PREVALENCE AND LATERALITY OF SUPRAORBITAL ETHMOID CELL AND ITS RELATIONSHIP WITH THE ANTERIOR ETHMOID ARTERY AMONG PATIENTS WHO UNDERWENT PARANASAL SINUS COMPUTED TOMOGRAPHY SCAN AT MUHIMBILI NATIONAL HOSPITAL.

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MMed (Otorhinolaryngology) Dissertation

Muhimbili University of Health and Allied Sciences

October, 2024

Muhimbili University of Health and Allied Sciences

School of Clinical Medicine

Department of Otorhinolaryngology

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By

Focus Kudra Cyprian.

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Medicine in Otorhinolaryngology at

Muhimbili University of Health and Allied Sciences

October, 2024

CERTIFICATION

The undersigned certify that she has read and hereby recommends for acceptance by the Muhimbili University of Health and Allied Sciences a dissertation entitled "**Prevalence and laterality of supraorbital ethmoid cell and its relationship with the anterior ethmoid artery among patients who underwent paranasal sinus computed tomography scan at Muhimbili national hospital**" in (partial) fulfilment of the requirements for the Degree of Master of Medicine (Otorhinolaryngology) of Muhimbili University of Health and Allied Sciences.

_____

Prof. Enica Richard Massawe

(Supervisor)

Date: _____

_____

Dr. Martin Elimath

(Co-supervisor)

Date: _____

DECLARATION AND COPYRIGHT

I, **Focus Kudra Cyprian,** declare that this **dissertation** is my original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Signature: _____ Date: _____

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ACKNOWLEDGEMENT

Above all, I want to express my gratitude to The Almighty God for giving me life and for all of the blessings I have experienced.

My deepest gratitude goes out to Dr. Martin Elimath and Prof. Enica Richard Massawe, my supervisors, for their unwavering work ethic, cooperation, and support without which this dissertation would not have taken shape.

I am most thankful to Dr. Daudi Ntunaguzi, the head of the Department of Otorhinolaryngology, Muhimbili University of Health and Allied Sciences (MUHAS), for his assistance, support, direction, and insightful recommendations during the entire dissertation process.

I would like to thank everyone who helped with this dissertation, especially Dr. Kassim Mapondella, Dr. Aveline Kahinga, and the staff of the MNH and MUHAS ENT departments.

Additionally, I want to thank Dr. Frederick R. Lyimo (Radiologist), and the entire MNH radiology department personnel for their assistance with data collection.

Finally, I would like to express my profound gratitude to my family and friends for their unwavering love and support during my postgraduate studies.

DEDICATION

I dedicate this to my mother, son, siblings, and fellow ENT residents for their unwavering love, support, and motivation.

ABSTRACT

Background: The anterior ethmoid artery (AEA) plays an important role in functional endoscopic surgery (FESS) as one of the surgical landmarks, it's a branch of the ophthalmic artery. The position of the anterior ethmoid artery in relation to the ethmoid roof is very variable as it courses through the ethmoid labyrinth, it can be altered by the presence of supraorbital ethmoid cell, thus, the artery becomes vulnerable to iatrogenic injuries and very serious complications such as severe bleeding. To prevent iatrogenic injury to the base of skull, a surgeon's knowledge of the anatomy of the ethmoid sinuses and orbital plate of the frontal bone is of utmost importance during opening into the sinuses. The possibility of iatrogenic injury during functional endoscopic sinus surgery exists due to presence of supraorbital ethmoid cell pneumatization, which may change the position of the anterior ethmoid artery as it courses within the ethmoid cavity.

Objective: To determine the prevalence and laterality of supraorbital ethmoid cell and its relationship with the anterior ethmoid artery among patients who underwent paranasal sinus computed tomographic scan at Muhimbili National Hospital in Tanzania.

Material and methods: A cross-sectional retrospective hospital-based study was conducted at Muhimbili National Hospital, radiology department, for a duration of six months, from December 2023 to May 2024, and included 316 paranasal sinus computed tomographic scans of patients aged 12 years and older. A convenience sampling method was employed, whereby data collection was done from all paranasal sinus computed tomographic scans that met criteria from 1st of January 2020 to 31st of December 2022. Data collection checklists were used to record the age, sex, presence, and laterality of supraorbital ethmoid cell, as well as the position of the anterior ethmoid artery about the base of the skull.

Results: A total of 316 paranasal sinus computed tomographic scans were included in this study, of whom 139 (44.0%) were males and 177 (56.0%) were females, with a female-to-male ratio of 1:3.1. The paranasal sinus computed tomographic scans studied were from patients aged 12 to 90 years, with a median age of 40 (28,53). The most common age groups were 32–51 years and 12-31 years (40.8% and 32.9%, respectively). The prevalence of supraorbital ethmoid cells was found to be 61 (19.3%). Supraorbital ethmoid cells were more

common in males as compared to females by 25.2% and 14.7%, respectively. Among the 61 paranasal sinus computed tomographic scan images, 68.9% were found to have bilateral supraorbital ethmoid cells, while 21.3% and 9.8% were found unilateral on the right and left sides, respectively. Males accounted for bilateral supraorbital ethmoid cells by 74.2%. The anterior ethmoid artery was found to be Group II by 45.6%, followed by Group I and Group III by 31.1% and 23.3%, respectively. The majority of the computed tomographic scans in Groups II and III were males, at 53.3% and 28.3%, respectively. Contrary to Group I, in which 48.8% were females.

Conclusion: The prevalence of supraorbital ethmoid cell was found to be 19.3%, with a high proportion of bilateral distribution of 68.9%. A large percentage of Group II anterior ethmoid arteries was found to be related to supraorbital ethmoid cell by 45.6%. The position of the anterior ethmoid artery in the ethmoid labyrinthine varies between the two sides of the same patient depending on the laterality of the supraorbital ethmoid cell, so this variation is very crucial to be known by a surgeon before and during endoscopic sinus surgery.

Recommendations: Owing to a significant supraorbital ethmoid cell's prevalence among the population, Clinicians should be aware to include preoperative evaluation of the PNS CT scan for the presence and laterality of supraorbital ethmoid cell and the position of the anterior ethmoid artery in patients undergoing endoscopic sinus surgery so as to minimize iatrogenic injuries and complication. Radiologists should also be aware that PNS CT scans with supraorbital ethmoid cell have to be reported.

More emphasis on the use of preoperative paranasal sinus computed tomographic scans in the management guidelines of patients requiring endoscopic sinus surgery. Due to Tanzania's data shortage, additional research at various health institutes throughout the nation is advised.

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LIST OF ABBREVIATIONS

AEA	Anterior ethmoid artery.
CSF	Cerebrospinal fluid.
CT	Computed tomography
DPGS	Director of postgraduate studies
ENT	Ear, nose and throat
ESS	Endoscopic sinus surgery
FESS	Functional endoscopic sinus surgery
LLCP	Lateral lamella of cribriform plate
MNH	Muhimbili national hospital
MUHAS	Muhimbili university of health and allied sciences
ORL	Otorhinolaryngology
PNS	Paranasal sinuses
SOEC	Supraorbital ethmoidal cell
SPSS	Statistical package for the social sciences

DEFINITION OF TERMS

The anterior ethmoid artery- is a branch of the ophthalmic artery that emerges from the internal carotid artery, penetrates the medial orbital wall at the frontoethmoidal suture line, travels through the anterior ethmoidal foramen on the medial orbital wall, enters the ethmoid sinuses, and then takes a variable path to supply the mucosa and send branches to the upper nasal mucosa part (1,2).

Ethmoid roof- is a structure that divides the ethmoid air cells from the anterior cranial cavity and its contents. It is made up of a thinner vertical component known as the lateral cribriform plate lamella and a thicker horizontal orbital plate (3,4).

Ethmoid sinuses- These are sieve-like paired labyrinths consisting of numerous cells per side which provide a lightweight, honeycombed support for the midface, split into anterior and posterior by a basal lamella, situated medial to the orbit, anterior to the sphenoid sinus, and inferior to the frontal sinus (5,6).

Functional endoscopic sinus surgery (FESS)- is used to treat medically unresponsive chronic rhinosinusitis with or without polyps and recurrent acute rhinosinusitis. It is a minimally invasive, mucosal-saving surgical approach (7).

Lateral lamella of the cribriform plate- Is the medial portion of the ethmoidal roof, which connects to the cribriform plate and forms the lateral part of the olfactory fossa (8).

Paranasal sinuses- Are the four paired air-filled hollow spaces around the nasal cavity and the skull bone, which serve as a voice resonant chamber, lighten the skull, and humidify the air (6,9).

Skull base- refers to a complex bone part of the skull that serves as the floor of the cranium which houses the brain; it contains foramen and fissures through which vessels and nerves pass (10).

Supraorbital ethmoidal cell- is the air cell that develops as a result of superolateral pneumatization of the frontal bone's orbital plate, which is lateral to the lamina papyracea's most medial plate (11,12).

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

One of the frontal pneumatization patterns that is determined by the varied fronto-ethmoidal cells is the supraorbital ethmoid cell (13). According to Van Alyea in 1942, supraorbital ethmoidal cells are the most anterior ethmoid cells that invade the supraorbital plate of the frontal bone (Figure A) (14). It is an anterior ethmoid cell that pneumatizes over the orbital roof, either anteriorly, posteriorly, or around the anterior ethmoid artery(15).

The AEA crosses the ethmoid cavity at a considerably lower level when SOECs are present than when they are absent, making the AEA more vulnerable to iatrogenic injury during functional endoscopic sinus surgery. The existence of SOEC determines the anatomic location of the AEA in the ethmoid cavity. Before surgery, it is crucial to recognize SOEC as it serves as a warning that the AEA canal is significantly lower from the ethmoidal roof and freely runs within it (2,13).

The AEA is an important landmark in the endoscopic sinus surgery of the anterior ethmoid sinus; It is a branch of the ophthalmic artery that emerges from the internal carotid artery. It enters the medial orbital wall at the frontoethmoidal suture line and exits through the front ethmoidal foramen (1). Along its path in the olfactory fossa, it gives rise to meningeal arteries. It then descends to the nasal fossa to supply the nasal lateral wall and the anterior portion of the nasal septum.

The intra-orbital, ethmoidal, and intracranial segments of the AEA are its three divisions. It travels via the anterior ethmoidal sulcus and reaches the olfactory fossa through the lateral lamella of the cribriform plate (16). It could travel down the ethmoids either freely or within a bony canal, or it could be closely attached to the base of the skull. When AEA courses less than 2.5 mm from the skull base, it is classified as group I; when it courses between 2.5-5 mm from the skull base, it is classified as group II; and when it courses more than 5 mm from skull base, it is classified as group III(1,2,4,17). Understanding these structural variations is crucial for reducing the possibility of iatrogenic artery injury and possible complications, such as intra-orbital hemorrhage as well as blindness (1).

Computerized tomography scans are the accepted gold standard in not only evaluating sinonasal disease and characterizing the anatomy of the paranasal sinus but also as a road map while operating on patients with PNS diseases (4). Due to the PNS's proximity to important structures such as the orbital space, brain, and other associated anatomical variations, such as the ethmoidal roof, supraorbital ethmoidal cells, and the anterior ethmoid artery (AEA), knowing the PNS anatomy of an individual patient before surgery is critical. Surgery risks like bleeding and orbital damage are avoided with the help of computer tomography (8).

Endoscopic sinonasal surgery refers to the minimally invasive procedure discovered in Germany in 1960 and has become cutting edge in the treatment of chronic rhinosinusitis with and without nasal polyposis if comprehensive medical care is unsuccessful (18). It was introduced in Tanzania at Muhimbili National Hospital in 2010.

Therefore, this study aims to add more knowledge and increase awareness among ear, nose and throat (ENT) surgeons on the anatomical variations of SOEC and its relation to the position of AEA to prevent injury to nearby structures like the orbit and brain (19).

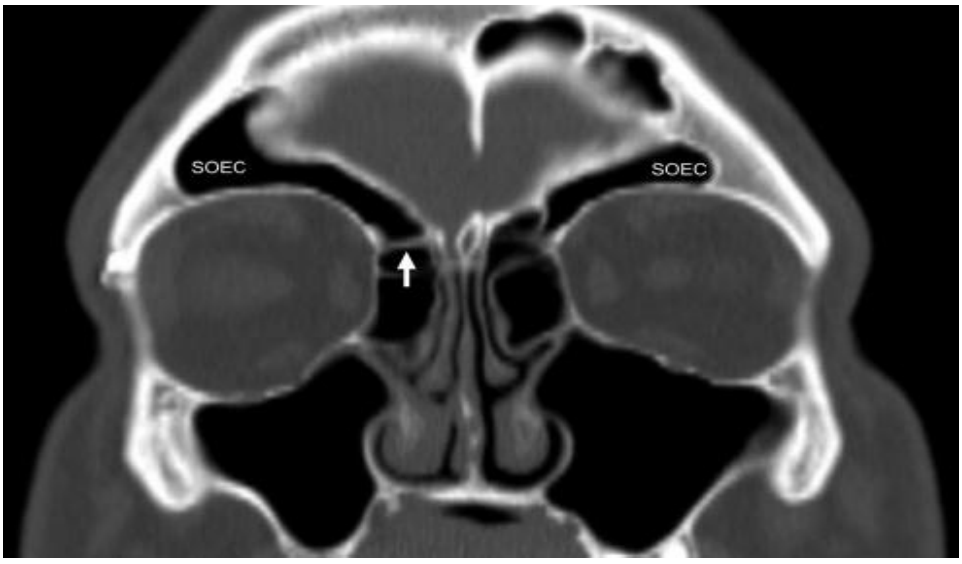


Figure 1: A coronal PNS CT image showing the anterior ethmoid artery (white arrow) and bilateral supraorbital ethmoid cell (SOEC) (12)**.**

1.2 Problem statement.

Before undergoing any endoscopic sinonasal surgery, a CT scan examination is crucial because it provides a road map and helps the surgeon recognize key critical structures and anatomical variations. One of the key landmarks for predicting surgical difficulties is anatomical variations of the paranasal sinuses, particularly of the SOEC in relation to the position of the AEA. The position of AEA within the ethmoid sinuses is altered by the presence of SOEC, moving it further from the ethmoid roof and raising the risk of iatrogenic injuries and sequelae such as intra-orbital bleeding and potential blindness (1,2,4,13). Despite FESS being done at MNH since 2010, there is limited data on the prevalence and laterality of SOC and its relationship with the AEA among the patient population.

Hence, this study aims to add more knowledge and increase awareness among ENT surgeons about the anatomical variations of SOEC and its relation to the AEA to prevent and minimize iatrogenic complications during FESS.

1.3 Conceptual framework.

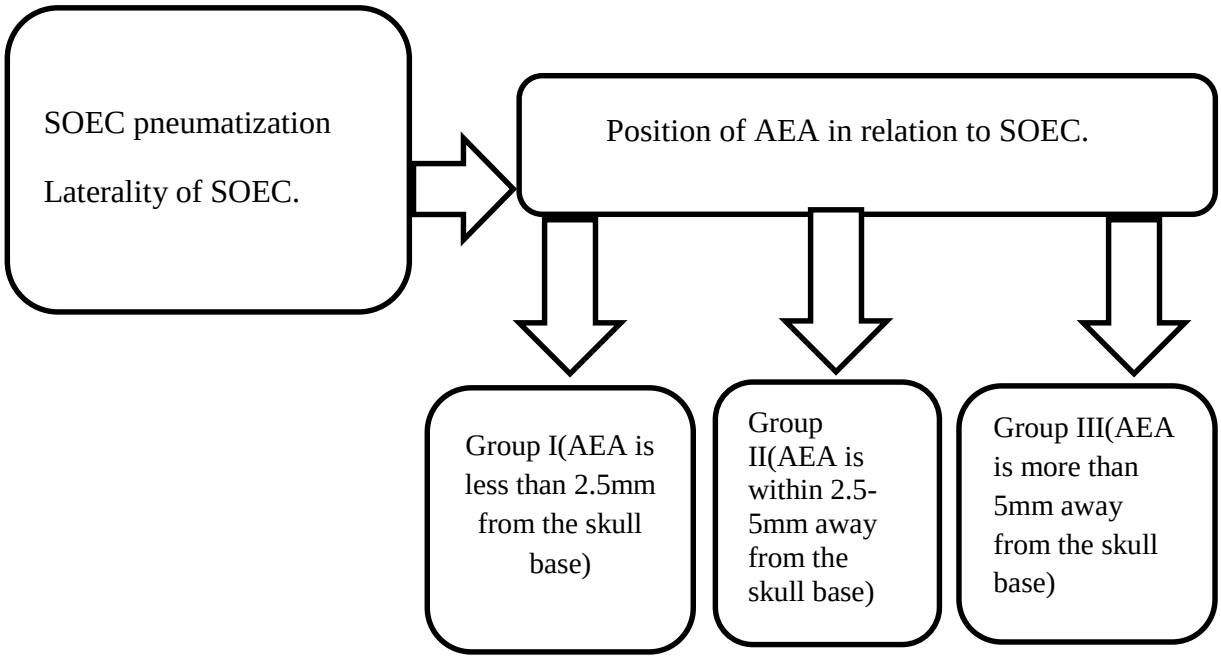


Figure 2: Shows the interaction between variables relating to SOEC pneumatization

Supraorbital ethmoid cell pneumatization and its laterality alters the position of the AEA to be distant from the skull base as it courses within the ethmoid labyrinth.

1.4 Rationale

The results of this study aimed to add knowledge and raise awareness among ENT surgeons about the prevalence and laterality of SOEC among the patient population. Furthermore, the study contributes information on how far the AEA courses distant from the skull base within the ethmoid labyrinth in relation to the presence of SOEC.

Incorporating the SOEC variation and its relationship to the AEA during the surgeon's pre-operative evaluation will help to prevent or minimize iatrogenic injury to the skull base and its associated vital structures. Also, this study raises awareness among radiologists about the importance of reporting supraorbital ethmoid cells in CT scans of the paranasal sinus.

Also, this study was a partial fulfilment requirement for MUHAS's Master of Medicine in otorhinolaryngology program.

1.5 General Research Questions

What is the prevalence and laterality of supraorbital ethmoid cell and its relationship with the anterior ethmoid artery among patients who underwent paranasal sinus computed tomography scan at MNH?

1.6 Research questions

i. What is the prevalence of supraorbital ethmoid cell?
ii. What is the laterality of the supraorbital ethmoid cell?
iii. Is there a relationship between supraorbital ethmoid cell with the position of anterior ethmoid artery?

1.7. Broad Objective

To determine the prevalence and laterality of supraorbital ethmoid cell and its relationship with the anterior ethmoid artery among patients who underwent paranasal sinus computed tomography scan at Muhimbili National Hospital.

1.7.1 Specific Objectives

i. To determine the prevalence of supraorbital ethmoid cell among patients who underwent PNS CT scan at MNH.
ii. To determine the laterality of the supraorbital ethmoid cell among patients who underwent PNS CT scan at MNH.
iii. To determine the relationship between supraorbital ethmoid cell with the position of anterior ethmoid artery.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Prevalence of supraorbital ethmoid cell.

Endoscopic sinus surgery targets pathologies of both nose and paranasal sinuses and currently is the gold standard for treating chronic rhinosinusitis, sinonasal tumours, etc. Preoperative evaluation of the SOEC variations and their relation to the position of the AEA is important before paranasal sinus surgery so as to minimize or prevent injury to the anterior base of skull structures and complications like intra-orbital haemorrhage (4,13,20).

Globally, different kinds of literature have shown the variation of SOEC in the population, and these variations may differ among countries. A retrospective study done in 2018 in the Philippines found that 69.7% of CT scans had SOEC (8). Another study done in 2009 by Souza et al. revealed a 35% prevalence of SOEC among Brazilians (13). Josh et al. (2010), in India, showed that among fifty patients,45% had SOEC in a retrospective study of the correlation between the AEA and SOEC (1). However, a retrospective study of the paranasal sinus and nasal cavity between Turkish and Polish populations done by Gruszka et al. in 2022 revealed 57.8% of the Turkish Population has SOEC (20).

A recent study on the variability of the AEA and its relationship to SOEC, done in the United States of America in 2022 by Taha et al., revealed that 56% of the CT scans had SOEC (2). When compared to patients of other ethnicities, such as Japanese and Koreans, SOEC prevalence in patients of Western ethnicity is significantly higher (12,21).

Low prevalence of SOEC was observed in studies done in India, Nepal, Turkey, Portugal, and Italy, where the supraorbital ethmoid cells were found to be 28%, 26.5%, 23%, 22% and 18%, respectively (22–26).

There are surprisingly few studies on the prevalence, laterality, and relationship between SOEC with the position of AEA in Africa. In a study on the geographic and racial variations in SOEC pneumatization conducted in Egypt in 2021 by Kamel et al., the prevalence of SOEC was found to be 59.6% among 47 patients with chronic rhinosinusitis (18). Another study done by El-Anwar et al, in Egypt, reported the prevalence of supraorbital ethmoid cell as 16% in a retrospective study of hundred and fifty computerized tomographic scans of paranasal sinuses (27). Studying the pattern of SOEC pneumatization in our local population is important as evidenced by variations in the prevalence of SOEC pneumatization in other populations.

Despite a significant number of hospitals, including the Muhimbili National Hospital, adopting FESS, no literature was found in Tanzania describing the variation of pneumatization of SOEC and its relationship to the position of AEA. The difference in SOEC prevalence between countries, regions, and ethnic groups is therefore adequately supported by the available data.

2.2 Laterality of supraorbital ethmoid cell.

The laterality of SOEC is a crucial factor to be considered during pre-operative evaluation; whereas most research indicated a high incidence of bilateral SOEC pneumatization in a population, some studies found a significant prevalence of unilateral SOEC pneumatization.

A retrospective study done in Sao Paulo, Brazil, in 2009 by Souza et al. showed that a large percentage (27%) of CT scan images had bilateral SOEC pneumatization as compared to 9% with unilateral SOEC pneumatization (13). Another retrospective study done in the Philippines by Carlos et al. in 2018 revealed a dominance of bilateral SOEC pneumatization, which accounted for 50.41% of the total as compared to 18.70% of the counterpart (8). Furthermore, Bhatt et al. (2004) in a retrospective study of the anatomical prevalence of SOEC revealed that bilateral SOEC were dominant by 56.3% over unilateral lateralization by 4.7% (28).

A retrospective study done in the United States of America in 2022 revealed that 60% of CT scan images have left-sided SOEC and 52% having right-sided SOEC, almost equally distributed between the left and right sides. However, the study did not address the bilateralism of SOEC (2).

A cross-sectional study on variations of the frontal sinus and its drainage pathway done in Nepal in 2023 by Gyawali et al. revealed a distribution of supraorbital ethmoid cells more on the right side by 28.2% as compared to the left side by 24.8% (23).

In Africa, a study conducted in Egypt revealed a considerable asymmetry of the SOEC pneumatization, with unilateral supraorbital ethmoid cell pneumatization making up 31.9% of the total, as opposed to 27.7% of the counterpart (18).

2.3 Relationship between supraorbital ethmoid cell with the position of the anterior ethmoid artery.

It is crucial to be aware of the AEA's course prior to surgery in order to reduce and prevent iatrogenic injury since there is enough variance in the AEA's canal course in the ethmoid sinus that, during ESS, iatrogenic injury to the AEA may occur with serious complications (15). Different authors have demonstrated that the presence of SOEC pneumatization determines the anatomical location of the AEA. When AEA courses less than 2.5 mm from the skull base, it is classified as group I; when it courses 2.5-5 mm from the skull base, it is classified as group II; and when it courses more than 5 mm from skull base, it is classified as group III (1,2,4,17).

Supraorbital ethmoid cell pneumatization is an important and a trustworthy AEA position predictor, as the SOEC is one of the adjacent structures to the AEA in its course within the base of the skull. During embryological development, pneumatization of the SOEC influences the position of the anterior ethmoid artery, as it is postulated that the ethmoid sinus may be pushing the AEA during expansion (29).

A retrospective study done by Souza et al. in 2009 revealed SOEC and the location of the AEA in the ethmoid sinus to be significantly correlated; all cases with SOEC correlated with the presence of the AEA coursing freely and positioned distant from the ethmoid roof (13); so, preoperative evaluation of the SOEC pneumatization on CT scan is very important as it brings an alert on the position of the AEA to avoid iatrogenic injuries associated complications.

Lannoy-Penisson et al. (2007) showed a significant relationship between SOEC and the position of the AEA, 85.7% of the CT scans in which the AEA was discovered to be distant from the ethmoid roof were associated with the presence of SOEC (17). Another study done in Nepal by Sah B et al. in 2018 showed that the presence of SOEC pneumatization is related to a significant increase in the distance of the position of the AEA from the base of the skull as group II and III AEA were the most prevalent types by 32% and 56% respectively (4).

A retrospective study done in India by Josh A et al. in 2010 also showed a correlation between the position of the AEA and the presence of SOEC; in this study, group II AEA was the most prevalent type accounting for 54% (1). In the United States of America, recent retrospective study done by Taha et al in 2022 revealed a relationship between the presence of SOEC and the anterior ethmoid artery, in which the AEA was found either prominent or suspended below the base of the skull in 45% of the CT scans with SOEC (2).

The presence of SOEC is associated with AEA coursing below the base of the skull. A study done by Li et al. in 2019 found that the presence of SOEC was related to a higher prevalence of AEA being located below the base of the skull by 53.8% as compared to 18.1% of those without SOEC (12). Gyawali et al, reported the presence of SOECs was highly related to the mesentery form of the anterior ethmoid artery by 88.1% in a cross-sectional study of frontal sinus variations done in Nepal (23).

The anterior ethmoid artery was found lying freely on mesentery away from the skull base in all cases with supraorbital ethmoid cell pneumatization, this finding was observed in a retrospective study done in India by Noori et al; in 2017 (22).

Regarding the distribution of groups of the anterior ethmoid artery, Wang et al in 2023 observed a statistical insignificance variation of groups of anterior ethmoid artery among sex, where Group I and II AEA were dominated by females by 26.5% and 27.3%, respectively, as compared to Group III AEA which had a high proportion of males by 58.8% (30).

In Africa, no published study has been done on the relationship between the supraorbital ethmoid cell with the anterior ethmoid artery's position.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study area.

This study was carried out in the Muhimbili National Hospital (MNH) radiology department, situated in Upanga, Ilala district, in Dar es Salaam. The Muhimbili National Hospital, which serves as both Tanzania's largest teaching and tertiary referral facility, accepts patients on referral from all areas of the nation's mainland, Zanzibar, and neighbouring countries.

There is a total of 16 radiologists working in the radiology department, which is well-equipped and staffed to serve the needs of the hospital's various departments. Each year, the department conducts more than 200 PNS CT scans using two Siemens multi-slice computed tomography scanners.

3.2 Study design

This study was a cross-sectional, retrospective hospital-based.

3.3 Study population.

This study included PNS CT scans done at the radiology department for patients 12 years of age and above who attended services at the radiology department from the 1st of January 2020 to the 31st of December 2022.

3.4 Sample size.

The sample size, n, of the PNS CT scans, was calculated by using the formula,(31).

$$n= Z^2p(1-p)/\epsilon^2$$

Where Z= Level of confidence interval which of 95% = 1.96

P=prevalence of supraorbital ethmoid cell in Egyptians =59.6%=0.596
ϵ= margin of error of 7%=0.07

The minimum sample size obtained was 316 PNS CT scans which was considered as sampling frame.

3.5 Sampling technique

A non-probability convenience sampling method was used.

3.6 Inclusion and exclusion criteria.

3.6.1 Inclusion criteria

i. All PNS CT Scans of patients 12 years and above done at the radiology department.

3.6.2 Exclusion criteria

PNS CT scan with any condition which obscures clear visualization of supraorbital ethmoid cell and anterior ethmoid artery. For example, PNS CT scans with malignancy, PNS CT scans with evidence of base of skull fracture especially ethmoid sinuses.

3.7 Variables.

Independent variables-Age in years, sex, supraorbital ethmoid cell and its laterality.

Dependent variable-Position of the anterior ethmoid artery in millimeters.

3.8 Data collection methods.

The study included the PNS CT scans of individuals who matched the inclusion criteria, and each CT image had its own data checklist and distinct serial number. Data were recorded in a data collection checklist by a principal investigator and two research assistant investigators.

3.8.1 Data collection procedure.

By using an individualized checklist, information was collected, including age and sex. The presence of the supraorbital ethmoid cell, the laterality of the supraorbital ethmoid cell, and the position of the anterior ethmoid artery with SOEC were recorded.

3.8.2 Prevalence of supraorbital ethmoid cell.

The data were obtained using a digital screen through the evaluation of a PNS CT scan by identifying a SOEC as defined by Van Alyea (11) and tracing the border of the air cell from the anterior ethmoids superiorly towards the ethmoid roof and laterally towards the medial orbital wall (8). This identification of SOEC was done on both the right and left sides of each PNS CT scan.

3.8.3 Laterality of supraorbital ethmoid cell.

Identification of supraorbital ethmoid cell was done on both the left and right sides of the PNS CT scan for assessment of lateralization.

3.8.4 Relationship between supraorbital ethmoid cell with the position of the anterior ethmoid artery.

By using a PNS coronal CT scan, the anatomical landmarks for the position of the AEA and its relation to the SOEC were identified. These landmarks are the anterior ethmoidal foramen (figure 3), which is the medial notch of the orbit, the medial rectus muscle and the superior oblique muscle.

The vertical distance at the midpoint from the most inferior point of AEA descent to the inferior border of the ipsilateral orbital plate of the frontal bone was measured digitally in Millimeters on both sides and the parameters to be investigated were divided into one of three positional groups; When AEA courses less than 2.5 mm from the skull base, it is classified as group I; when it courses between 2.5-5 mm from the skull base, it is classified as group II; and when it courses more than 5 mm from skull base, it is classified as group III (figure 4).

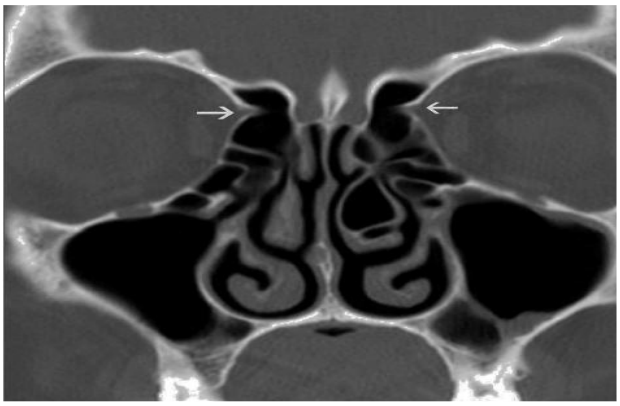


Figure 3: Coronal PNS CT image showing anterior ethmoid foramen(arrow) on the medial orbital walls (13)**.**

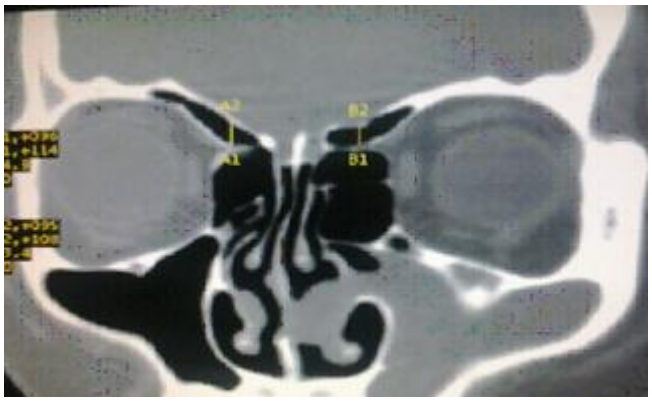


Figure 4: Coronal PNS CT image with SOEC depicting measurements of vertical distance between AEA and skull base (4)**.**

3.8.5 Investigation tools, validity and reliability issues.

A bone window coronal CT scan was used to visualize the supraorbital ethmoid cell, the anterior ethmoidal artery on the medial wall of the orbit and the anterior ethmoid sulcus of the LLCP and the vertical distance at the midpoint from the most inferior point of AEA descent to the inferior border of the ipsilateral orbital plate of the frontal bone on the MNH radiology department digital screen. The validity and reliability of the data collected were ensured by using a standardized data collection tool and a radiologist's guidance.

3.9 Data analysis.

Prior to analysis, the data was reviewed for completeness, accuracy, and internal consistency before being entered into the SPSS software version 26. The categorical data were summarized as proportions and analyzed using a Pearson Chi-square test, while the quantitative variables were summarized as the median and interquartile range. A 95% confidence level, a p-value of less or equal to 0.05% was regarded as significant.

3.9.1 Descriptive analysis of all variables.

The descriptive statistics provided a summary of the sample and all variables that were measured and were presented in tables and diagrams. The categorical variables were analyzed using frequencies while quantitative variables which includes both median and range were calculated.

3.10 Ethical Considerations.

The Muhimbili University Health and Allied Sciences Ethical Committee's approval requested. The MNH radiology department contacted to obtain permission to carry out this study. The waiver of consent was obtained because if informed consent was requested from each patient's CT scan, loss of follow-up and death would have an impact on the findings. PNS CT scans of the patients were used; however, to guarantee anonymity, the data collecting Checklists identified the relevant PNS CT scans by utilizing serial numbers rather than the patients' names.

Patients' anonymity was maintained by not recording any names in the data collecting tool and by entering the data into SPSS using codes instead of names. All other identifying information was kept completely private.

3.11 Study limitation.

The sample size was not representative of all people in the country because it is a hospital-based study, but it serves as a pilot for research at other facilities around the nation.

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic characteristics.

A total of 632 sides were analyzed from 316 CT images of the paranasal sinuses. The study duration was six months, from December 2023 to May 2024. Females accounted for 56.0% (n=177) of the 316 CT scans, whereas males accounted for 44.0% (n=139), with a female: male ratio of 1.3: 1. Paranasal sinus CT scans were of patients that ranged from 12 to 90 years old, with a median age of 40 (28,53). The age groups 32-51 years accounted for 40.8% (n=129) of all CT scans, followed by the age group 12-31 years accounting for 32.9% (n=104), and the least common being ≥ 72 years,4.1% (n=13), (table 1).

Table 1: Demographic characteristics (N=316)

Variable	Frequency (n)	Percent (%)
Age group (years)		
12-31	104	32.9
32-51	129	40.8
52- 71	70	22.2
≥72	13	4.1
Total	**316**	**100**
The median age in years (IQR)	40 (28,53)	
Sex		
Male	139	44.0
Female	177	56.0
Total	**316**	**100**

4.2 The prevalence of supraorbital ethmoid cell.

Among the 316 paranasal CT scan images, 19.3% (n=61) were found to have supraorbital ethmoid cells. Supraorbital ethmoid cells were common in CT scans of males as compared to females by 25.2% (n=35) and 14.7% (n=26) respectively (table 2).

Table 2: Prevalence of supraorbital ethmoid cell by sex (N=316)

Sex	Status of SOEC		Total N (%)
	Present n (%)	Absent n (%)	
Male	35 (25.2)	104 (74.8)	139 (44.0)
Female	26 (14.7)	151 (85.3)	177 (56.0)
Total	**61 (19.3)**	**255 (80.7)**	**316 (100)**

4.3 laterality of supraorbital ethmoid cell.

Among the 61 paranasal sinus CT scan images, 68.9% (n=42) were found to have bilateral supraorbital ethmoid cells as compared to 31.1% (n=19) with unilateral distribution, where by 21.3% (n=13) and 9.8% (n=6) were found unilateral on the right and left sides respectively (figure 5).

A Large percentage of male CT scans accounted for bilateral supraorbital ethmoid cells by 74.2% (n=26). Females accounted for 19.2% (n=5) of the left side, while the right side was dominated by males by 22.9% (n=8), figure 6.

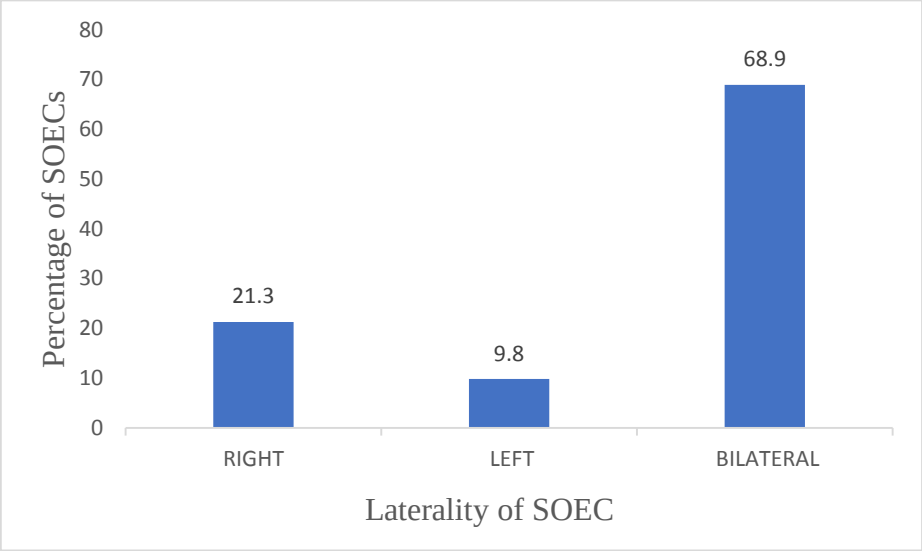


Figure 4: Laterality of supraorbital ethmoid cell (n=61)

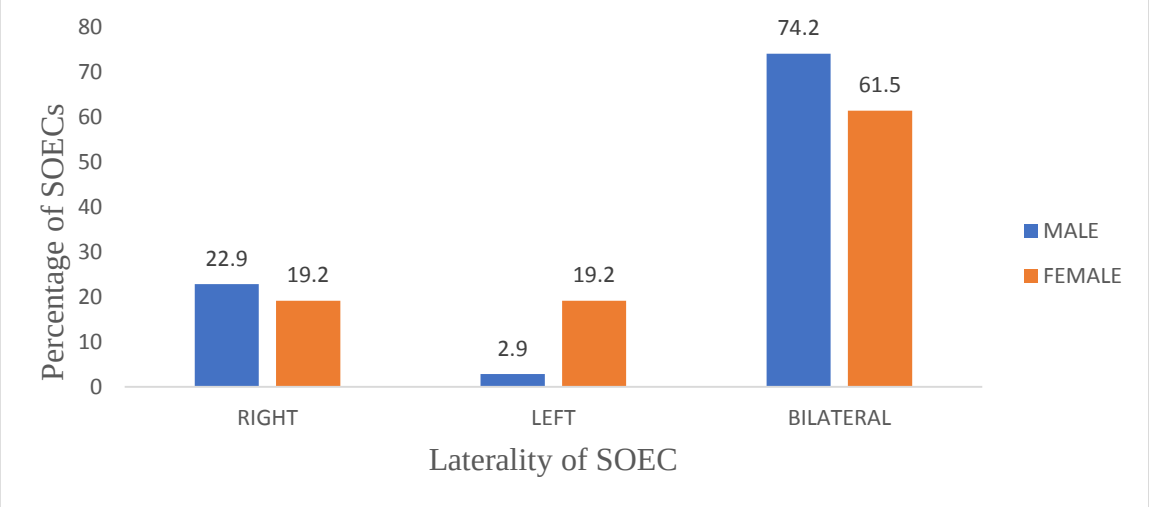


Figure 5 Laterality of supraorbital ethmoid cell by sex (n=61)

4.4 Relationship between supraorbital ethmoid cell with the position of anterior ethmoid artery.

Among the 61 paranasal sinus CT scans with supraorbital ethmoid cells, a total of 103 sides were assessed for the position of the AEA in relation to the skull base. The position of the AEA was found to be Group II by 45.6% (n=47 sides) followed by Group I and Group III by 31.1% (n=32 sides) and 23.3% (n=24 sides), respectively (figure 7).

The majority of the CT scans in Groups II and III were from males, at 53.3% (n=32) and 28.3% (n=17), respectively, contrary to Group I, in which 48.8% (n=21) were females, these differences were statistically significant with the P-value of 0.038 (table 3).

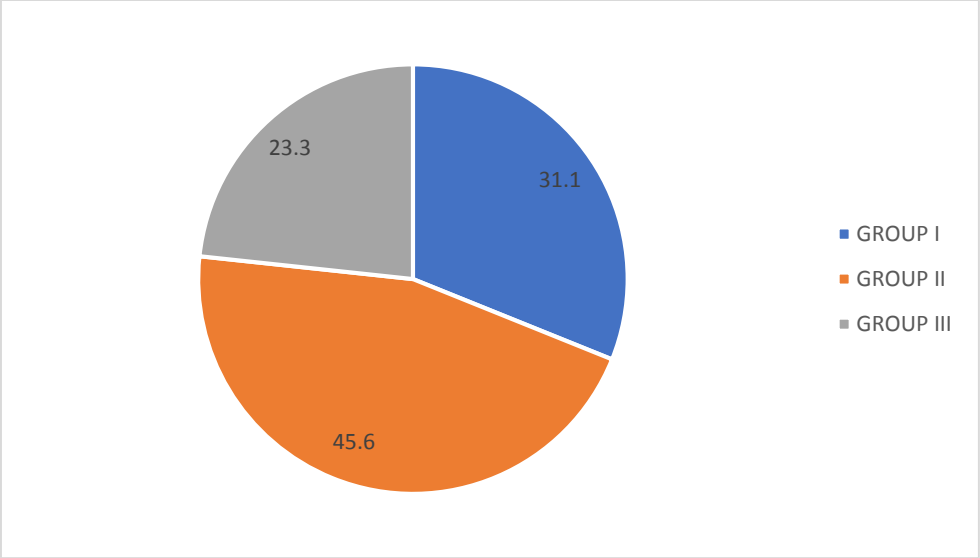


Figure 6: Distribution of groups of the anterior ethmoid artery (n=103)

Table 3: Distribution of groups of anterior ethmoid artery by sex (n=103)

Sex	Groups of AEA			Total n (%)	P-value
	Group I n (%)	Group II n (%)	Group III n (%)		
Male	11(18.3)	32(53.3)	17(28.3)	60(58.3)	0.038
Female	21(48.8)	15(34.9)	7(16.3)	43(41.7)	
Total	**32(31.1)**	**47(45.6)**	**24(23.3)**	**103(100)**	

CHAPTER FIVE

5.0 DISCUSSION

Assessment of paranasal sinus CT scan images for the presence of supraorbital ethmoid cells pneumatization and the position of the anterior ethmoid artery is an important step before an ENT surgeon embarks on functional endoscopic sinus surgery. Evaluation for the presence of SOEC guides the surgeon to have a clue on the position of the AEA as it courses distant from the skull base so as to avoid iatrogenic injuries such as intra-orbital hemorrhage and blindness (4,13,20). When the AEA courses away from the skull base, it poses a high risk of iatrogenic injury. Few published studies have been done in Africa so far regarding the prevalence and laterality of SOEC, but none of the studies correlated with the position of the anterior ethmoid artery, despite the significance.

The paranasal CT scans that were assessed in this study included patients aged 12 to 90 years with a median age of 40 and interquartile range of (28,53) years and a female-to-male ratio of 1.3:1. The minimum age in this study was 12 years, which coincides with the study done in Brazil by Souza et al (13), this was because the ethmoid sinuses achieve adult size at this age.

In this study, supraorbital ethmoid cells were found in 19.3% of 316 CT scans; these findings coincide with studies done in, Turkey, Portugal, Italy, Egypt, and Yugoslavia, which revealed the prevalence of SOEC to be 23%,22%,18%,16%, and 21%, respectively (24–27,32). On the contrary, studies conducted in the India, the United States of America, Nepal, Philippines, Brazil, and Egypt (1,2,4,8,13,18) showed a significantly higher prevalence of SOEC. These variations in the prevalence of SOEC could be accounted for by the involvement of different ethnic populations and different races in the studies. Craniofacial variations between different ethnicities account for the observed difference in the prevalence of SOEC in different studies (33,34). The Prominence of the glabella and superior orbital rim in Caucasians is related to the development of SOEC (8,35).

Supraorbital ethmoid cells were more prevalent in CT scans of males by 25.2% as compared to females by 14.7%. Similar findings were observed in a study done in Egypt by Kamel et al.,

which showed a male predominance of SOECs by 38.3% compared to 21.3% in females (18). However, supraorbital ethmoid cells were more prevalent in females by 53.7%, and 63.5% a in studies done by Jang et al, and Wang et al, respectively (11,30). These disparities in prevalence according to sex could be accounted for by the inclusion of different ethnic populations and races as well.

Regarding the laterality of SOEC, bilateral distribution was found to be dominant by 68.9% and was common in males PNS CT scans. Similar findings were observed in studies done in the Philippines (50.4%), the United States of America (56.3%), and Brazil (27%) (8,13,28). Different findings were noted in a study conducted in the United States of America by Taha et al where the unilateral distribution of SOEC accounted for 52% and 60% on the right and left sides respectively (2), furthermore, a study done in Egypt by Kamel et al revealed a unilateral predominance of SOEC of 31.9% (18).

On the laterality of SOEC regarding sex, this study observed that bilateral and right-sided SOEC had a higher proportion of males by 74.2% and 22.9%, respectively. Contrary to left sided SOEC in which females accounted for a high proportion of 19.2%. The difference in laterality among sexes could be accounted for by the high prevalence of SOEC among male CT scans.

This study found that SOEC pneumatization was highly related to Group II AEA by 45.6%, followed by Group I and III by 31.1% and 23.3%, respectively. This finding coincides with studies done in Nepal and India, which showed a high proportion of Group II AEA by 55.9% and 53.5%, respectively (1,4). However, contrary results were observed in a study done in China by Wang et al in which Group III AEA had a high proportion of 79.79% (30). The findings of this study indicate that the presence of SOEC is related to the AEA crossing the ethmoid cavity at a lower level, which poses a greater risk of iatrogenic injury during ESS.

This study found variations in the distribution of groups of AEA among sexes. Group II and III AEA were dominated by CT scans of males by 53.3% and 28.3%, respectively, as compared to their counterparts, which accounted for 34.9% and 16.3%, respectively. However, Group I AEA had a higher number of CT scans of females by 48.8% as compared to 18.3% of their

counterparts. The observed difference was statistically significant (p=0.038). Different findings were observed in a study done by Wang et al in 2023 which observed a statistical insignificance variation of groups of anterior ethmoid artery among sex, where Group I and II AEA were dominated by CT scans of females by 26.5% and 27.3%, respectively, as compared to Group III AEA which had a high proportion of CT scans of males by 58.8% (30). The observed variation could be because males tend to have larger head size and circumference which increases the height of the SOEC, eventually altering the location of the AEA away from the skull base (30), also, the high prevalence of SOEC among male CT scans.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The prevalence of SOEC was found to be 19.3%, with a high proportion of bilateral distribution of 68.9%. Supraorbital ethmoid cells were more common in males as compared to females by 25.2% and 14.7%, respectively.

A large percentage of Group II AEA was found to be related to SOEC by 45.6%. Group II and III AEA had a high proportion of males, 53.3% and 28.3%, respectively.

The position of the AEA in the ethmoid labyrinthine varies between the two sides of the same patient depending on the laterality of the SOEC, so this variation is very crucial to be known by a surgeon before and during endoscopic sinus surgery.

6.2 Recommendations

Owing to a significant supraorbital ethmoid cell's prevalence among the patient population, Clinicians should be aware to include preoperative evaluation of the PNS CT scan for the presence and laterality of SOEC and the position of the AEA in patients undergoing endoscopic sinus surgery so as to minimize iatrogenic injuries and complication. Radiologists should also be aware that PNS CT scans with SOEC have to be reported.

More emphasis on the use of preoperative PNS CT scans in the management guidelines of patients requiring ESS. Due to Tanzania's data shortage, additional research at various health institutes throughout the nation is advised.

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APPENDICES

Appendix 1: Data Collection Checklist

Serial number……. Registration number……. Date of imaging……

A. Demographic information
   a) Age in years……
   b) Sex
      1) Male □
      2) Female □

B. Status of supraorbital ethmoid cell.
   1) SOEC Present □, if present go to section C.
   2) SOEC Absent □

C. Laterality of supraorbital ethmoid cell and position of the anterior ethmoid artery.
   1) Right side □ Group of AEA □
   2) Left side □ Group of AEA □

Description of the position of the anterior ethmoid artery with supraorbital ethmoid cell.

1) When AEA courses less than 2.5 mm from the skull base (Group I)
2) When it is found between 2.5-5 mm from the skull base (Group II)
3) When it courses more than 5 mm from the skull base (Group III)

Appendix II: Ethical clearance

UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

OFFICE OF THE DIRECTOR – RESEARCH, PUBLICATIONS AND INNOVATION

Ref. No.DA.282/298/01.C/1976

Date: 28/11/2023

MUHAS-REC-11-2023-1976
FOCUS KUDRA CYPRIAN
COLLEGE OF MEDICINE
MUHAS

RE: APPROVAL FOR ETHICAL CLEARANCE FOR A STUDY TITLED: PREVALENCE AND LATERALITY OF SUPRAORBITAL ETHMOID CELLS AND ITS CORRELATION WITH THE ANTERIOR ETHMOID ARTERY AMONG PATIENTS WHO UNDERWENT PARANASAL SINUS COMPUTED TOMOGRAPHY SCAN AT MUHIMBILI NATIONAL HOSPITAL.

Reference is made to the above heading,

I am pleased to inform you that the Chairman has on behalf of the University Senate, approved ethical clearance of the above-mentioned study, on recommendations of the Senate Research and Publications Committee meeting accordance with MUHAS research policy and Tanzania regulations governing human and animal subjects research.

APPROVAL DATE: 28/11/2023
EXPIRATION DATE OF APPROVAL: 28/11/2024

STUDY DESCRIPTION:
Purpose:

The purpose of this cross-sectional retrospective hospital-based study is to determine the proportion and laterality of supraorbital ethmoid cells and its correlation with anterior ethmoid artery among patients who underwent paranasal sinus CT scan at Muhimbili National Hospital in Tanzania.

The approved protocol and procedures for this study is attached and stamped with this letter, and can be found in the link provided:
https://irb.muhas.ac.tz/storage/Certificates/Certificate%20-%2014801.pdf and in the MUHAS archives.

The PI is required to:

1. Submit bi-annual progress reports and final report upon completion of the study.
2. Report to the IRB any unanticipated problem involving risks to subjects or others including adverse events where applicable.
3. Apply for renewal of approval of ethical clearance one (1) month prior its expiration if the study is not completed at the end of this ethical approval. You may not continue with any research activity beyond the expiration date without the approval of the IRB. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.
4. Obtain IRB amendment (s) approval for any changes to any aspect of this study before they can be implemented.
5. Data security is ultimately the responsibility of the investigator.
6. Apply for and obtain data transfer agreement (DTA) from NIMR if data will be transferred to a foreign country.
7. Apply for and obtain material transfer agreement (MTA) from NIMR, if research materials (samples) will be shipped to a foreign country,
8. Any researcher, who contravenes or fail to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III section 10 (2)
9. The PI is required to ensure that the findings of the study are disseminated to relevant stake holders.
10. PI is required to be versed with necessary laws and regulatory policies that govern research in Tanzania. Some guidance is available on our website https://drp.muhas.ac.tz/.

Dr. Nahya Salim Masoud,
Chairperson, MUHAS Research and Ethics Committee

Muhimbili University of Health and Allied Sciences
DIRECTOR
Research, Publications & Innovations
Box 65001

Appendix III: Introduction letter

UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES
OFFICE OF THE DIRECTOR – POSTGRADUATE STUDIES

In reply quote;
Ref. No. HD/MUH/T.182/2021

05th December, 2023

The Executive Director,
Muhimbili National Hospital,
P.O. Box 65000,
DAR ES SALAAM

Re: **INTRODUCTION LETTER**

We would like to inform you that the bearer of this letter is Focus Kudra Cyprian with Reg. No. HD/MUH/T.182/2021 is a student at Muhimbili University of Health and Allied Sciences (MUHAS) "pursuing MMed. Otorhinolaryngology.

As part of his studies, he will be doing an elective research titled: **"Prevalence and Laterality of Supraorbital Ethmoid Cells and Its Correlation with the Anterior Ethmoid Artery Among Patients Who Underwent Paranasal Sinus Computed Tomography Scan at Muhimbili National Hospital."** He is being supervised by Dr. Enica Richard from MUHAS and Dr. Elimath Martin from MNH.

The research has been approved by the Chairman of University Senate.

Kindly provide him the necessary assistance to facilitate the conduct of his research.

We thank you for your cooperation.

Mr. Sebe Mohamed
For: DIRECTOR, POSTGRADUATE STUDIES

c.c Focus Kudra Cyprian

9 United Nations Road; Upanga West; P.O. Box 65001, Dar Es Salaam: Tel. G/Line: +255-22-2150302/6; Ext. 1015; Direct Line:+255-22-2151378;Telefax:+255-22-2150465;E-mail:dpgs@muhas.ac.tz;Web:https://www.muhas.ac.tz

Appendix IV: Permission letter

THE UNITED REPUBLIC OF TANZANI

MINISTRY OF HEALTH

MUHIMBILI NATIONAL HOSPITAL

In reply please quote;

Ref. No.: MNH/CRTCU/Perm/2023/572 Date: 07th December, 2023

Head of Department

-Radiology

Muhimbili National Hospital

RE: PERMISSION TO COLLECT DATA AT MNH

Name of Student	**Focus K. Cyprian**
Title	**" The Prevalence And Laterality Of Supra Orbital Ethmoid Cells And Its Correlation With The Anterior Ethmoid Artery Among Patients Who Underwent Paranasal Sinus Computed Tomography At Attended MNH"**
Institution	Muhimbili University of Health and Allied Sciences
Supervisor	Dr. Enica Richard (MUHAS)
Co-supervisor	Dr. Elimath Martin (MNH)
Period	07th December, 2023 to 07thFebruary, 2024

Approval has been granted to the above principal investigators to collect data at MNH. Dissemination of study findings at MNH shall be overseen by **Dr. Elimath Martin (MNH)** supervisor.

Kindly ensure the named principal investigator abide to the ethical principles and other conditions of the research approval.

Sincerely,

Dr. Charles Pallangyo
For: Head of Clinical Research, Training and Consultancy Unit

c.c DCSS
c.c Focus K Cyprian
c.c Dr. Elimath Martin

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