PATTERN OF MAXILLOFACIAL INJURIES IN PATIENTS WITH TRAUMATIC HEAD INJURY AT THE KENYATTA NATIONAL REFERRAL AND TEACHING HOSPITAL IN NAIROBI, KENYA

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V60/7186/2017

A RESEARCH DISSERTATION SUBMITTED AS PART FULFILMENT FOR THE AWARD OF THE MASTER OF DENTAL SURGERY DEGREE IN ORAL AND MAXILLOFACIAL SURGERY OF THE UNIVERSITY OF NAIROBI

STUDENT DECLARATION

I hereby declare that this research dissertation is my original work and has not been presented in any other institution for an academic award.

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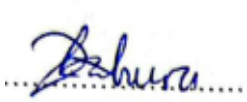

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DEDICATION

This is for the glory of God. To the postgraduate residents in Oral and Maxillofacial Surgery for their ever dedicated team-work and continuous harmonious delivery of surgical services; To all the aspiring future scholars, my daughter, Leona Florence Wangari Kahura-Ad astra per aspera!

ACKNOWLEDGEMENT

I would like to thank the Kenyatta National Hospital Administration and Management for allowing me to conduct this research. I would like to give special thanks to my team of supervisors led by the Chairman of Department of Dental Sciences and former Head of Oral and Maxillofacial Surgery, Oral Medicine and Oral Pathology, Dr. Walter Odhiambo, Prof. Mark L. Chindia and Dr T.J. Ochola, as well all the senior lecturers in the department for their guidance and insights during the entire period of carrying out this research. I would like also to acknowledge Mr Desmond K'Owino for his immense help and assistance with data management and analysis.

Special thanks to my fellow registrars in the Division of Oral and Maxillofacial Surgery for their encouragement during the postgraduate course work.

Many more thanks to my dear partner, Lucyann Munyasya, for putting up with me in the long nights of study and hours of absence. Thank you very much for the moral support.

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LIST OF ABBREVIATIONS

AO- Arbeitsgemeinschaft für Osteosynthesefragen/ Association for Osteosynthesis

CT SCAN – Computed Tomography Scan

GCS- Glasgow Coma Scale

HTI-Hard Tissue Injury

IPV-Inter Personal Violence

KNH – Kenyatta National Hospital

MFI-Maxillofacial Injury

MVA- Motor Vehicle Accidents

MVC-Motor Vehicle Crashes

NOE-Nasal-Orbital-Ethmoid

RTA-Road Traffic Accident

RTC-Road Traffic Crash

STI-Soft Tissue Injury

TBI-Traumatic Brain Injury

THI-Traumatic Head Injury

UON – University Of Nairobi

ZMC-Zygomatic Maxillary Complex

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ABSTRACT

Background: Maxillofacial and traumatic head injuries are a major cause of morbidity and mortality worldwide. The causes of these injuries vary and are attributable to motor vehicle and cycle crashes, fall from heights and interpersonal violence, among others. There is a paucity of hospital studies in the East African region reporting on the pattern of these combined injuries occurring concurrently.

Research methodology: Study objective: The aim of this study was to assess the incidence and pattern of concurrent occurrence of maxillofacial injuries (MFIs) and traumatic head injury (THI).

Study design: A cross-sectional descriptive prospective study

Study area and population: Study was undertaken at the Kenyatta National hospital's accident and emergency, maxillaofacial surgery, neurosurgical and the ICU units. Study duration was 3 months where 336 patients after giving consent and who sustained concomitant maxillofacial and traumatic head injury participated.

Data analysis and presentation: Convenience sampling and quantitative data was collected using a specially designed questionnaire. Data analysis was done using the statistical package for social sciences (SPSS).

Results: Three hundred and thirty six patients were enrolled in the study. The patients' age ranged from 2.8 – 69.0 years. The majority of the patients were aged 21 – 30 years (133, 39.6%) followed by those aged 31 – 40 years (111, 33.0%). There were more males affected than females at a ratio of 8.3:1. The most common aetiology of injury was road traffic crashes (RTC) and motorcycles crashes 186 (55.4%). Drivers were mainly involved at 170(50.6%). The most common MFI involved the mid face 188 (56%). In the upper face zone, frontal bone fractures (27.2%) were the commonest. Orbital fractures constituted the commonest (23.2%) injuries of the mid-face component while the zygoma with zygomatic arch injuries at (14.8%) comprised the commonest zygomatic complex fractures. In the lower face zone, parasymphyseal mandibular fractures (20.2%) were the commonest. The most common head injury characteristic sign was loss of consciousness (63.6%). Cases of mild Glasgow Coma Scale (GCS) were found to have been at 317 (94.3%). Skull vault fractures constituted 86 (25.6%) of the injuries while patients who had basilar fractures were 7 (2.1%). The

commonest intracranial injury comprised of diffuse lesions at 264 (78.6%) with concussions having been the commonest at 256 (78%). Among the focal lesions, the commonest lesion was epidural hemorrhage at 31 (68.9%). Seven classification patterns of MFIs in THI were observed and arbitrarily developed from the data which ranged from Type 1A to Type 7C combined injury patterns.

Conclusion: There was a significant number of MFIS among patients with THI, with the commonest gender affected having been male and age group 21-30year olds. Commonest aetiology of injury was RTC and involving motorcycle drivers. The developed classification of combined injuries is a useful practical and simple system that may be used in case diagnosis and treatment planning.

Recommendations: Based on the high incidence rate and observed trauma patterns in concurrent MFIs and THI, specialized institutions should review existing multidisciplinary management protocols to provide for adequate resource allocation in the care and management of combined injuries. There is a great need for continuous education and public health policies on road accidents in order to prevent and reduce incidence of MFIs and THI among the males of 21-30 years age group especially those using motorcycles. The developed classification of combined injuries should be considered as a possible mode of classification of MFIs in THI. Future studies involving multiple centers and larger sample sizes may be conducted to improve on present study findings, limitations and injury classification methodology.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Background

A human body injury is any form of physical injury which occurs when the human body is exposed to excessive levels of energy that result in physiological intolerance and disruption.[1] Usually the exposure time to the energy and the presentation of a physical injury is short and sudden. Some of the commonest causes of physical body injuries are traffic collisions, interpersonal violence, collective violence including wars, civil insurrections and riots, occupational incidents, domestic accidents and sporting and recreational activities. Worldwide, injuries account for about five per cent of the total mortality. In Africa and other developing countries, the burden and pattern of injuries is generally poorly known owing to the few intensive studies conducted on the subject. The incidence of various types of injury is on the increase[2]. Physical body injuries can be partly attributed to the increase in motor vehicle transport, proliferation of firearms, insurgent terrorist activities among others.

Trauma continues to remain a challenge to the public health systems due to the associated high incidence and monetary costs required in the treatment of cases. According to Trunkey et al. (1974) while studying traumatic death series, it was reported that the young productive age group is most at risk for accidental death. In this series, 44.9% of the deaths were due to brain injury, subdural or epidural hematomas. Thirty-five percent of the deaths were due to hemorrhage and probably represent the most potentially salvageable group. Eight patients had preventable deaths, and eleven patients had possible preventable deaths. Trunkey observed that prevention of these deaths was dependent upon adequate ambulance personnel, physician judgment, quality of assessment and aggressive resuscitation and treatment. Regionalization of trauma centers could also aid in the reduction of mortality from accidental death[3].Another study by Baker et al. (1980) reports that the key areas in which advances are necessary in order to reduce the number of trauma deaths are prevention of trauma, more rapid and skilled transport of injured victims, better early management of primary brain injuries, and more effective treatment of the late complications of sepsis and multiple organ failure[4]. It is therefore against this background on trauma studies that this study of MFIs in THI is undertaken.

A review of MFI studies shows that these have generally been undertaken in isolation with some describing patterns, assessing preventive measures as well as health policies to reduce the burden of injuries[5]. Epidemiological features studied also vary greatly and seem to be related to geographical aspects of the areas studied. In East Africa, research assessing the pattern of MFIs in traumatic head injury (THI) has hardly been done. Studies available include prevalence studies of MFIs, those on patterns of MFIs as per the different modes of causation, road traffic accident/crash (RTA/RTC), motorcycle crashes, firearms and even bicycles[6].

MFIs are commonly described on the basis of the specific areas of the face and names of the fractured bones involved. Various classification systems of MFI have been separately done and have been based on the facial bones affected. It is also good to note that the design of a classification system needs to demonstrate its intended utility. It is for this reason that an extensive review of literature was done to establish that there exists a gap in the classification of combined MFI and THIs. This study, therefore, was undertaken to document the pattern of MFIs in THI in one of the major national referral hospitals in Kenya and also attempted to classify combined MFI and THIs using radiological information together with clinically related factors. The envisaged classification is meant to simplify and propose standardized diagnostic and treatment planning categories to guide clinicians in the interpretation of combined MFIs and THI.

1.2 Maxillofacial Injuries

The maxillofacial region is comprised of organs performing vital bodily functions such as upper airway/respiration, mastication, speech and vision. Studies have shown that MFIs are some of the commonest injuries and RTC constitute one of the major causes of these injuries in low and middle income countries[7]. Facial fractures in MFIs are common owing to the face being anatomically vulnerable and formative bones being delicate. Furthermore, it has been shown that MFIs often occur in association with THI. An appreciation of the incidence, occurrence patterns of MFIs in THI can, therefore, assist in establishing research needs towards the management of this type of trauma.

MFIs are reported to make up 7.4–8.7% of the cases attended to at emergency centres[8]. This information has generally been sourced from data that have been collected from a single institution, therefore, it would be much better if researchers had a way of collating all multicenter studies in order to give a more accurate position on the burden of maxillofacial

trauma. A review report by Kanala et al. (2021) in one of the maxillofacial units in a hospital in India, reported that men aged between 20–40 years were the commonest casualties of facial trauma[9]. RTAs comprised 70% of the participants with mandibular fractures having been 47% of the injuries studied. MFIs associated with THI were found to have been 1.3%.

In a 14-year retrospective study by Manodh et al. (2016) in Chennai it was revealed that male patients mostly in the third decade of life sustained more injuries than females[10]. RTAs were also the commonest cause of injury with mandibular injury having been the most prevalent. On analysis of neurological injuries, 14% of participants had loss of consciousness (LOC) during presentation at the emergency centres which was recorded using the Glasgow coma scale (GCS). A GCS of 12 was recorded in 8% of the participant. Le Fort II and zygomatic complex injuries were the commonest. Patients with GCS less than 9 suffered panfacial and Le Fort III injuries with indications of delirium, disorientation, vomiting and Cerebral Spinal Fluid (CSF) rhinorrhea[11]. Similarly, Rajendra et al. (2009) in a study of cranio-facial trauma at Mangalore reported that patients in the 2nd to 4th decades (79%) were commonly injured and the female to male proportion was 1:8.09. [12] RTAs (54%) were the leading cause of craniofacial trauma followed by falls from heights (30%) while loss of consciousness having been the commonest clinical symptom (62%). The zygoma was the commonest fractured facial bone at 48.2% (21.2%). Most patients had mild head injury with reported intracranial injury comprising of such injuries as compound depressed fractures, contusion and intracranial haemorrhage.

Several aetiological studies have been undertaken to describe patterns of injuries as well as associated injuries, for instance, Padmanaban et al. (2017) in a 2-year retrospective Indian study reported a prevalence of 12.5% of MFIs, males were the majority affected and in the 21-30-year-old age group[13]. RTAs were the primary aetiological factor. Among the maxillofacial fractures, the mandible was most frequently involved followed by the midface, particularly the zygomaticomaxillary complex region with head injury making up 72.9% of the majority. In a Kenyan study by Guthua et al. (1990) on analysis of 355 cases with fractures of the mandible it was reported that 74.9% of the cases were due to interpersonal violence and 13.8% were caused by road traffic accidents. The men to women ratio was 8.4:1 and 75.5% of the fracture cases had single fractures while 24.5% had multiple fractures. In cases with a single fracture, the most commonly involved mandibular site was the body (42.2%). The angle of mandible was most frequently fractured (50.5%) in cases with multiple

fractures.[11] Teshome et al. (2017) undertaking a study in Ethiopia that reported maxillofacial trauma was majorly caused by interpersonal violence with the mandible having been the most affected facial area[14]. Head and neck concomitant injuries accounted for 31.65% of the casualties. Deogratius et al. (2006) in a Tanzanian study reported that interpersonal violence was the commonest cause of MFIs, with most of them occurring in males and in the 2nd decade of life[15]. The mandible was the commonly injured bone while Lefort I level of injury was the commonest maxillary fracture. Another prospective hospital based study of MFI patients reported that RTAs were the common cause of injury[16]. Soft tissue and mandibular injuries were the commonest types of injury with an association of 53.1% of head and neck injuries. These four studies demonstrate that aetiology and prevalence of MFIs varies based on the geographical location. A critical review of these studies shows that patterns of MFIs in association with THIs is an area that requires more comprehensive studies. Another study by Akama et al. (2007) on the pattern of maxillofacial and associated injuries following RTA reported that 89.6% of the non-fatal casualties had soft tissue injuries in the craniofacial region with 69.2% comprising of facial injuries among which 5.1% of the non-fatal injuries had maxillofacial fractures[17]. This study sought to only assess injuries associated with RTAs. It is helpful in the current study on the pattern of MFIs in THIs as it gives an insight into the baseline prevalence of MFIs in a Kenyan population as at the time of the study.

In 2012 a cross-sectional study conducted at the Kenyatta National Hospital (KNH), by Edalia et al. (2012) it was reported that 32.7% of the patients attended to had come in with MFIs[18]. Among patients with MFIs, facial soft tissue injuries (STIs) were 81.7% whereas facial fractures in isolation were 18.2%. Facial fractures in combination with STIs comprised 26.7% and those with associated head injuries were 36%. Another study by Tuganeiyo et al. (2012) reported that the 21-30-year-old age group was commonly afflicted with MFIs[19]. RTAs were responsible for majority of the injuries. Mandibular injuries constituted 62%, mid-face at 24%, and pan-facial injuries at 14%. Head injury was the most prevalent associated injury. This study attempted to explore all the associated traumatic injuries. However, it did not major on any particular area as the current study.

In a study by Nyameino et al. (2018) to assess the pattern of motorcycle-associated MFIs reported that those studied constituted STIs at 98% and hard tissue injuries (HTIs) at 63.7%[20]. HTIs constituted midface fractures (38%), mandible (15%), and dentoalveolar (18%), with STI comprising of moderate lacerations (37.4%) and through-and-through perforations

(33%). The midface was the commonly injured area (38%). Maxillary fracture type distribution was mostly Le Fort II(14.3%) and Le Fort I (5.5%). Combined MFIs and THIs constituted 40% of the cases. In a study by Ndungu et al. (2017) on the assessment of the pattern and management of paediatric MFIs at KNH it was reported that there was a prevalence of 29.8% of such injuries[21]. The main cause of MFIs was accidental falls among whom 31.4% presented with facial fractures with a majority having been fractures of the mandible. Few cases of pediatric age group facial fractures are reported and this is attributed to the underdeveloped facial skeleton, deformable structure of facial bones, protection of the zygomatic areas by the prominent buccal fat pad, lack of pneumatization of the paranasal sinuses, and lack of an erupted dentition[22]. Associated THIs were reported at 23%.

Other rare occurrence aetiological studies undertaken such as the study by Odhiambo et al. (2002) at the Kenyatta National Referral and Teaching Hospital in Nairobi it was found that of the 290 bomb-blast survivors, 78% had sustained one or more maxillofacial injuries. Soft-tissue injuries (cuts, lacerations or bruises) were the most common, constituting 61.3% of all injuries in the maxillofacial region; 27.6% had severe eye injuries, while 1.4% had fractures in the cranio-facial region.[16]

1.3 Maxillofacial Injury Classification

Several classification systems have been described. Traditional classification systems have described MFIs in an isolated manner but have not taken into account concurrent injuries to the head as a body region. One of the classification systems divides the face arbitrarily into horizontal facial thirds (transfacial), the upper third comprising of the frontal bone, the mid third made up of the maxilla, zygoma, orbits, nose and the lower third comprising of the mandible[23].

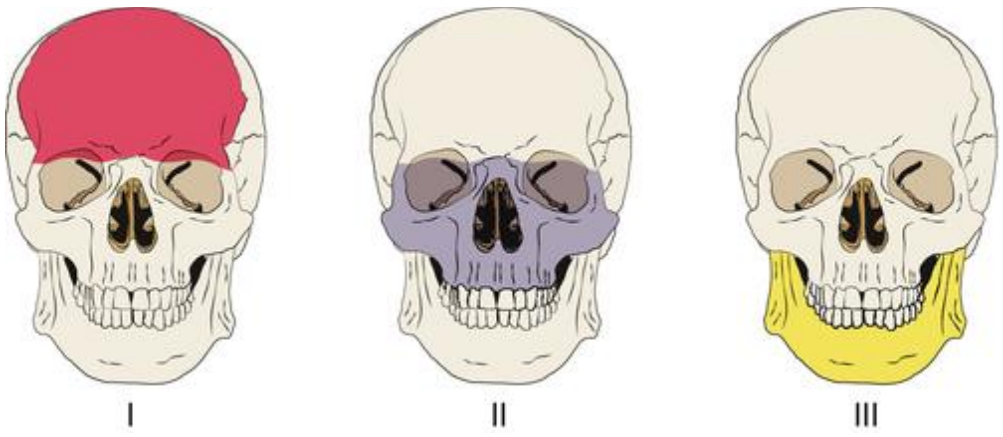

Fig. 1 Facial Zones: Upper Face-I, Midface-II, Lowerface-III. Adapted from Vujcich.[7]

Other existing systems that have been used to classify MFIs include systems such as the Le Fort Classification of Midface/Upper Jaw fractures[24], Duke classification system for the hierarchical ordering of facial fractures[25]. Other isolated systems have also been described such as the medial orbital wall classifications[26] and the zygomatic fracture classification systems[27]. Manson et al. (1990) suggested a non-unified typology of nasal, zygoma, Le Fort, nasoethmoidal, frontal sinus and frontal bone fractures[28]. Cooter and David (1989) recommended the need of a more wide-ranging method of classification to include the cranial component of craniofacial injuries[29]. A major setback of the Cooter and David's classification, apart from its difficulty and extension, is the overlap of facial and cranial areas such as the orbital walls and the pterygoid plates which lack direct anatomic delineation. Buitrago-Téllez et al. (2002) suggested a midfacial/craniofacial fracture classification method that is organised into triads similar to the scheme developed by AO[30]. In the researchers opinion this system allows a comprehensive categorization of injuries. This AO-similar classification system is reported to enable users categorize with ease bone injury in the craniofacial area. Skull-base fractures are also easily classified in this system. Some drawbacks of this system are that it requires users to have prior knowledge of the Müller et al. (1990) AO classification method[31]. The system has also not factored in the lower third of face fracture patterns nor the involvement of STIs.

In the assessment of MFIs, severity scores have also been established though the scope of this study shall not include such reviews. Some of the known severity scores include the facial injury severity score (FISS)[32], MFI severity score(MFISS)[33]. Craniofacial trauma scoring systems have their pros. Mostly, they allow for ease of communication in a standardised and uniform way in the care of patients. Injury scales do also serve to assist care givers explain the nature and extent of injury in a predictive manner to patients.

1.4 Traumatic Head Injury

This is defined as non-degenerative, non-congenital damage to the intracranial contents from an extracranial mechanical form of energy.[34] An alternative description of THI can be stated as a mixed pathological entity comprising of a group of injuries such as cerebral contusions, epidural hematoma (EDH), subdural hematoma, subarachnoid hemorrhage (SAH) and diffuse axonal injury[35]. According to Centers for Disease Control and Prevention it is reported that THI is caused by a blow, jolt or bump to the head or a penetrating head injury that results in diminished functioning of the normal brain[36]. THI is among the commonest cause of disability and death globally. The clinically reported and pathological elements of THI are

useful for its diagnosis and treatment[37]. According to wide-scale population studies, CNS injury caused over 40% of autopsied cases of violent death and disability caused by brain injury was at 2%[38]. In both developed and developing countries, and in recent years, THI cases have been gradually increasing, and therefore this is one of reasons for the unlimited importance to assess the pattern of MFIs in THI.

1.5 Traumatic Head Injury Classification

THI has been commonly classified by one or more of the following three main systems: a physical mechanism of injury, patho-anatomy of injury, or clinical indices of injury severity and morphology[41-46,95]. Mechanism of injury may be blunt or penetrating trauma. Anatomical classifications may be based on skull fracture types and patterns. Pathological classifications usually involve intracranial typologies of focal or diffuse lesions[96]. Some of the THI classification systems described in clinical application include the brain injury index by Bennet and coauthors (grade I-loss of consciousness to grade IV-brain death)[39], the Glasgow Coma Scale (GCS) as by Teasdale and Jennett[40], Marshall classification of traumatic brain injury[41] and the Rotterdam CT score of traumatic brain injury[42]. The Rotterdam score is a recent system that addresses reported challenges of using the Marshall system such as difficulty in classifying patients with multiple types of injury[43,44,45]. Other advantages of the Rotterdam score is that it can also predict a clinical outcome and also has added variables such as subarachnoid hemorrhage (SAH) that make the system more elaborate to use[46]. In this present study the GCS scoring system was used because of its universal adoption in the assessment of reduced levels of consciousness following trauma and the fact that it provides a standardized way to communicate information about a patient's level of consciousness.

1.6 Concurrent MFI and THI

The prevalence of these type injuries appears to range from 7.6% to as high as 86%[47,48]. The reason for this wide prevalence range can be inferred from the habitual, socioeconomic, and cultural differences that exist in the populations under study in addition to the different injury aetiologies studied or the study methodology applied. It has been hypothesized that MFIs especially midfacial injuries serve to act as shock absorbers minimizing injury to the brain in case of high impact energy trauma. On the contrary, some researchers have reported irrespective of the shock absorption effect of facial bones, the brain still gets to suffer traumatic injury. Other studies have reported that MFIs are a marker of increased risk of THIs[51,52,53,54]. One of the largest studies on the association of THI among MFI patients was undertaken by Mulligan *et al.* (2010). This had over 1.3 million participants from over 700

hospitals. About 67.9% MFI patients had THI among these 29.5% had fractures of the skull, 28.6% had hemorrhage intracranially, 16.9% had brain contusion and 11.2% had concussion with loss of consciousness.[58]

Olubunmi et al. (2020) did a synopsis of the epidemiology and patterns of associated injuries in mild and moderate head injuries in the literature and they concluded that the pattern of associated injuries with traumatic brain injury largely determines the outcome of the patient[55]. A study by Agbara et al. in 2018 reported that RTAs were the commonest cause of MFI, that the major skeletal injuries were Le Fort II fractures, that GCS of 13–15 was the most prevalent and that commonest cerebral injury was intracerebral haemorrhage. The researchers also reported the commonest facial skeletal injury was that of the mid-facial third and that a lower GCS score was associated with fractures of the upper third of the facial skeleton.[57]

From the foregoing reviews of past studies it is evident that MFIs are quite commonly associated with other forms of traumatic injury and it would be important if notable evidence was recorded regarding the association of these injuries among patients with concomitant THIs. The present study was, therefore, designed to demonstrate the patterns of MFIs among patients with THIs as well as attempt to develop a simple classification of these combined injuries.

1.7 Research Problem

Study findings on traumatic injuries have been reported separately and have focused mostly on characterization and description of injuries sustained in the different maxillofacial regions. There lacks consensus on a common classification methodology to be used in describing MFIs in THI. It was, therefore, proposed that in the study of patterns of MFIs among patients with THIs, a simple categorization classification system would be developed to describe the combined injury patterns.

1.8 Study Justification

There lacks a local study in the past decade that specifically reports on the pattern of MFIs in THI patients hence the need to undertake the current study. Further, in observation of the high incidence of MFI in THI in the population, as well as the possibility for neurological morbidity and mortality, the practising maxillofacial and craniofacial surgeon ought to be familiar of these conditions including their management. An elaborate appreciation of the patterns of MFIs in THI will therefore assist healthcare managers to design and to

continuously inform multidisciplinary care protocols between maxillofacial surgeons and neurosurgeons.

Current patterns of injuries and existing classification of MFI and THI exist in isolation which requires a multiple analysis and listing of injuries which could delay decision making during the primary survey of trauma case management. This study therefore attempts to simplify MFI in THI classification and uses defining criteria which can be used globally in all situations, avoiding wherever possible the use of complex methodology and techniques which may not be easy to describe because of existing multiple diagnosis.

Further, the information from this study will be useful in advising on proposals intended for prevention and public education on traumatic maxillofacial and head injury, as well as contribute to the existing body of knowledge in maxillofacial and neurosurgical fields.

1.9 Study Objectives

1.9.1 Broad Objective

This study was aimed to assess the incidence of MFI in THI patients, and to analyse the pattern of MFIs in THIs among patients seen at KNH.

1.9.2 Specific Objectives

1. To assess incidence of MFIs in THI at KNH
2. To analyse the pattern of MFIs in THIs of patients at KNH

2.0 Variables

	Variable	**Measurement**
Sociodemographic variables	Age	Chronological years from date of birth
	Sex	Male, Female
	County	County of Residence
	Aetiology	RTA(automobile,motocycles,bicycles),IPV, Falls, Other
	RTA patient status	Driver,passenger,pedestrian
Independent variables	Maxillofacial Injuries Characteristics	Facial Soft tissues-Open/Closed fracture Fractures on upper face-Frontal bone,Frontal sinus involvement, Nasofrontal duct injury Communition/Noncommunition Depressed/Nondepressed Midface-Orbital,Nasal,Zygomatic Complex,Lefort I,II,III, Palate,Dentoalvolar Communition/Noncommunition Lower face-Mandible symphysis, body, angle, ramus, condyle Communition/Noncommunition
Dependent variables	Head Injury Characteristics	GCS Score from 3-15
		Skull fracture: Vault –Linear/Stellate; Depressed/Non-Depressed Basilar-CSF Leak/Facial Nerve injury
		Intracranial Hemorrhage: Focal-Epidural, Subdural, Intracerebral Diffuse-Concussion/Multiple contusions/Ischemic injury/Axonal Injury,

CHAPTER 2

RESEARCH METHODOLOGY

2.1 Study Design

This was a hospital based descriptive and prospective cross-sectional study.

2.2 Study Site

The study was undertaken at KNH which is a public national referral hospital that also serves as a major trauma management centre. The hospital is situated in an urban setting and caters to serves both urban and rural populations.

2.3 Study Population

All patients with MFIs in THIs who presented for treatment at the Accident and Emergency (A & E), Maxillofacial and Neurosurgical departments from the month of January-June 2022.

2.4 Sampling and Sample Size

The Fisher's formula was used to calculate the sample size as follows[59]:

$n_0=(Z^2P(1-P))d^2$

Where

n_0=sample size

Z value corresponding to 95% confidence level= 1.96

d is precision=0.05

P=proportion of maxillofacial injuries from a previous study*=40%

(The proportion of maxillofacial injuries combined with head injuries, the value of P was estimated at 40% based on the Nyamieno et al., 2014 study at KNH and Mama Lucy Kibaki Hospitals in Kenya)[20]

Therefore,

$n_0=(1.96^2 \times 0.4(1-0.4))/0.05^2=369$

Sample size was adjusted for finite population using the formula below

$$n = \frac{n_0}{1+(n_0- 1)/N}$$

Where:

n=sample size with finite correction

n_0=sample size without finite correction

N=study population

$$n= \frac{369}{1+\frac{(369-1)}{3650^*}} \qquad n=336$$

*From hospital records, KNH attends to an average of 10 patients with MFIs in THI patients every day. This is about 3650 patients in a period of one year. Therefore, 3,650 was chosen as the population under study.

2.5 Sampling Method

A convenience sampling method was applied in this study.

2.6 Data Collection

After being attended to in the respective clinical units, patients were selected for eligibility. Informed consent was acquired for all study participants. Participants were interviewed, examined and had their head and facial computed tomography (CT) scans studied by the researcher as reported by attendant neurosurgeon or radiologist. Quantitative data was then collected in a pre-designed validated questionnaire form (Appendix II) and this included sociodemographic data such as age, gender; aetiology of injury; clinical and radiological data on maxillofacial injury characteristics-on the upper, mid and lower face parts, and hard and soft tissues involved, head injury characteristics, GCS head injury score signs, type of skull

fractures, associated intracranial injuries and imaging findings.

On quality assurance, inter-observer variability was checked by having every 10^{th} patient radiological scans transmitted for reexamination by the supervisor radiologist to ensure reproducibility and validity of all study observations.

2.7 Data Analysis and Presentation

The research assistant aided in quantitative data entry into the MS Excel 2016 system. Statistical analysis was computed using the Statistical Package for Social Sciences (SPSS) version 24.0 software. Data frequencies, means, median and standard deviations were computed on the variables reported. This was recorded in organized tables and charts. Test of significance were interpreted at a *p*-value less or equal to 0.05. An arbitrary use of facial zones and associated GCS scores was used to develop a proposed classification of the combined injuries.

2.8 Inclusion Criteria

All patients who visited the hospital with combined MFIs and THIs and who gave consent or consent was given on their behalf participated in the study.

Patients with full set of clinical and radiographic records including head CT scans were also included in study.

2.9 Exclusion Criteria

Patients without MFI traumatic injuries were excluded from study.

Patients who were seen within the study period but with incomplete medical records were excluded from study.

2.10 Ethical Consideration

Informed consent

The purpose and processes of the study were described, in a language (Kiswahili/English) best understood by the patient, close relatives and/ or guardian. All participants queries were clarified before acquiring an informed consent. Where the participant was unable to consent due to the injury sustained, a close relative or guardian was asked to give consent. In

compliance with Good Clinical Practice (GCP) guidelines, participants without relatives/guardians were excluded from the study.

Confidentiality

All information recorded about participants was treated with strict confidentiality. The data collection instrument (questionnaire form) did not have personal identifiers (e.g. hospital numbers, patients' names, residential address) and documents containing patients' confidential information were not photocopied. Only investigator, research assistanct and the statistician accessed information on the questionnaire.

Ethical Approval

The study was approved by the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (KNH/UON – ERC) reference number P807/10/2021 (Appendix V).

CHAPTER 3

RESULTS

3.1 Socio-demographic characteristics

336 patients with MFIs in THI were studied among the 2160 patients seen in the hospital during the period. This translated into an incidence rate of about 15.6%. The patients' age ranged from 2.8 – 69.0 years with a mean age 30.1years (*SD* = 11.3), a modal age of 29.0 and a median of 29.0 years. The majority 133 (39.6%) of the patients were in the category of 21 – 30-year-olds followed by the 31 – 40-year-olds (111, 33.0%). There were more males at 300 (89.3%) than females at 36 (10.7%) with an overall ratio of 8.3:1. The difference in gender distribution among age groups was statistically significant (*Fisher's* = 19.109, *p* = .001) (Fig. 2).

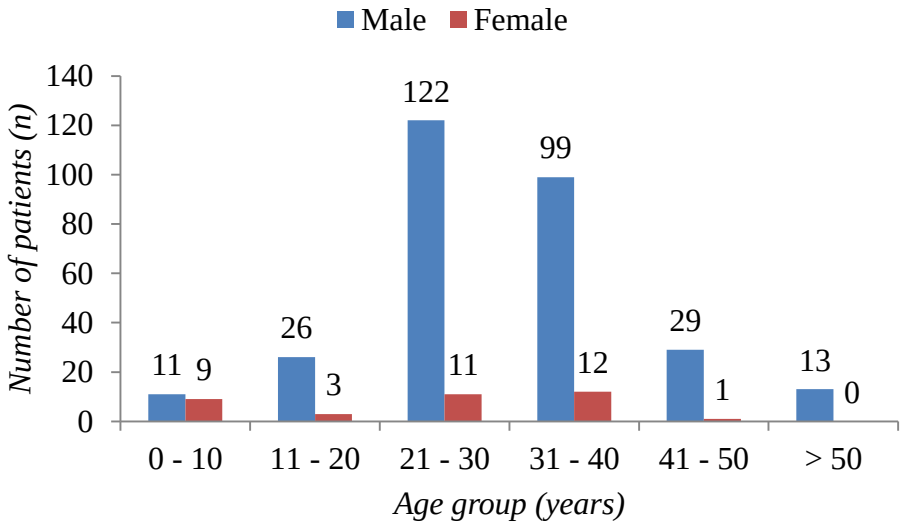

Fig. 2. *Distribution of cases by gender and age groups (n = 336)*

3.2 Aetiology of Injury

The most common aetiology of injury was RTA involving motorcycle crashes (55.4%) followed by automobile accidents (17.9%) and interpersonal violence (15.2%). The peak age groups involved in the majority of MFI in THI were aged 21 – 30 years with 133 (39.6%) followed by 31 – 40-year-olds with 111 (33.0%) cases. The difference between males and females based on the aetiology of injuries was statistically significant (*Fishers* = 21.098, *p* <

.001) inferring that there was a statistically significant association between gender and aetiology of injuries (Table 1).

Table 1. Comparison of patients' aetiology of injury by gender (n = 336)

Aetiology of injury	*n (%)*	*Gender n (%)*	
		Male	*Female*
Overall	336 (100)	300 (89.3)	36 (10.7)
Motorcycles	186 (55.4)	177 (52.7)	9 (2.7)
Automobile	60 (17.9)	44 (13.1)	16 (4.8)
Interpersonal violence	51 (15.2)	44 (13.1)	7 (2.1)
Falls from a height	24 (7.1)	21 (6.3)	3 (0.9)
Bicycle, sports and other injuries	15 (4.5)	14 (4.2)	1 (0.3)
		Fisher's = 21.098***, $p < .001$	

Fisher's exact test was used.
Analysis of variance (ANOVA) test was used.
****where p < .001.*

The patient category commonly involved in RTAs were motorcycle drivers at 170 (50.6%), followed by passengers at 55(16.4%) and pedestrians at 26(7.7%). The difference among RTA patient status within the age groups was statistically significant (*Fishers* = 69.796, $p < .001$) inferring that there was a statistically significant association between the patients' RTA patient category and age groups. The difference between males and females among the patients' RTA status was statistically significant (*Fishers* = 41.873, $p < .001$), inferring that there was a statistically significant association between gender and patients' RTA status.

3.3 Maxillofacial Injury Pattern

The most common MFI involved the mid face at 188 (39.1%) followed by the lower face at 182 (37.8%). The difference between males and females among patients MFI was statistically significant ($X^2 = 18.095$, $p = .021$) inferring that there was a statistically significant association between gender and the patients' MFI. The difference in patients' age among the MFI was also statistically significant ($F = 13.586$, $p < .001$) Table 2.

Table 2. Comparison of patients' MFI characteristics by gender and age (n = 336)

MFI characteristics	*n (%)*	*Gender n (%)*		*Age (years)*	
		Male	*Female*	*Range*	*M ± SD*
Overall	481 (100)	300 (89.3)	36 (10.7)	2.8 – 69.0	30.1 ± 11.3
Upper face	111 (23.1)	99 (29.5)	12 (3.6)	2.8 – 56.0	31.9 ± 10.5
Mid face	188 (39.1)	173 (51.5)	15 (4.5)	5.0 – 69.0	32.1 ± 10.3
Lower face	182 (37.8)	159 (47.3)	23 (6.8)	3.0 – 68.0	29.4 ± 11.7
		X^2 = 18.095**, p = .009		F = 13.586***, p < .001	

Chi square test was used.
Analysis of variance (ANOVA) test was used.
****where p < .001; There's less than 1 in 1,000 chances of being wrong.*
***where p < .01; There's less than 1 in 100 chances of being wrong.*

Among the upper face MFI charateristics, there were 76 cases (23.0%) with open STIs, frontal bone involvement with fractures was at 27.2%. Among the fracture patterns on the upper face, communited fractures were 19.3%, and depressed fractures at 15.4% (Fig. 3).

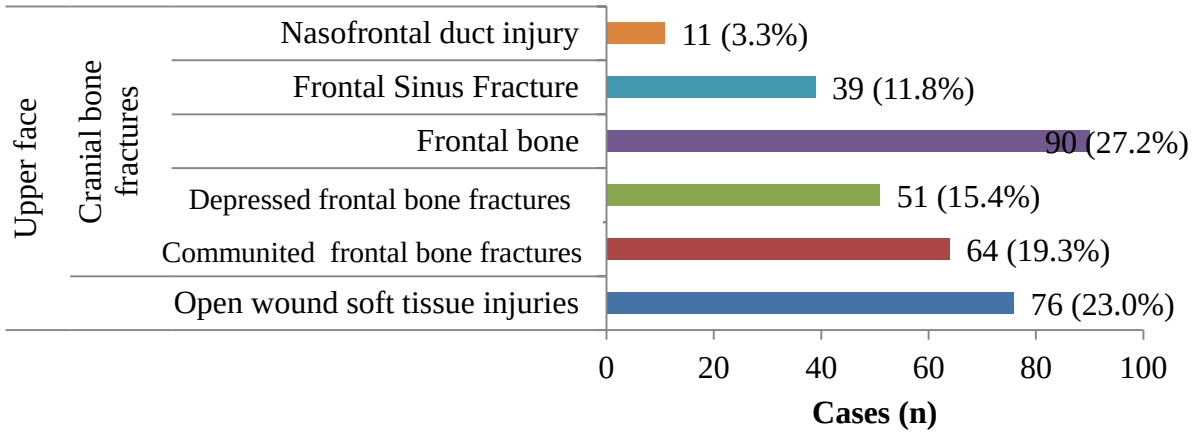

Fig. 3. *Distribution of upper face maxillofacial injuries by type*

Some of the maxillofacial injury characteristics observed are as shown in Fig. 4,6 and 8.

Fig 4. *Upper face injury, fracture of frontal bone*

Amongst the mid face MFI characteristics, there were 89 (13.4%) open STIs, with the zygoma bone with the zygomatic arch fracture (14.8%) having been the commonest zygomatic complex injury. Orbital fractures were the commonest (23.2%) fractures involving the maxilla and mid-face component while tooth avulsion was the most common dentoalveolar injury (Fig. 5).

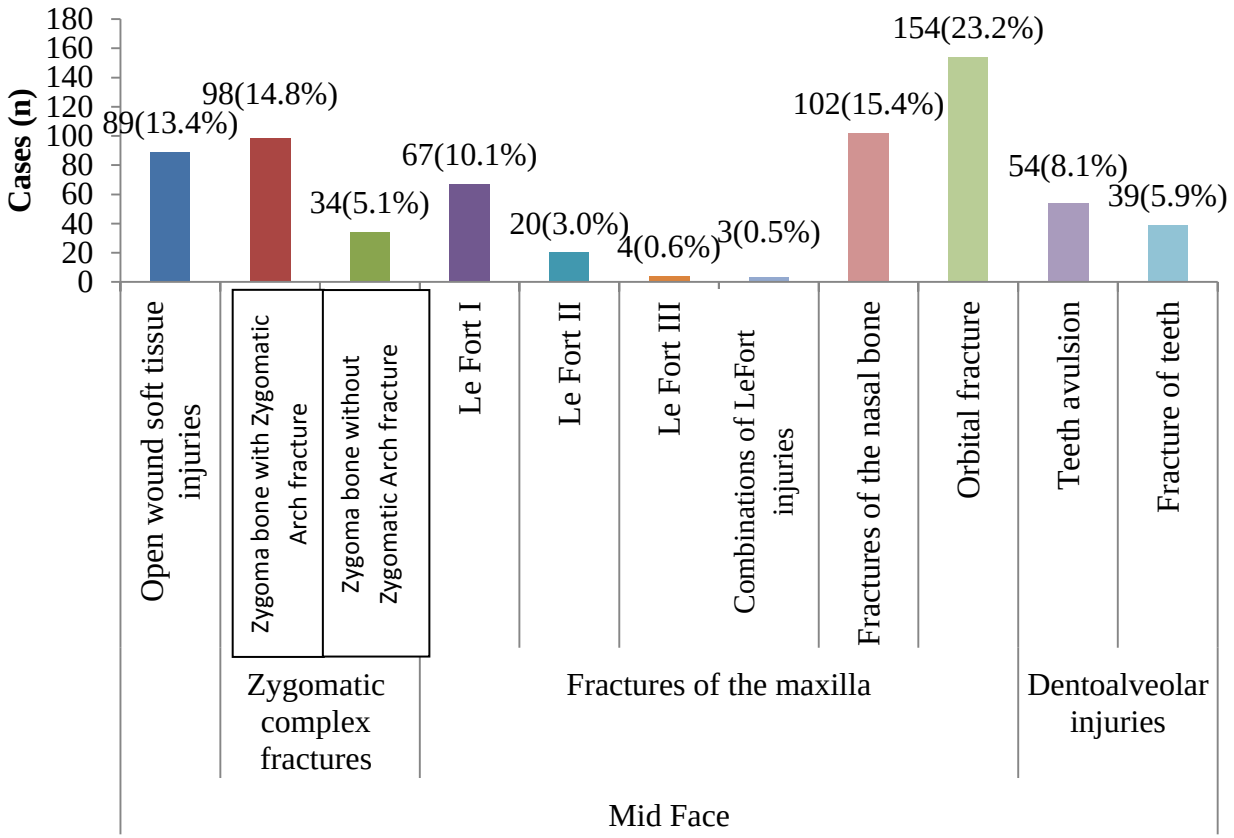

Fig. 5. *Distribution of mid face MFIs by site and type of injury*

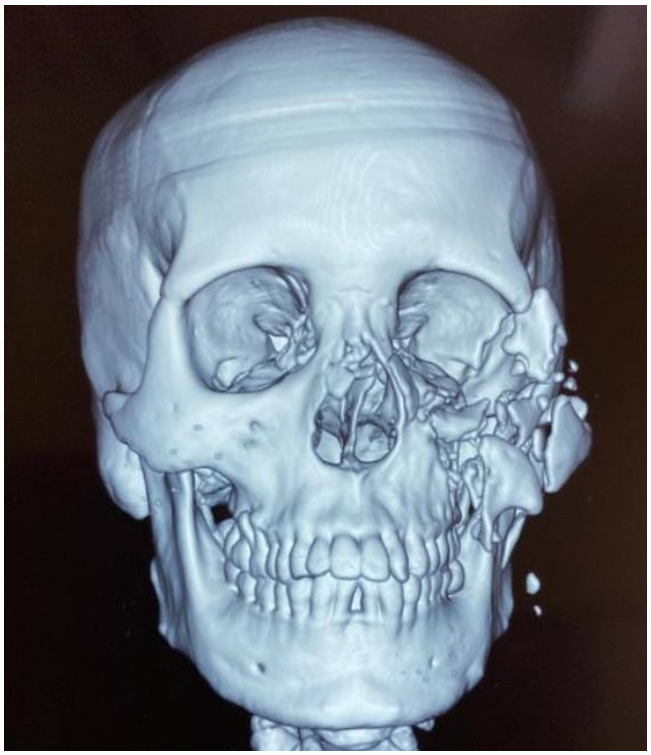

Fig 6. *Mid face injury, fracture of zygoma*

Amongst the lower face MFIs, there were 149 (28.2%) open STIs with the parasymphysis (20.2%) having been the commonest fractures of the mandible. Tooth avulsion (10.6%) was the most common dentoalveolar injury (Fig. 7).

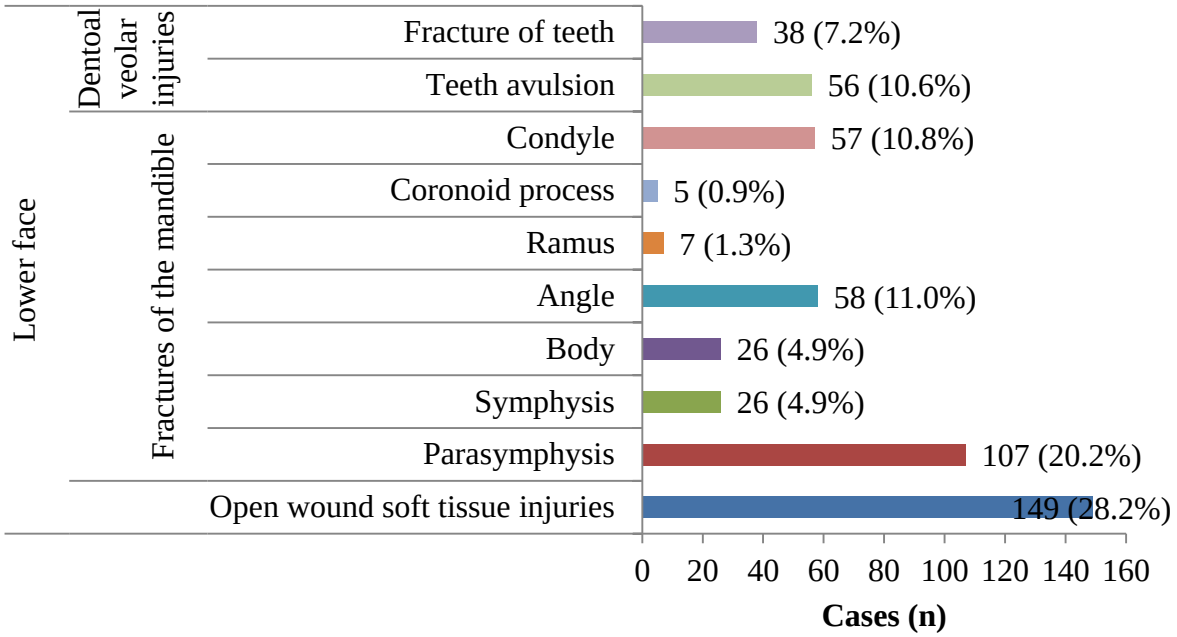

Fig. 7. *Distribution of lower face maxillofacial injuries by site and type*

Fig 8. *Lower face injury, fracture of mandible*

Among the paediatric patients (<18years), the lower face (64.9%) followed by the mid face (32.4%) were the commonest involved facial zones.

3.4 Head Injury Characteristics

The most common head injury category was loss of consciousness 91(27%) with vomiting having been at 52 (15.8%). The peak age groups involved were the 21 – 30-year-olds with 35 (35.4%) followed by the 31 – 40-year-olds at 32 (32.3%). The difference between males and females was statistically significant (*Fishers* = 7.173, $p < .001$), inferring that there was a statistically significant association between gender and head injury characteristics. Most common GCS was mild (94.3%) followed by moderate (5.1%). The peak age groups of patients with mild GCS (13-15) were the 21 – 30-year-olds with 133 (39.6%) cases followed by the 31 – 40-year-olds with 111 (30.0%) cases. A mild GCS was associated with lower face injuries at 174 (51.8%) followed by mid-face injuries while in moderate GCS with mid-face injuries was at 14(4.2%) followed by those of the upper face injuries at 12(3.6%), and the severe GCS was associated with both the upper and mid-face injuries at 2(0.6%).

The most common MFI and THI GCS classification among the paediatric participants (<18years) was mild GCS classification at 36 (97.3%) with no case of severe GCS classification.

While most patients (72.3%) did not have skull fractures, the most common fracture amongst those who had skull injuries (27.7%) was vault fractures at 86 (25.6%) followed by basilar fractures at 7(2.1%). The peak age group affected was the 31 – 40-year-olds with 37 (11.0%) followed by the 21 – 30-year-olds with 29 (8.6%) cases. The difference in skull fracture cases among the age groups was statistically significant (Fisher's = 28.085, p = .002) inferring that there was a statistically significant association between skull fractures and age groups. There was also a statistically significant difference in patients' age among skull fracture cases (F = 4.744, p = .009).

The most common vault fracture was the comminuted type at 54 (38.0%) followed by the depressed ones at 45(31.7%). The peak age group affected was the 31 – 40-year-olds with 36 (42.4%) followed by the 21 – 30-year-olds with 27 (31.8%) cases. The difference between males and females among the vault fracture cases was statistically significant (*Fishers* = 6.362, p = .006) inferring that there was a statistically significant association between gender

and vault fractures (Table 3). Some of the head injury characteristics observed are as shown in Fig. 9 and 10.

Table 3. Comparison of patients' vault fractures by gender and age (n = 336)

Vault fractures		*Gender n (%)*		*Age (years)*	
	n (%)	*Male*	*Female*	*Range*	*M ± SD*
Overall	142 (100)	76 (89.4)	9 (10.6)	2.8 – 69.0	30.1 ± 11.3
Depressed	45 (31.7)	40 (47.1)	5 (5.9)	9.0 – 55.0	33.8 ± 9.7
Communited	54 (38.0)	47 (55.3)	7 (8.2)	9.0 – 55.0	33.3 ± 9.3
Linear	36 (25.4)	34 (40.0)	2 (2.4)	3.0 – 58.0	33.4 ± 11.8
Stellate	7 (4.9)	6 (7.1)	1 (1.2)	24.0 – 47.0	36.4 ± 9.3
		Fisher's = 6.362**, *p* = 0.006		*F* = 0.886, *p* = .349	

Fisher's exact test was used.
Analysis of variance (ANOVA) test was used.
***where p < .01; There's less than 1 in 100 chances of being wrong.*

Fig 9. *Skull vault communited fracture*

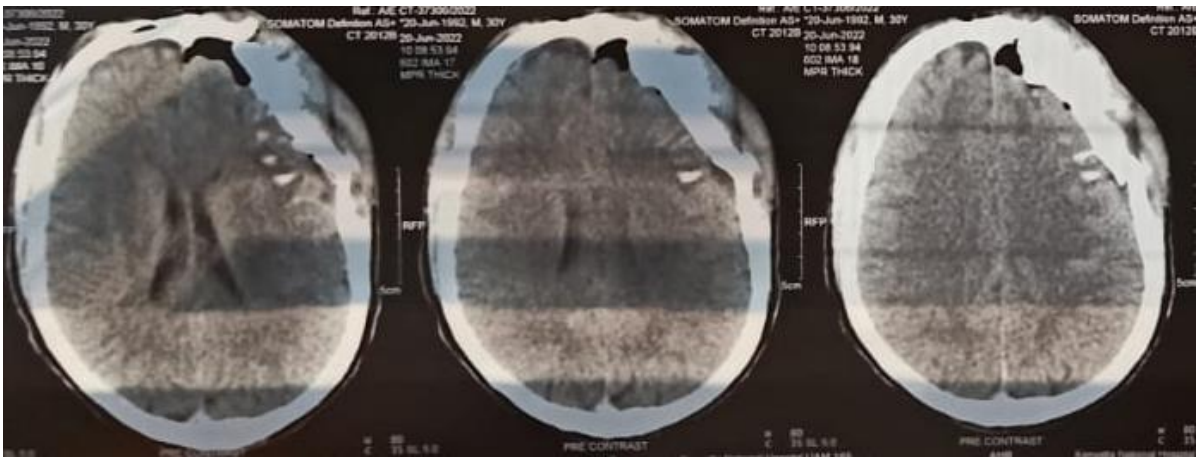

Fig 10. *Intracranial hemorrhage*

Amongst patients who had basilar fractures, there were 5 (71.4%) cases of cranial number 7 deficits and 2 (28.6%) cases of CSF leak. The most common intracranial lesion was the diffuse type 264 (78.6%). The peak age group affected was the 31 – 40-year-olds with 14 (38.9%) followed by the 21 – 30-year-olds with 12 (33.3%) cases. There was a statistically significant difference in patients' age among intracranial lesion cases (F = 4.611, p = .011) (Table 4).

Table 4. Comparison of patients' intracranial lesions by gender and age (n = 336)

Intracranial Lesions		*Gender n (%)*		*Age (years)*	
	n (%)	*Male*	*Female*	*Range*	*M ± SD*
Overall	336 (100)	300 (89.3)	36 (10.7)	2.8 – 69.0	30.1 ± 11.3
None	35 (10.4)	31 (9.2)	4 (1.2)	2.8 – 55.0	27.9 ± 11.9
Focal lesions	37 (11.0)	35 (10.4)	2 (0.6)	16.0 – 58.0	35.1 ± 9.6
Diffuse lesions	264 (78.6)	234 (69.6)	30 (8.9)	3.0 – 69.0	29.7 ± 11.3
		Fisher's = 1.047, *p* = .599		*F* = 4.611*, *p* = .011	

Fisher's exact test was used.
Analysis of variance (ANOVA) test was used.
**where p < .05; There's less than 5 in 100 chances of being wrong.*

Among the focal lesions, the commonest lesion comprised epidural lesions (68.9%), while concussion (78.0%) was the commonest lesion among patients who had diffuse lesions (Fig. 11).

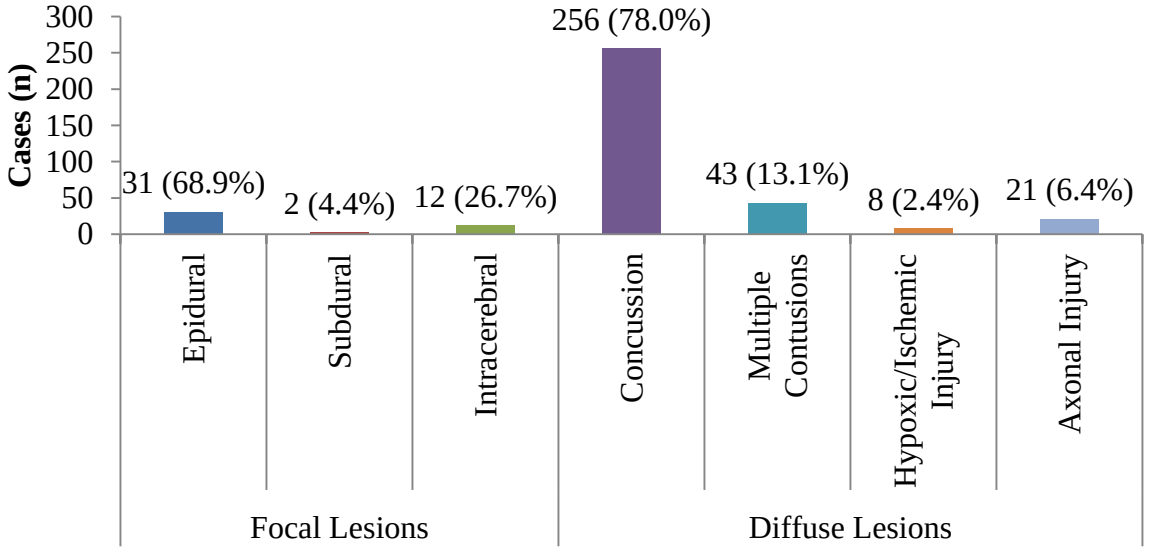

Fig. 11. *Distribution of intracranial lesions in patients with traumatic head injury*

3.5 Classification of combined maxillofacial and traumatic head injury

This study sought to arbitrarily classify zones of the face into horizontal thirds and relate the same with the GCS clinical index of THI. Seven categories of combined anatomical facial zone injuries were observed (Type 1-7) from the data set which were all distributed across mild, moderate and severe head injury scores (Type A,B,C). Type 1A injury as categorized includes the upper face and a mild GCS score. Accordingly, all severe head injury score categories would indicate more combined traumatic injuries. Further statistical analysis among the injury categories would need to be undertaken to demonstrate more clinical patterns among the groups.

Table 5: Classification patterns of combined maxillofacial and traumatic head injury (n = 336)

Combined Injury Classification	*Maxillofacial Injury (Zone Frequency)*	*n (%)*	*Head Injury (GCS Score Frequency)*	*n (%)*
Type 1 A	*Upper Face*	111(33.0)	*Mild*	97(28.9)
Type 1 B	*Upper Face*		*Moderate*	12(3.6)
Type 1 C	*Upper Face*		*Severe*	2(0.6)
Type 2 A	*Mid Face*	188(56.0)	*Mild*	172(51.2)
Type 2 B	*Mid Face*		*Moderate*	14(4.2)
Type 2 C	*Mid Face*		*Severe*	2(0.6)
Type 3 A	*Lower Face*	182(54.2)	*Mild*	174(51.8)
Type 3 B	*Lower Face*		*Moderate*	7(2.1)
Type 3 C	*Lower Face*		*Severe*	1(0.3)
Type 4 A	*Upper &Mid Face*	61(18.2)	*Mild*	49(14.6)
Type 4 B	*Upper &Mid Face*		*Moderate*	10(3.0)
Type 4 C	*Upper &Mid Face*		*Severe*	2(0.6)
Type 5 A	*Mid & Lower Face*	80(23.8)	*Mild*	73(21.7)
Type 5 B	*Mid & Lower Face*		*Moderate*	6(1.8)
Type 5 C	*Mid & Lower Face*		*Severe*	1(0.3)
Type 6 A	*Upper & Lower Face*	27(8.0)	*Mild*	21(6.3)
Type 6 B	*Upper & Lower Face*		*Moderate*	5(1.5)
Type 6 C	*Upper & Lower Face*		*Severe*	1(0.3)
Type 7 A	*Panfacial*	23(6.8)	*Mild*	17(5.1)
Type 7 B	*Panfacial*		*Moderate*	5(1.5)
Type 7 C	*Panfacial*		*Severe*	1(0.3)

Mild; 13 – 15 GCS
Moderate; 9 – 12 GCS
Severe; <= 8 GCS
Panfacial=Upperface, midface,lower face

3.6 Intra-rater and Inter-rater Analysis

Ten percent of questionnaire forms were filled by both radiology specialist and the PI. Cohen's (κ) kappa for intra-rater and inter-rater reliability and validity test was run to determine the level of agreement for MFIs, THIs and GCS scores. There was an overall statistically significant perfect agreement scores, κ = 0.947 (95% *CI*, 0.126 to 0.698), p = .017.

CHAPTER 4

DISCUSSION

336 patients with concurrent MFIs and THI were identified from the 2,160 cases who presented at the hospital for intervention during the study period. This was an incidence rate of about 15.6%. It has been demonstrated that MFIs are amongst the common type of injuries in trauma with incidence rates of about 40 to 60% and wide variations in different countries[60]. The chances of head injury increase by 1.5 times in a patient with MFI[61]. The large variability in reported incidence and aetiology has been attributed to variety of contributing factors including environmental, cultural and socioeconomic factors[19,64,73-75]. The low incidence rate in the present study could probably be attributed to the shorter period of undertaking of the investigation and time of month when data was collected or other confounders that are not expressly observable. In the present study the commonest affected age was the 21-30-year-olds category which is similar to other studies[9,12,13,15,19,20]. Applicable inference would be to state that persons aged between 20-40years are the most commonly affected in MFI category[12]. Males were affected more than females at a ratio of 8.3:1 which is a similar pattern as was observed in an Asian study which had a male to female ratio of 8.09:1[12]. East African studies have reported male to female ratio of 4.6:1[19] and 5:1[20]. A higher incidence rate of 16.9:1 has also been reported by Adekeye et al. (2003) in Nigeria[67]. It, therefore, can be concluded that the male gender is commonly afflicted with MFIs[13,17,18,65,70,78]. The likely postulation as to why males are commonly involved in trauma would be because of their involvement in most outdoor socioeconomic activities and the generally physically aggressive nature that exposes them to violence[64,65,71]. In the present study most of the MFIs in THI were as a result of RTA and motorcycle crashes at 186 (55.5%) which is a similar finding as that reported by Akama et al (2007) where it was observed that 69.2% of patients involved in RTA had MFIs[17]. Most other studies have also generally reported that RTA is the leading cause of MFI injuries[9,10],[12,13,19,65].[66].

In the present study the upperface was least affected (32.44%) compared to the other facial zones. The commonest injury in the upper face involved the frontal bone (26.8%). This was close to the comparative finding of the study undertaken by Nyamieno et al. (2014)[20].Another study reported a rate of 7.1% involvement of the frontal bone[97]. The lower incidence could be attributed to reduced rates of RTAs[98]. The present investigation found that the midface was

the most commonly involved zone of the face (58%) which is similar to findings by Nyamieno et al. (2014) that reported the midface as the most commonly affected zone[20]. The present findings also indicate that the zygoma with the zygomatic arch involvement was the commonest part affected at 14.8% which is similar to the findings of other studies[10,12, 20,65,79]. Similar to the present findings, Kalathil et al. (2021) found that the prevalent type of fracture reported involved the middle third of the face, followed by the lower third[65]. This could be postulated to be due to the existence of "crumble zones" of the mid-face which absorb forces and act as a cushion for forces transmitted to the cranium that protect the brain and spinal cord[65].

Lefort I type of midface fractures were found to have been the commonest at 19.9%. This is similar to findings reported by Manodh et al. (2012)[10]. This is, however, different from the finding by Nyamieno et al. (2014) who reported Lefort II as the commonest type of midface injuries among motorcycle crash victims[20]. Orbital fractures reported in this study were at 154 (23.2%) which is a similar finding as was observed by Manana et al. (2017)[78]. The infraorbital wall and floor were the commonly affected sites which concurs with Goelz et al. (2021) who reported that single- or two-wall fractures of the orbit were prevalent; and that the orbital floor was commonly affected[81].

In this study the lower face was the second most affected zone of the face at 53.8% after the mid face zone. The mandibular body and parasymphyseal fractures were also the commonest at 20.2% which is similar to what was observed by Manodh et al. (2012)[10] and Nyamieno et al. (2014)[20]. Multiple other studies have reported varied mandibular fracture patterns based on the various aetiological factors[4,8,9,65,77,79,80]. Kar et al. (2012) made the proposition that increased fractures of the mandible resulted owing to patients reflexively turning to their side when there is a sudden impact directed to the face. This presented the mandible as the first bone to directly meet the traumatic force. Other related propositions are associated with the fact that the mandible is the most mobile part in the facial region and the fact that it has less bony support than the maxilla[80].

STIs were common in all facial zones in this study with the upper face at 22.62%, midface at 26.49% and lower face at 44.3% which is similar to findings in other studies[10,14,18]. Subclassification of associated STIs in MFI was done by Nyamieno et al. (2014) who reported that moderate lacerations were at 37.4% and through and through soft tissue perforations were at 33%[20]. Manodh et al. (2012) reported that STIs occurred more in road

traffic accidents with the upper lip as the commonest site of injury[10]. In the present study dentoalvoeloar injuries were common with tooth avulsion at 16.7% and tooth fractures at 11.3% which concurs with findings observed by Nyamieno et al. (2014) [20] and higher incidence rates having been reported by Gassner et al. (2003)[82,83].

Associated Head Injury Patterns

The closeness of maxillofacial bones to the cranium suggests that there are chances of cranial injuries occurring simultaneously[58,84,85]. The current study applied the GCS THI classification system according to Teasdale and Jennett in 1974 [40]. In this study 317(94%) of all the cases observed had a mild GCS which is similar to that reported by Agbara et al. (2018)[57]. Paediaric cases in our study also had a mild GCS score at 36(97.3%) which is a similar finding by Joshi et al. (2018)[86]. Though specific head injury scores were not reported, increased prevalence of head injury in MFI was reported by Tuganeiyo et al. (2012)[19]. A study by Manana et al. (2017), reported that head injury (33.3%) was the most prevalent concomitant injury involved in MFIs[78]. Nyamieno et al. (2014) reported a higher incidence of 40% of concomitant head injuries[20]. Paediatric incidence of associated head injuries has been reported as 23%[21]. All these highlight the important need of having to study MFIs in THI patients. The present study reported that the upper face at 0.6% and midface at 0.6% zones were associated with a severe GCS score (less than 8) compared to the lower face zone(0.3%). It was also noted that 27% of patients had a history of loss of loss of consciousness. This is a higher incidence compared to Manodh et al. (2012) who reported that 14% of patients reported loss of consciouness[10]. A higher incidence of loss of consciousness of 62% was reported by Rajendra et al. (2009) in study done in India[12]. A moderate GCS score was reported in Lefort II and zygomatic complex fractures with severe GCS scores associated with panfacial and Lefort III fractures[10]. Joshi et al. (2018) reported that there was increased risk of head injury with increase in the number of fractures[86]. This fact has been disputed by Davidoff et al. (1988) who did not find any increased risk of head injury with an increase in the number of fractures. In their study it was presumed that there might have been a correlation between increased forces and rotational components to the cranial vault with an increased number of fractures to the facial bones[92].

Diffuse intracranial injuries were at 78.6% and this was characterized by concussions at 76.2%. In a study by Joshi et al. (2018) it was reported that among all the patterns of head injury, concussion accounted for 38.46% as the most common head injury associated with

maxillofacial trauma[86]. Various other studies show concussion with normal brain study (closed head injury) to have been more frequently associated with facial fractures [87-91]. In the present investigation the commonest focal injuries were epidural hematomas at 9.23%. A lower incidence rate has been reported by Joshi et al. at 6.41%[86].These findings are, however, lower than the study findings by Mulligan et al. (2010) who reported that intracranial hemorrhage was at 28.6% in a trauma study of 1.3million patients in more than 700 hospitals across the USA[58].

Further analysis of the present data elicited statistically significant associations between upper and mid face MFIs and GCS among patients. Lower face MFIs were not statistically significantly associated with patients' GCS. Similarly it was determined that the difference between males and females among the THI characteristics was statistically significant inferring that there was a statistically significant association between gender and head injury characteristics. While most patients (72.3%) did not have skull fractures in the present study, Mulligan et al. (2010) reported that 29.5% of trauma cases had skull fractures[58]. In the present study the most common fracture amongst those with skull fractures (27.7%) was found to have been vault fractures at 25.6% and the age group 31 – 40-year-olds was the most predominantly associated with skull fractures. These findings are similar to what was observed by Joshi et al. (2018)[86].

Various systems of classification have been used to classify the two types of injuries, MFI and THI[41-46,24-34,93,95,96,99]. In this study an arbitrary categorization of MFIs in THI is developed based on definite clinical observations and radiological findings. Horizontal facial thirds are matched with the GCS scores. The resulting categories of combined injuries is then reported as seven (7) facial zones which are co-related with the 3 GCS scores to propose a diagnostic, prognostic and treatment planning classification system. Interpretation of the classification system is for instance as follows: Type 1A injuries refer to the upper face injuries with mild GCS, whereas Type 7A refers to panfacial injuries with mild GCS. This classification system is easy and simplified, and applies the findings reported by Manson et al. (1990)[28] as well as other trauma studies[51,57,77,99.] The proposed classification system can however be improved on and be peer-reviewed to make it more robust to address some of the study limitations which included the fact that this was a single-centre study with challenges in data collection over in 24 hours at all the study areas conflated with lack of adequate methodologies in literature to classify combined MFIs in THI.

CONCLUSIONS

1. There was a significant number of MFIS among patients with THI at 15.6%, with the commonest gender affected having been male, at male to female ratio of 8.3:1, and age group 21-30year olds at 133 (39.6%) cases.
2. Commonest aetiology of injury was RTC at 186 (55.4%) cases and involving motorcycle drivers at 170(50.6%) cases.
3. The developed classification of combined injuries is a useful practical and simple system that may be used in case diagnosis and treatment planning.

RECOMMENDATIONS

1. Based on the high incidence rate and observed trauma patterns in concurrent MFIs and THI, specialized institutions should review existing multidisciplinary management protocols to provide for adequate resource allocation in the care and management of combined injuries.
2. There is a great need for continuous education and public health policies on road accidents in order to prevent and reduce incidence of MFIs and THI among the males of 21-30 years age group especially those using motorcycles.
3. The developed classification of combined injuries should be considered as a possible mode of classification of MFIs in THI. Future studies involving multiple centers and larger sample sizes may be conducted to improve on present study findings, limitations and injury classification methodology.

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APPENDICES

APPENDIX I PATIENT INFORMATION

Appendix Ia: Consent information document [English]

CONSENT INFORMATION DOCUMENT

Study topic: Pattern of maxillofacial injuries in traumatic head injury patients at Kenyatta national hospital

Principle investigator: Dr David Kahura Mundia

Background.

In Kenya, there exists no studies done on pattern of maxillofacial injuries in traumatic head injuries patients. This study, therefore, seeks to establish medical evidence about the pattern of maxillofacial injuries in traumatic head injuries patients seen at Kenyatta National Hospital (KNH). This information will be used in formulating measures to mitigate the burden of maxillofacial and traumatic head injuries among patients as well as aid in traumatic injuries diagnosis, treatment and prevention.

Objectives of the study

i. To assess incidence of maxillofacial injuries in traumatic head injury patients at KNH

ii. To analyse pattern of maxillofacial injuries in traumatic head injury of patients seen at KNH

iii. To classify combined maxillofacial and traumatic head injury.

Right to Withdrawal and Voluntary Participation.

Participation in the study is voluntary, this means, patients reserve the right to take part in the study. Even after opting in, participants have the right to opt out of the study at any time, if they wish to. Information collected, thus far, shall not be used in the study. Declining to participate or withdrawal from the study will not result in any penalty or loss of benefits to which the patient is otherwise entitled, including treatment and care.

Confidentiality. All the information used in the study will be handled with strict confidentiality, and shall only be used for the purposes of this study. Participants' names and hospital numbers shall not be used and none will be published. However, knowledge gained from this study shall be shared with other experts throughout the world through conferences and publications.

Benefits and Expectations of participation. There are no direct benefits (financial or otherwise) to the individual patient for taking part in this study. However, the results of the study will be vital in the creation of a body of evidence in the management of combined maxillofacial and traumatic head injuries. Participants shall be engaged in the study for a duration of about 15minutes during the data collection exercise.

Risks of participation. This study will not alter, or interfere with, the course of patient treatment. Therefore, no physical or mental injury is anticipated to result from participating in this study.

Cost of treatment. No extra cost will be incurred for participating in this study. However, the normal cost of treatment [including necessary investigations] at KNH shall apply and will be borne by the participating patient.

Signature ……..

Principal Investigator: Dr David Kahura Mundia

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Lead Supervisor: Dr Walter Odhiambo, Chairman, Dept of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine at The University of Nairobi Dental Hospital P.O. Box 30197 Nairobi

UON/KNH, Research, Ethics and Standards Committee, University of Nairobi, College of Health Sciences P.O. Box 1976-00202 Nairobi. Tel. 020 2726300 ext. 44355

Appendix Ib: Consent Certificate [English]

CONSENT CERTIFICATE

Study Topic: Pattern of maxillofacial injuries in traumatic head injuries among patients at Kenyatta National Hospital

Principal investigator: Dr David Kahura Mundia

I,_____have read/ have been explained to and clearly understand the content of the consent information document. My questions and concerns have been addressed. I hereby DO AGREE [ ] / DO NOT AGREE [ ] to participate in this study.

Signature of participant/ relative/ guardian _____

Signature of witness_____Date_____

Signature of researcher_____Date _____

Investigator's declaration

As the Principal Investigator in this research I declare that:

1. Any change to this protocol and/or procedure shall be notified to the Scientific Steering Committee and effected only after approval by the Ethical Review Committee.

2. The results of this study shall not be published, presented in any journal and/or conference without the written approval of the Chairman, Dept of Oral and Maxillofacial surgery, Oral Medicine and Oral Pathology.

3. Other members of the research team are bound by 1) and 2) above.

_____Date_____

Principal Investigator's Signature

For further information/enquiries/complaints please contact

1. **Principal Investigator Dr David Kahura Mundia at Phone Number 0714 220 120**
2. **Lead Supervisor Dr Walter Odhiambo, Chairman, Dept of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine at The University of Nairobi Dental Hospital P.O. Box 30197 Nairobi**
3. **Chairman UON/KNH, Research, Ethics and Standards Committee on 020 2726300 ext. 44355**

Appendix Ic: Consent information document [Kiswahili]

HATI YA KUKUBALI KUSHIRIKI KATIKA UTAFITI

Mada ya utafiti: Matukio na muundo wa majeraha ya maxillofacial kati ya wanaopata ajali za kuumia kichwa katika Hospitali ya Taifa ya Kenyatta

Mpelelezi Mkuu: Dr David Kahura Mundia

Mandharinyuma:Nchini Kenya, hakujakuwepo na ripoti nyingi za utafiti wa matukio na muundo wa majeraha ya maxillofacial kati ya wanaopata ajali za kuumia kichwa. Utafiti huu unaofanywa hapa hospitali ya Kenyatta National Hospital (KNH) una manna ya kwamba utaenda kuongeza ujuzi zaidi kuhusu jinsi ya kupunguza, kudadisi na kutibu matukio za ajali zinazohusu uso na kichwa.

Malengo ya utafiti:

i. Kuzindua kiwango cha majeraha ya uso kati ya majeruhi wa ajali walioumia kichwa wanaoonekana katika Hospitali ya Taifa ya Kenyatta (KNH)
ii. Kuthibitisha muundo wa majeraha ya maxillofacial kati ya wanaopata ajali za kuumia kichwa katika Hospitali ya Taifa ya Kenyatta
iii. Kuorodhesha aina za majeraha za uso na kichwa

Ushiriki wa hiari na uhuru wa kujiondoa: Ushirika kwa utafiti ni wa hiari. Kuna haki ya kushiriki ama kutoshiriki. Hata baada ya kukubali kushiriki, kuna uhuru wa kujiondoa kutoka utafiti wakati wowote na habari iliyokusanywa haitatumiwa. Kukataa kushiriki ama kujiondoa kutoka utafiti huu hakutasababisha kupoteza faida ambayo ni haki ya mgonjwa kama kutibiwa na kuhudumiwa.

Usiri: Habari ambazo zitakusanywa katika utafiti zitashughulikiwa kwa usiri dhabiti na zitatumika kwa ajili ya utafiti huu pekee. Majina ya washiriki na nambari zao za hospitali hazitatumiwa wala kuchapishwa. Hata hivyo, habari zitakazo tokana na utafiti huu zita shirikishwa kwa wataalam kote duniani kupitia mikutano na kuchapishwa.

Manufaa na Matarajio ya kushiriki: Hakuna manufaa ya moja kwa moja (kifedha ama vinginevyo) kwa mgonjwa binafsi kwa kushiriki kwa utafiti huu. Hata hivyo, matokeo ya

utafiti yatakuwa na umuhimu wa kutafuta suluhisho la kudumu ili kuzuia na/ama kupunguza na ulemavu kutokana na majeraha ya uso na kichwa. Kama dakika kumi na tano zitatumika kwa kila mhusika katika utafiti huu.

Adhari za kushiriki: Utafiti huu hautabadilisha wala kuingilia kati ya matibabu ya mgonjwa. Kwa hivyo, hakuna mathara ya mwili wala ya mawazo yanayotarajiwa kutokana na kushiriki katika utafiti huu.

Gharama ya matibabu: Hakuna gharama ya ziada kutokana na kushiriki katika utafiti huu. Hata hivyo, gharama za kawaida za matibabu [ikiwa ni pamoja na uchunguzi unaohitajika] za KNH zitahitajika na zitagharamiwa na mgonjwa anayeshiriki katika utafiti.

Sahihi ……..

Mchunguzi Mkuu: Dkt David Kahura Mundia,

Idara ya Upasuaji wa Kinywa na Uso, Magonjwa na Matibabu ya Kinywa

Shule ya Daktari wa Meno, Chuo Kikuu Cha Nairobi

S.L.P 19176-00202 Nairobi, Kenya

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Msimamizi wa Mpelelezi Mkuu Dkt Walter Odhiambo, Mwenyekiti, Idara ya Upasuaji wa Kinywa na Uso, Magonjwa na Matibabu ya Kinywa, Katika Hospital ya Chuo Kikuu Cha Nairobi S.L.P 30197 Nairobi

Kamati ya maadili ya Chuo Kikuu cha Nairobi na Hospitali ya kitaifa ya Kenyatta (UON/KNH, Research, Ethics and Standards Committee) S.L.P 1976-00202 Nairobi. Simu 020 2726300 urefu. 44355

Appendix Id: Consent certificate [Kiswahili]

CHETI CHA RIDHAA

Mada ya utafiti: Matukio na muundo wa majeraha ya maxillofacial kati ya wanaopata ajali za kuumia kichwa katika Hospitali ya Taifa ya Kenyatta

Mpelelezi Mkuu: Dr David Kahura Mundia

Mimi,_____nimesoma/nimeelezewa na nimeelewa wazi yaliyo ndani ya fomu ya kukubali kushiriki katika utafiti. Nimejibiwa maswali na yaliyokuwa yakinipatia wasi wasi yameshughulikiwa.
Kwa hivyo NIMEKUBALI [ ] / SIJAKUBALI [ ] kushiriki katika utafiti huu.

Sahihi ya mshiriki/ jamaa/ mlezi _____

Sahihi ya shahidi_____Tarehe_____

Sahihi ya mtafiti_____Tarehe _____

Azimio la Mtafiti

Mimi kama mpelelezi mkuu wa utafiti huu, natangaza ya kuwa:

Mabadilisho yoyote katika itifaki hii na/ama utaratibu yatajulishwa kwa kamati ya uendeshaji wa kisayansi na kutekelezwa mara moja baada ya kupitishwa na kamati ya maadili na utafiti

1. Matokeo ya utafiti huu hayatachapishwa, kuwasilishwa kwa jarida na/ama mkutano bila ruhusa iliyoandikwa na Mkurugenzi wa Taasisi.

2. Washiriki wengine wa timu ya utafiti wamefungwa na masharti yaliyotangulia.

_____Tarehe_____

Sahihi ya Mpelelezi Mkuu

Kwa maelezo zaidi/maswali/malalamishi tafadhali wasiliana na

1. **Mpelelezi Mkuu Dkt David Kahura Mundia Kwa Simu ya Rununu 0714 220 120**
2. **Msimamizi wa Mpelelezi Mkuu Dkt Walter Odhiambo, Mwenyekiti, Idara ya Upasuaji wa Kinywa na Uso, Magonjwa na Matibabu ya Kinywa, Katika Hospital ya Chuo Kikuu Cha Nairobi S.L.P 30197 Nairobi**
3. **Mwenyekiti,Kamati ya maadili ya Chuo Kikuu cha Nairobi na Hospitali ya kitaifa ya Kenyatta (Chairman UON/KNH, Research, Ethics and Standards Committee) Simu 020 2726300 urefu 44355**

APPENDIX II DATA COLLECTION TOOLS

Data Collection Tool (Please circle/shade appropriate response)

File No:…… Patient's initials: …….

1. **Age:**

0-10;	11-20;	21-30;	31-40;	41-50;	51-60;	61-70;	71-80;	81-90;	91-100

2. **Sex:**

Male	Female

3. **Aetiology of Injury**

RTA	Falls from a height	Interpersonal Violence	Sports	Other injury
Automobile				
Motorcycles				
Bicyle				

4. **RTA patient status**

	Driver	Passenger	Pedestrian
Y			
N			

5. **Maxillofacial Injury Characteristics**

UPPER FACE	**MIDFACE**	**LOWER FACE**
Soft tissue injuries Open Wound Y/N?	Soft tissue injuries Open Wound Y/N?	Soft tissue injuries Open Wound Y/N?
Cranial bone fractures	Zygomatic complex	Fractures of the mandible

a) Comminuted Y/N? b) Depressed Y/N? c) Frontal bone Y/N? d) Frontal Sinus Fracture Y/N? e) Nasofrontal duct injury Y/N?	fractures a) zygomatic bone with without zygomatic arch; Y/N? b) zygomatic bone with without zygomatic arch; Y/N? Fractures of the maxilla a) Le Fort I b) Le Fort II c) Le Fort III d) Combination of these; e) Fractures of the nasal bone; f) Orbital fracture Dentoalveolar injuries, a) Teeth Avulsion b) Fracture of teeth.	a) Parasymphysis b) Symphysis, c) Body, d) Angle, e) Ramus, f) Coronoid process g) Condyle Dentoalveolar injuries, a) Teeth avulsion b) Fracture of teeth.

6. Head Injury Characteristics

	Loss of Consciousness	**Vomitting**
Y		
N		

GCS

Mild (13-15)	Moderate (9-12)	Severe <=8

Skull fractures

Vault Fractures	Depressed	Comminuted	Linear	Stellate
Y				
N				

Basilar Fractures	CSF Leak	Cranial Number 7 Deficits
Y		
N		

Intracranial Lesions

Focal Lesions	Epidural	Subdural	Intracerebral
Y			
N			

Diffuse Lesions	Concussion	Multiple Contusions	Hypoxic/Ischemic injury	Axonal Injury
Y				
N				

APPENDIX III GLASGOW COMA SCALE CHARTS

Glasgow Coma Scale (for age 4yrs and above)

Points†	Best eye opening	Best verbal	Best motor
6	–	–	obeys
5	–	oriented	localizes pain
4	spontaneous	confused	withdraws to pain
3	to speech	inappropriate	flexion (decorticate)
2	to pain‡	incomprehensible	extensor (decerebrate)
1	none	none	none§

Children's Glasgow Coma Scale (for children < 4yrs)

Points†	Best eye	Best verbal		Best motor
6	–	–		obeys
5	–	smiles, oriented to sound, follows objects, interacts		localizes pain
		Crying	Interaction	
4	spontaneous	consolable	inappropriate	withdraws to pain
3	to speech	inconsistently consolable	moaning	flexion (decorticate)
2	to pain	inconsolable	restless	extensor (decerebrate)
1	none	none	none	none

APPENDIX IV MFI AND THI CLASSIFICATION CHART

Combined Injury Classification	Maxillofacial Injury	Head Injury
Type 1-A		
Type 1-B		
Type 1-C		
Type 2-A		
Type 2-B		
Type 2-C		
Type 3-A		
Type 3-B		
Type 3-C		
Type 4-A		
Type 4-B		
Type 4-C		
Type 5-A		
Type 5-B		
Type 5-C		
Type 6-A		
Type 6-B		
Type 6-C		
Type 7-A		
Type 7-B		
Type 7-C		

APPENDIX V RESEARCH PROPOSAL ETHICAL APPROVAL

UNIVERSITY OF NAIROBI
FACULTY 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/26

7th February, 2022

Dr. David Kahura Mundia
Reg. No. V60/7186/2017
Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine Unit
Dept. of Dental Sciences
Faculty of Health Sciences
University of Nairobi

Dear Dr. Mundia,

RESEARCH PROPOSAL: PATTERN OF MAXILLOFACIAL INJURIES IN PATIENTS WITH TRAUMATIC HEAD INJURY AT KENYATTA NATIONAL HOSPITAL (P807/10/2021)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P807/10/2021.** The approval period is 7th February 2022 – 6th February 2023.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KNH-UoN ERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KNH-UoN ERC 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected 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.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. 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.
vii. Submission of an executive summary report within 90 days upon completion of the study to KNH-UoN ERC.

Protect to discover

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

DR. BEATRICE K.M. AMUGUNE
SECRETARY, KNH-UoN ERC

c.c. The Dean-Faculty of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Chair, Dept. of Dental Sciences, UoN
Supervisors: Dr. Walter A. Odhiambo, Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine Unit, UoN
Prof. Mark L. Chinida, Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine Unit, UoN
Dr. T.J. Ochola, Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine Unit, UoN

APPENDIX VI STUDY TIMELINE

Activity June 2021-June 2022	Jun 2021	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June 2022
Proposal Development													
Ethics Committee Proposal Evalaution													
Data Collection													
Data Analysis Report Writing Results Presentation Dissertation Defence													

APPENDIX VII BUDGET AND BUDGET JUSTIFICATION

This was a self-funded study with the following expenditure breakdown.

	Item (qty)	**Unit cost (Ksh)**	**Total cost (Ksh)**
1	Training of research assistants	5,000.00	5,000.00
2	Stipend for research assistants (01)	30,000.00	30,000.00
3	Stationery	10,000.00	10,000.00
4	Printing, photocopying and binding	40,000.00	40,000.00
5	Communication	10,000.00	10,000.00
6	Statistician fee	40,000.00	40,000.00
7	Research fee (KNH/UoN - ERC)	5,000.00	5,000.00
8	Incidentals	10,000.00	10,000.00
	GROSS TOTAL		**150,000.00**

Appendix I Declaration Form for Students

UNIVERSITY OF NAIROBI

Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for examination.

Name of Student	**MUNDIA DAVID KAHURA**
Registration Number	**V60/7186/2017**
Department	**DENTAL SCIENCES**
Faculty	**HEALTH SCIENCES**
Course Name	**MASTER OF DENTAL SURGERY IN ORAL AND MAXILLOFACIAL SURGERY**
Title of the Work	**PATTERN OF MAXILLOFACIAL INJURIES IN PATIENTS WITH TRAUMATIC HEAD INJURY AT THE KENYATTA NATIONAL HOSPITAL IN NAIROBI,KENYA**

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard
2. I declare that this dissertation is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work
5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy

Signature Kahura

Date 26-8-2022

PATTERN OF MAXILLOFACIAL INJURIES IN PATIENTS WITH TRAUMATIC HEAD INJURY AT THE KENYATTA NATIONAL HOSPITAL IN NAIROBI, KENYA

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