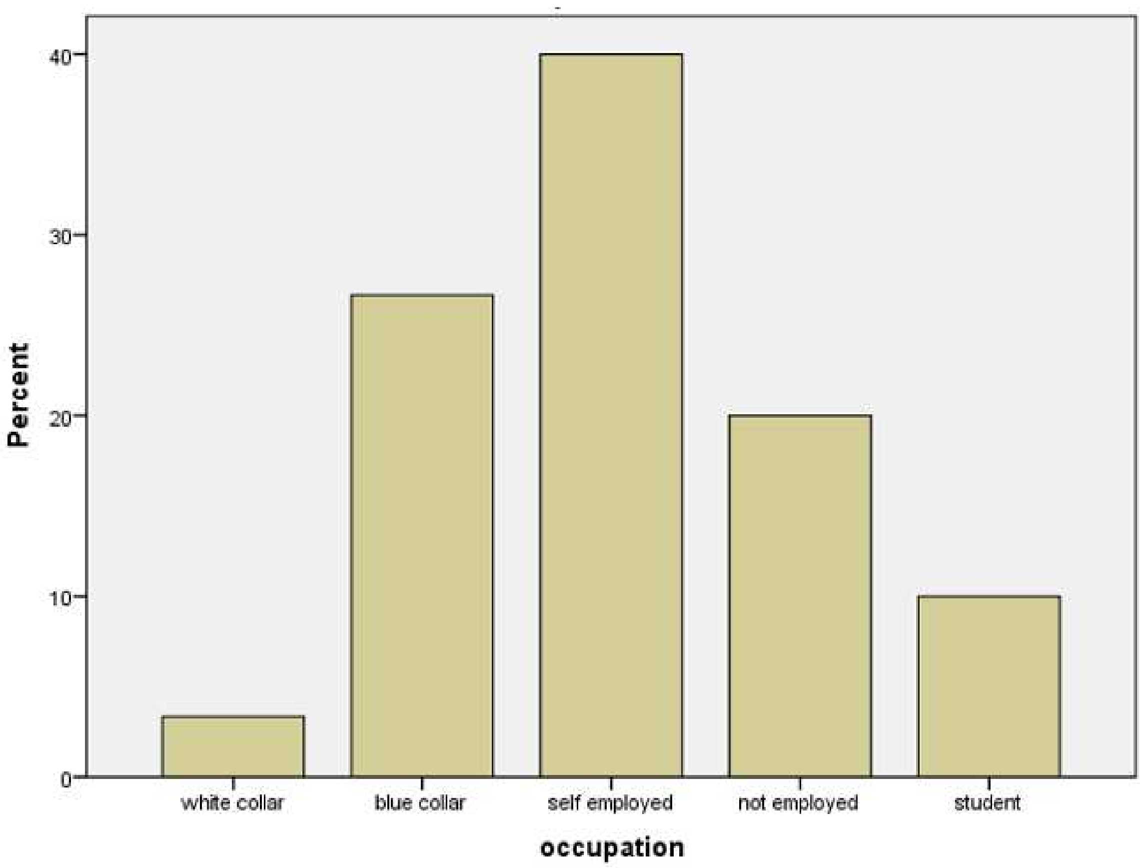


Figure 3.1: Distribution of orbital fractures according to the age

The most affected group was the self-employed (40%) whilst the least affected was the white collar (3.3%) job group (Fig. 3.2). The variation in the distribution of orbital fractures according to occupation was statistically significant ($X^2=23.500$, $df=4$, $p<0.05$). The mean delay between the day of injury and the date first seen by the oral and maxillofacial surgery (OMFS) team was 15.5 days (SD +/- 38.8 days). On one extreme some patients were seen by the OMFS team as early as hours after the injury whilst on the other extreme others were seen 2 years after the injury. To avoid skewing the mean days of delay, one patient seen 733 days after the injury was excluded from the mean calculation.



3.2: Distribution of orbital fractures according to occupation

The principal aetiology of orbital fractures was motor cycle crashes (MCCs; 30 %) followed by IPV (23.3%), public vehicle (20%) and private vehicle crushes (10%), injury by flying objects (10%) and falls (8.3%). The difference in distribution of orbital fractures according to aetiology was statistically significant *(X^2=22.367, df =6, p=0.001)*. Combined, road traffic crashes (RTCs) constituted 60% of the patients (Fig. 3.3.). Unlike public vehicle crashes in which passengers (n=10) were affected more than drivers (n=0), motor cycle riders (n=13) were affected more than passengers (n=4). The predominance of orbital injuries among passengers in public vehicles *(X^2=68.133, df =3, p=0.000)* and among motor cycle riders *(X^2=60.400, df=2, p=0.000)* was statistically significant. While one person was hit by a motor cycle, two were hit by a public vehicle. Notably, there was an equal distribution of passengers, pedestrians and drivers among the patients involved in private vehicle crushes.

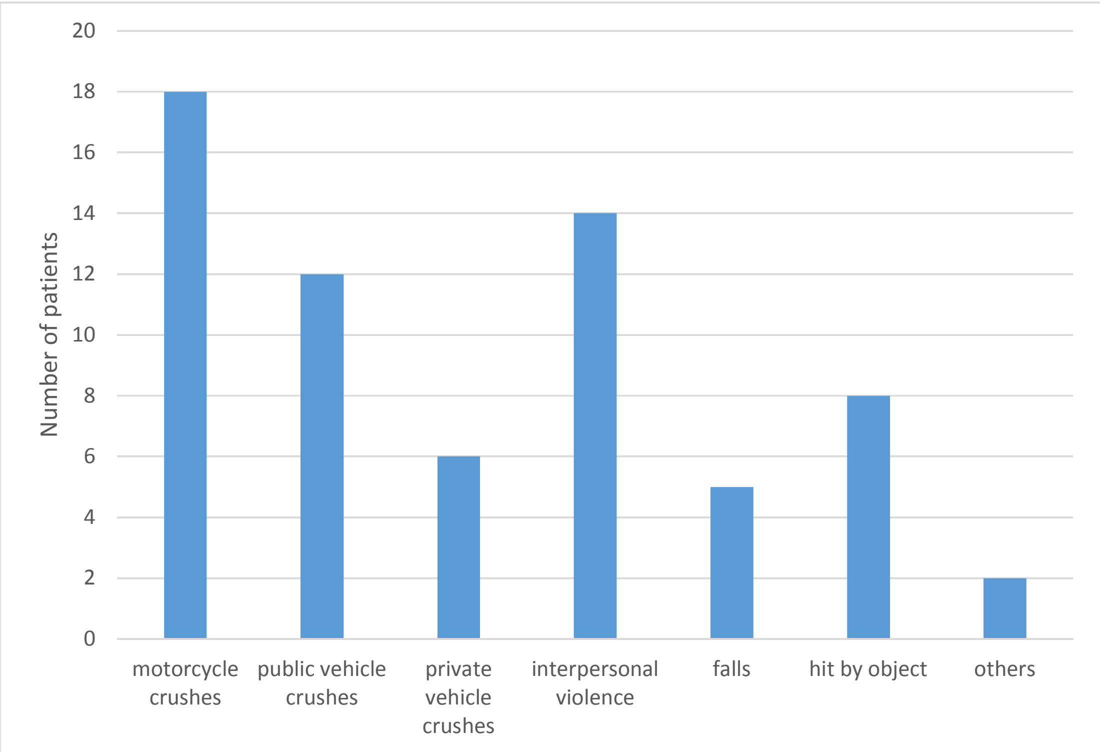


Figure 3.3: The distribution of injured persons according to aetiological factors

For all the aetiological agents other than IPV, the main age group affected was the 31-40-year-old age cohort. Remarkably, 8 out of the 14 patients who were involved in IPV were in the 21-30-year-old age group. The difference in the distribution of age groups among the IPV cases was, however, not statistically significant *(X^2=5.286, df =2, p=0.071)*. All the 14 IPV cases and the 5 who had fallen were male. The difference in the frequencies between males and females was statistically significant for IPV ($p<0.05$). All women who presented with orbital fractures were involved in RTCs (Fig. 3.4.).

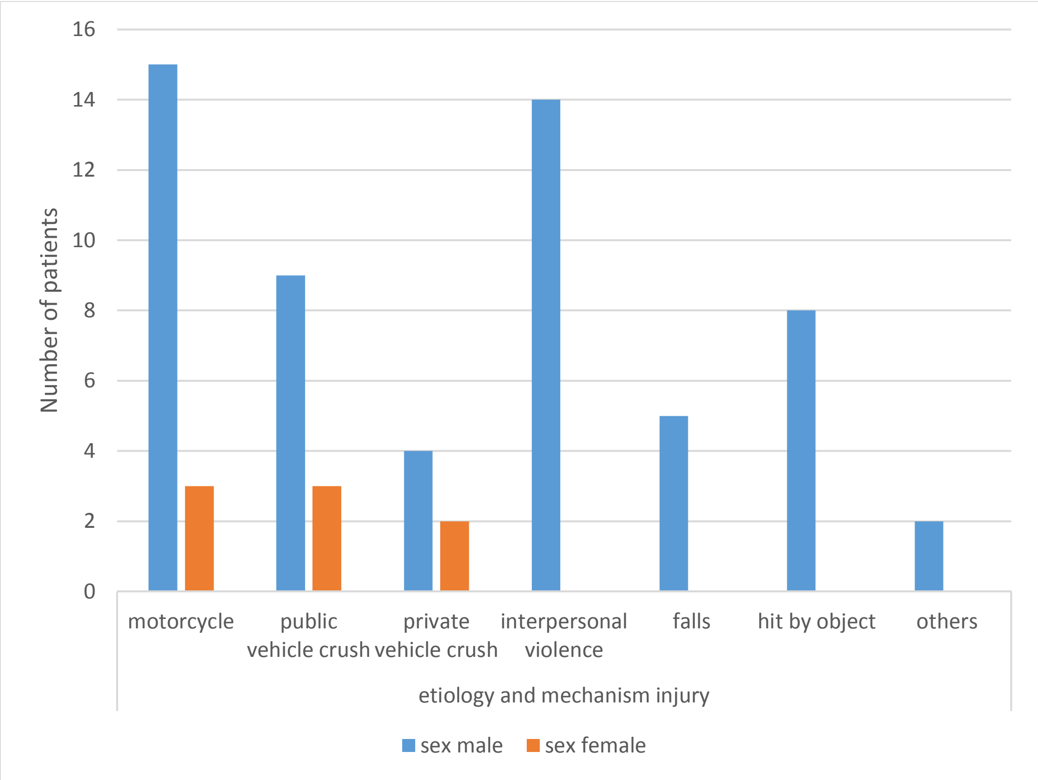


Figure 3.4: Distribution of aetiology according to gender

3.2. Clinical features of orbital fractures

In the present study, ocular and peri-ocular findings included; peri-orbital oedema, subconjuctival haemorrhage (SCH), step deformity on the rim, peri-orbital ecchymosis, trismus, eyelid laceration and avulsion, paresthesia, malar collapse in and telecanthus. Total blindness arising from orbital fractures was noted in 5 cases but no patient experienced bilateral loss of vision. Because of oedema, unconsciousness and pain, vision could not be assessed in another 5 cases. There was partial loss of vision in 4 patients. Table 3.1. illustrates the distribution of ocular and peri-ocular findings. The difference in the distribution of ocular and peri-ocular findings was statistically significant *($X^2=46.667$, $df=5$, $p<0.05$).*

Table 3.1: Distribution of ocular and peri-ocular findings in patients with orbital fractures

Sign/symptom	**Frequency**	**Percentage**
Peri-orbital oedema	55	91.7
Subconjuctival haemorrahge	50	84.8
Step deformity on the rim	29	48.3
Peri-orbital ecchymosis	25	41.7
Trismus	23	38.3
Eyelid laceration and avulsion	17	28.3
Paresthesia	15	25
1. Infra-orbital	10	16.9
2. Supra-orbital/trochlear	5	8.3
Malar collapse	8	
Telecanthus	6	10
Vision		
1. Blindness	5	8.3
2. Partial loss	4	6.7
3. Not assessable (pain, oedema, comatose)	5	8.3
Diplopia /entrapment	4	6.7
Enophthalmos	4	6.7
Vertical dystopia	3	5
Exophthalmos	2	3.3
Ptosis	2	3.3
CSF leak	1	1.7%
Nasal telescoping	1	1.7%

Up to 76.7% of the patients with orbital fractures had concomitant soft tissue injury (STI). The most commonly involved region was the face (68.3%) followed by scalp wounds (20%) (Table 3.2.).

Table 3.2: Distribution of Concomitant Soft Tissue Injuries

Region	Frequency	Percentage
Face	41	68.3
Scalp	12	20
Upper limb	8	13.3
Lower limb	8	13.3
Torso	4	6.7

3.3. CT Scan findings

From the findings of this study, the most commonly affected anatomical site was the floor (75%) and the lateral wall of the orbit (71.7%). Table 3.3. summarizes the distribution of orbito-zygomatic fractures.

Table 3.3: Distribution of the orbito-zygomatic fractures

Site	Frequency	Percentage
Floor	45	75
Lateral wall	43	71.7
ZM Buttress	42	70
Infra-orbital rim	40	66.7
ZT (Zygomatic Arch)	39	65
ZF Suture (Rim)	38	63.3
Tripod/ ZMC or Tetrapod	31	51.7
Medial wall	28	46.7
Roof	15	25

In this study, only 8.3% of the patients had pure (blow out) orbital fractures whilst 91.7% had impure fractures. The frequency distribution of orbital fractures according to pure vs. impure variants showed a statistically significant difference (p 2-tailed<0.5). Among the 5 patients with pure orbital fractures, 4 had isolated medial wall fractures while one had an isolated orbital floor blow-out fractures. The majority of patients with impure fractures had injuries of the infra-orbital rim followed by those of the ZF suture. For fractures involving multiple sutures or multiple bones, those of the ZMC fractures were by far the most common impure fractures followed by the NOE, frontal bone/supra-orbital rim and the Lefort II level injuries (Table 3.4.).

Table 3.4: Distribution of impure and pure orbital fractures

	Frequency	Percentage
Isolated (Pure) orbital fractures	5	8.3
1. Isolated medial wall	4	6.7
2. Isolated floor	1	1.7
Concomitant (Impure) fractures	55	91.7
1. Infra-orbital rim	42	70
2. ZF	38	63.3
3. ZMC	31	51.7
4. NOE	15	25
5. Frontal bone/orbital roof	15	25
6. Le Fort II	11	18.3
7. Le Fort III	3	5

There were more fractures involving the left orbit (46.7%) than the right (23.3%). Bilateral orbital fractures were seen in 30% of the patients. The ratio of left to right was, therefore, 2:1. This difference was not statistically significant *(X^2=5.200, df =2, p=0.074).* The infra-orbital rim had the highest number of bilateral fractures (Table 3.5). No patient had bilateral orbital roof fractures.

Table 3.5: Distribution of bilateral orbital fractures according to anatomical site

Region	Frequency	Percentage
Infra-orbital rim (ZM)	13	21.7
Floor	10	16.7
Lateral wall	8	13.3
ZF suture	7	11.7
Medial wall	5	8.3
ZT (arch)	4	6.7
Tripod/ ZMC or Tetrapod	2	3.3
Roof	0	0

Out of the 5 patients who sustained blindness following orbital fractures, 3 had ZMC, 2 orbital roof and 1 medial wall fractures. Remarkably, all the 5 cases of blindness were involved in high impact trauma. The relationship between blindness and anatomical site of fracture was however not statistically significant *($p>0.05$).*

In the present study, the mandible was the most common concomitant CMF site (31.7%) with the symphysis having had the highest frequency (20%) followed by the body and parasymphysis (16.7%). The rest of the concomitant injuries are illustrated in Table 3.6.

Table 3.6: Distribution of concomitant craniomaxillofacial fractures

Region	Frequency	Percentage
Mandible	19	31.7
1. Symphysis	12	20
2. Body/parasymphysis	10	16.7
3. Angle	3	5
4. Coronoid	1	1.7
NOE	15	25
Cranial bones	14	23.3
Le Fort II	11	18.3
Le Fort I	10	16.7
Sagittal split maxilla/palate	4	6.7
Nasal bones	3	5
Dento-alveolar	3	5
Le Fort III	3	5
Mastoid process	1	1.7

By far, head injury (33.3%) was the most prevalent concomitant injury. Other systemic anatomic regions affected included chest trauma in 3 patients, C-2 spine fracture in 1 patient, upper limb (radial-ulnar fracture) in 1 patient and lower limb (fracture proximal third femur) in 1 patient. Interestingly, the patient who had a C-2 spine injury had no neurological signs.

In this study the indirect CT scan findings were defined as CT scan findings other than fractures. In 90% of the patients there was evidence of swelling on the CT scans. Another strikingly common indirect CT scan finding was haemosinus (air-fluid level) which was evident in 78.3% of the patients. The frequency distribution of haemosinus among the cases of orbital fractures was statistically significant *(p 2-tailed=0.000)*. Other indirect CT scan findings in order of decreasing frequency are as summarized in Table 3.7.

Table 3.7: Indirect CT scan findings

Indirect CT scan finding	**Frequency**	**Percentage**
Soft Tissue Swelling	54	90
Haemosinus	47	78.3
1. Maxillary Sinus	39	65
2. Ethmoid Sinus	26	43.3
3. Frontal Sinus	11	18.3
4. Sphenoid Sinus	3	5
Soft Tissue Emphysema	16	26.7
Intra-cranial bleeds/hemtoma	9	15
Tear drop	7	11.7
Pneumocephalus	4	6.7
Optic canal obliteration	0	0
Retrobulbar haemorrhage	0	0

3.4. Management of orbital fractures

Broadly, all the patients with orbital fractures were either managed conservatively or surgically. Notably, more patients were managed conservatively (60%) than surgically. Among the 24 patients who were managed surgically, 22 had rigid fixation using titanium miniplates while the other two cases had semi-rigid wire osteosynthesis and an autogenous iliac crest bone graft to repair an orbital floor defect. No form of fixation was done to secure the autogenous iliac crest bone graft.

In as much as the floor of the orbit was the most common site of orbital fractures (n=45), internal repair of the orbital floor was done in only 5 cases. Most patients with ZMC fractures (32%) had the 3-point fixation at the ZF suture, ZM buttress and the infra-orbital rim. Out of the 15 patients who presented with orbital roof fractures only 3 had fixation done. Interestingly, all the three patients had concomitant frontal bone fractures. Fixation of the supra-orbital rims in these three patients, therefore, was achieved using frontal titanium meshes to support either the comminuted frontal segments or to close the frontal bone defect. Of the 39 patients who presented with zygomatic arch fractures, only 2 had rigid fixation using titanium miniplates. Closed reduction of the arch with no fixation was done using the Gillies' approach and the Keen's approach in 11 patients. Surgical incisions used varied depending on the site of the fractures. Table 3.8. depicts the various surgical approaches employed in the present study.

Table 3.8: Distribution of surgical approaches used

Surgical incision	Frequency	Percentage
1. Infra-orbital rim access		
Transcutaneous	17	28.3
Subtarsal	14	23.3
Subciliary	2	3.3
Infra-orbital	1	1.7
Transconjuctival	3	5
2. **ZM buttress** (Upper vestibular)	19	31.7
3. ZF access		
Upper eyebrow	14	23.3
Upper blepharoplasty	2	3.3
Pre-existing scar	1	1.7
4. ZT access (Zygomatic arch)		
Upper eyebrow incision for closed reduction	8	13.3
Keen vestibular approach for closed reduction	4	6.7
Gillies temporal access for closed reduction	2	3.3
Coronal	1	1.7
Alkayat-Brammley	1	1.7
5. Supra-orbital rim		
Coronal	2	3.3
Pre-existing scar	1	1.7

CHAPTER 4

1.6. DISCUSSION

The present study has prospectively yielded useful information regarding the early and delayed clinico-radiologic features associated with injuries of the orbital skeleton and the contiguous structures. Notably, the existing information on this subject is, largely, retrospective in nature. As has been shown in the published literature and confirmed in the present study, injuries of the orbital skeleton and its related structures is indeed a “disease” of the young and middle aged male in the 20 to 40-year-old range[16, 25, 34]. The high incidence of orbital trauma among the young middle-aged, the self-employed and the blue collar groups could possibly be due to the high risk of industrial accidents in view of the manual nature of their jobs. Long hours of work, fatigue and the physical demand from these jobs could also be a contributing factor.

The window period between the time of injury and the time of treatment is critical to the management outcome. Complications such as retro-bulbar haemorrhage, white-eye trap-door phenomenon, superior fissure syndrome, orbital apex syndrome, haemorrhage, infections, no-union, malunion, permanent paeresthesia, malocclusion, diplopia, enophthalmos, epiphora and even blindness can all be avoided by timely intervention [33, 35, 36, 37, 38, 46, 47, 57, 58]. In this study the mean delay between the day of injury and the date first seen by the OMFS team was 15.5 days. Notably, one patient presented 2 years after injury with persistent diplopia and ophthalmoplegia. Because of fibrosis of the muscles, there was little that could be done. In a study by Roh et al (2014) the mean time between trauma and initial hospital visit was 1.8 days and the mean time between trauma and surgery was 12.2 days [49]. Our study, however, did not assess the duration between the time of trauma and the actual treatment. Reasons given for the delays were multifactorial, including patients' financial constraints, shortage of skilled workers in peripheral health centres and lack of knowledge among the health practitioners about the specialists who treat orbital fractures. It is paradoxical that the poly-trauma group presented to the hospital early and yet they had the highest incidence of delays. This is because in most instances upon admission, they were treated for life threatening injuries and upon recovery they were discharged from hospital to seek OMF surgical care as outpatients.

In this study the principal causes of orbital fractures were MCCs, IPV and public vehicle crushes which is comparable with the other literature[1, 17, 18, 19, 21, 23] in which the commonest causes of facial fractures were MVCs and assaults. The high incidence of MCCs in our study could be attributed to the general proliferation of motorcycles in Kenya and the poor enforcement of traffic regulations. This is perhaps due to the fact that motorcycles are more affordable, fuel efficient, cheap to maintain and above all, motorcycles are preferable because of their ability to maneuver the traffic jam and the poorly maintained roads. A report by the government's economic survey of 2009 showed that motorcycle registration rose from 2084 units in 2003 to 51 412 in 2008. In 2009, an average of 7000 motorcycles were registered every month [66]. Data reviewed from the Kenya traffic police revealed that between 2004 and 2009, the greatest increase in RTC fatality rates occurred among motorcyclists (51%) and pillion passengers (13%) [66].

In the present study, there was a statistically significant relationship between gender and IPV. In fact, all the cases of IPV and all the cases of falls were males. IPV was twice more common in the 21-30-year-old age group than the 31-40-year-old age range. This distribution could perhaps be attributed to the fact that those in the 21-30-year-old age group are more active, violent and outgoing. RTCs were, however, more common in the 31-40 age group which could be explained by the fact that the bulk of the working class who can afford motor vehicles are within this age range. The low incidence of fractures among the 41-50- year-old age group could be explained by the fact that as people grow older or settle down, they are less likely going to be engaged into risky habits that could potentially result in injuries [40].

The ocular and peri-ocular examination findings in our study were similar to results from other studies [6, 16, 39.] Notably, the high frequency of SCH, peri-orbital oedema and peri-orbital ecchymosis was statistically significant. The slightly lower percentage of periocular ecchymosis compared to other studies could have been attributed to the delay between the time of trauma and the time actually seen. The average delay of 15.2 days in our study meant that by the time some of the patients were examined, the signs/symptoms would have subsided. The other possible explanation for a higher rate of ecchymosis in other studies could be because of the masking effect of the dark skin colour among the African population[6, 16, 39]. From these studies it can, therefore, be prudent to say that in the absence of peri-orbital oedema, peri-orbital ecchymosis and SCH, the diagnosis of orbital fractures is least likely.

Pattern of orbital fractures

In the present study, the orbital floor was the most commonly affected site with up to 75% of patients affected which is comparable with what other authors have reported[1, 49]. Interestingly, unlike the findings from other studies, our study had a very high incidence of fractures of the other walls[1, 49]. The high incidence of the floor and the medial wall fracture could be attributed to their being the thinnest portions of the orbit[27]. The inter-racial morphometric variations of the orbital anatomy could possibly explain why our results may not be consistent with what other authors have reported [5, 13]. In a retrospective review of CT scans and demographics in an unselected cohort of 152 patients with orbital blowout fractures, it was shown that most blowout fractures involve the orbital floor in Caucasians and Asians, whereas in Afro-Caribbeans the most common site for fracture was the medial wall[13].

Our study confirmed the general perception that impure orbital fractures are much more common than isolated fractures. From the results, there was a statistically significant difference between the number of patients who presented with impure orbital fractures compared to the pure variant. The most common site of isolated and pure orbital fractures was the medial wall, constituting 80% of the patients. Again, similar to the other literature, the majority of patients with impure fractures had fractures of the ZMC, NOE, supra-orbital rim and Lefort II[33, 52]. There have been reports of the left orbit being affected more than the right[5]. This is consistent with our study in which the ratio of the left to the right side was 2:1. Despite this ratio, statistical tests yielded no significance. No attempt has been made to explain this trend. In our opinion, the natural reaction to trauma is a protective reflex of the face by the hands. The right side is, therefore, better protected than the left because the majority of people are right hand dominant. We also believe that the fist-punch of a right handed person is more likely to hit the left orbit.

In this study bilateral orbital fractures were seen in 30% of the patients. The infra-orbital rim and the orbital floor had the highest number of bilateral fractures. Bilateral orbital fractures have been shown to accounts for approximately 2 to 6% of all orbital fracture cases [48]. In their study, Roh et al. (2014), showed that the medial wall with nasal bone fractures was found to have been the most common type of bilateral fracture[49]. Catagay et al. (2013), however, reported bilateral orbital fractures having been commonest in the floor of the orbit[16]. Most authors argue that the nose is the most frequently injured part of the face because of its central prominent positioning and thin cartilaginous skeleton. It is, therefore, thought that the impact on the nasal bones is transmitted to the thin medial walls bilaterally[49, 50, 51]. However, depending on the striking angle and the magnitude of the force, fractures of the zygoma, maxilla, and frontal bone, which are thicker and harder than nasal bone, tend to occur unilaterally [50, 51] . This could explain why in the present study, there were only two cases of bilateral ZMC fractures.

Notably, in 5 cases there was total blindness and in another 4 there was partial/transient visual loss. More interestingly, there was no patient with bilateral loss of vision which is similar to the published literature in which the incidence of blindness following orbital trauma ranges from 0.67 to 9 %[4, 5, 16, 31, 32, 34]. As confirmed in this study, most literature agrees that blindness usually occurs in association with lateral orbital wall and roof fractures. Understandably, these are the thickest portions of the orbit and as such the amount of force required to cause fracture in these walls will most likely result in concomitant trauma to the globe. Also, the antero-posterior dimensions of the orbit are such that the lateral wall is half the length of the medial wall. This leaves the globe more exposed on the lateral aspect and hence a laterally directed force is more likely to result in blindness[11, 12, 34].The incidence of trismus in the present study was comparable to other studies[40, 53]. The high impact involved in orbital trauma explains why the majority of the patients in our study had concomitant soft tissue and skeletal injuries.

Indirect CT scan findings by definition are any CT scan findings other than fractures. Indirect findings can be pathognomic of fractures. This can be particularly useful in borderline situations in which the surgeon or the radiologist is not too sure whether a fracture is actually present. In the present study, the strikingly common indirect CT scan finding was haemosinus. More interestingly, 87% of all the patients with orbital floor fractures had accompanying maxillary haemosinus, 93% of patients with medial wall fractures had accompanying ethmoid haemosinus whilst 73% of patients with supra-orbital rim fractures had accompanying frontal sinus haemosinus. The ones who did not have haemosinus were those in whom the CT scans were taken 2 weeks after the injury. While the literature reports haemosinus as one of the indirect CT scan findings of orbital fractures[1, 5, 11, 45], to the best of the authors' knowledge, hardly any research has so far been done to quantify the prevalence of haemosinus among patients who present with orbital fractures. From the findings of this study, it is, therefore, prudent to say that the absence of haemosinus may rule out orbital fractures.

Management of orbital trauma follows the protocol of the basic ATLS in which the "ABCDE" sequence must guide the priorities of management. However, one of the most controversial areas in orbital traumatology is the decision on whether to do conservative or surgical management. Many orbitologists agree that clinical findings are the major indicator for open surgery followed by radiologic investigation [46, 57, 58.] In the present study, more patients were managed conservatively (60%) which consisted of pain management, tetanus toxoid, antibiotics, soft diet, wound care, cold compression, corticosteroid therapy and in some cases MMF. Because 51.7% of the patients in this study had ZMC fractures, for a significant number of cases, surgery was, therefore, mainly done to correct trismus, malocclusion, malar collapse, infra-orbital paraesthesia, diplopia, extra-ocular muscle/peri-orbital fat entrapment and restoration of orbital volume. Many of the patients who were managed conservatively could have benefitted more from surgery but most of them could not afford the high cost of implants and surgery.

1.7. CONCLUSION

The present study has reaffirmed that RTCs, especially motor cycle crashes and IPV are the leading cause of orbital injuries most commonly in the young males in their third and fourth decades of life. Evidently, haemosinus as demonstrated on CT scanning together with peri-orbital oedema and SCH constitute the clinical features most consistent with orbital fractures, most of which were the impure variants. The left side was more affected than the right whilst the floor and the lateral wall being the commonest sites of orbital fractures. Impure variants particularly zygomatico-maxillary-complex fractures are by far more common than the pure variant. Depending on the severity of the injury, orbital fractures can be managed either surgically or conservatively.

1.8. RECOMMENDATIONS

- Since the commonest cause of orbital fractures was road traffic crushes (particularly MCAs) and IPV, preventive measures to minimize the occurrence of these should be put in place. These should target the particular segment of the society mostly affected by these injuries and may include proper training of motorcycle riders, education of the public on observation of road traffic regulations and finally law enforcement against IPV.
- MDT approach to minimize delays between the time of injury and the time seen by the maxillofacial team.
- A long-term prospective study would particularly help in improving the study strength and to establish the long-term complications of the various treatment modalities

1.9. References

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APPENDIX I: DATA COLLECTION SHEET

1. **Demographics**

Date…………………………………………………………………………………………...

Serial number……………………………………………………………………………..

Patient's Initials………………………………………………………………………………

Age (pick appropriately)

a. [0-10] b. [11-20] c. [21-30] d. [31-40] e. [41-50] f. [51-60] g. [61-70]

Sex

(a).Male

(b).female

Residential Place ……………………………………………………………………………...

Occupation:

1. White collar
2. Blue collar
3. Self employed
4. Not employed
5. Student

Date of Injury…………………………………………………………………………………

2. **Etiology and Mechanism of Injury**

1. Motor cycle crush
    a. Rider
    b. Passenger
    c. Pedestrian
2. Public vehicle crush
    a. Driver
    b. Passenger
    c. Pedestrian
3. Private vehicle crush
    a. Driver
    b. Passenger

c. Pedestrian

4. Interpersonal Violence
5. Sports Related
6. Gunshot
7. Falls: specify
8. Hit by object: specify
9. Others: specify…………………………………………………………………………….

3. Examination of Eye: Clinical Features

	Right Eye	Left Eye

1. Vision

a. Normal
b. Partial loss
c. Total loss
d. Not assessable
e. Not applicable

2. Diplopia

a. present
b. absent
c. not assessable
d. not applicable

3. EOMM

a. free
b. entrapment
c. Not assessable
d. Not applicable

4. Visual Field (VF) – confrontational method

a. Normal
b. Abnormal
c. Not assessable
d. Not applicable

5. Orbital Rim

a. Step deformity
b. No step deformity
c. Not assessable

6. Eye Lids

a. Laceration/bruises
b. Oedema
c. Avulsion
d. Ecchymosis
e. No injury

7. Sclera

a. Subconjuctival haemorrhage
b. Perforation
c. No abnormalities

8. Cornea

a. Clear
b. Perforated

9. Pupils

a. Fixed and dilated
b. Bilaterally equal and reactive to light
c. Not assessable
d. Not applicable

10. Trismus

a. Done
b. Not done

11. Paresthesia

a. Infra-orbital
b. Supra-orbital and supra-trochlear
c. No paresthesia
d. Not assessable

12. Vertical dystopia

a. Present
b. Not present

13. Telecanthus

a. Present
b. Not present

14. Others: specify

---

15. Other associated Craniofacial STIs

a. Scalp wounds
b. Facial wounds
c. Others (specify)
d. No injuries

16. Other associated injuries

a. Upper limb
b. Lower limb
c. Torso
d. Others (specify)
e. No injuries

4. Radiological features

Table 1: Radiographic Features on CT scan

1. Direct Signs

	FLOOR	ROOF	MEDIAL WALL	LATERAL WALL	ZT	ZM	ZF	TRIPOD/ ZMC/ TETRAPOD
RE								
LE								

2. Other associated craniofacial fractures

	RE	LE
a. Le Fort I		
b. Le Fort II		
c. Le Fort III		

d. NOE
e. Cranial bones (specify)
f. Mandible
    a. Body
    b. Symphysis
    c. Angle
    d. Condylar
    e. Coronoid
    f. Ramus
    g. Parasymphyseal
g. Dento-alveolar fractures
h. Others (specify)
i. No injuries

3. Other associated fractures/injuries (whole body)

a. Upper limbs
    i. Humerus
    ii. Radius
    iii. Ulnar
    iv. Hand
    v. No injuries

b. Lower limbs
    i. Femur
    ii. Tibia
    iii. Fibular
    iv. Ankle joint
    v. Foot
    vi. No injuries

c. Torso
    i. Chest trauma
    ii. Abdominal injury
    iii. No injuries

4. Table 2: Indirect CT scan signs

	RE	LE
Air-fluid level (haemosinus) a. Ethmoid sinus b. Maxillary sinus c. Frontal sinus d. Sphenoid sinus e. No air-fluid level		
Optic nerve and optic canal a. Impingement b. Free		
Retro-bulbar hemorrhage a. Present b. Not present		
Tissue emphysema a. Present b. Not present		
Tear-drop a. Present b. Not present		
Trap-door a. Present b. Not present		
Soft tissue swelling a. Present b. Not present		
Other indirect signs a. Present b. Not present		

5. Management of orbital fractures

1. Conservative management

2. Surgical intervention

a. Rigid Fixation
    i. Titanium miniplates
    ii. Titanium orbital mesh
    iii. Autologous bone graft

b. Semi-Rigid Fixation

3. Fixation points

	FLOOR	ROOF	MEDIAL WALL	LATERAL WALL	ZT	ZM	ZF	RIM
RE								
LE								

INCISIONS

6. Management of concomitant injuries

1. Conservative
    a. MMF
    b. Neuro-observation
    c. Soft diet
2. Surgical Intervention
    a. Craniotomy and evacuation of haematoma
    b. Craniolization
    c. Elevation of depressed skull fractures
    d. ORIF mandible
    e. Others: specify

APPENDIX II: LETTER OF APPROVAL

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

KNH/UON-ERC
Email: uonknh_erc@uonbi.ac.ke
Website: www.uonbi.ac.ke

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

Ref: KNH-ERC/A/194 Link:www.uonbi.ac.ke/activities/KNHUoN 17th June 2014

Dr. Wayne Manana
Dept.of Oral and Maxillofacial Surgery
School of Dental Sciences
University of Nairobi

Dear Dr. Manana

RESEARCH PROPOSAL: AN ANALYSIS OF THE PATTERN OF ORBITAL FRACTURES AT TWO REFERRAL TEACHING INSTITUTIONS IN NAIROBI (P169/03 /2014)

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above proposal. The approval periods are 17th June 2014 to 16th June 2015.

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 severe 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-Ethics & Research Committee 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 **www.uonbi.ac.ke/activities/KNHUoN.**

Protect to Discover

Yours sincerely

PROF. M. L. CHINDIA
SECRETARY, KNH/UON-ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director CS, KNH
The Chairperson, KNH/UoN-ERC
The Assistant Director, Health Information, KNH
The Dean, School of Dental Sciences, UoN
The Chairman, Dept. of Oral and Maxillofacial Surgery, UoN
Supervisors: Prof. M.L.Chindia, Dr.W.A.Odhiambo, Dr.K. Koech

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