University of Nairobi, College of Health Sciences

School of Medicine

THE VARIANT ANATOMY OF THE SPHENOID SINUS AS SEEN IN PATIENTS UNDERGOING PARANASAL SINUS COMPUTED TOMOGRAPHY IMAGING AT THE NAIROBI HOSPITAL

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF MEDICINE IN OTORHINOLARYNGOLOGY, HEAD AND NECK SURGERY, UNIVERSITY OF NAIROBI

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I, **Dr. Allan Gray Mukuzi,** do hereby declare that this dissertation is my own original work and has not been presented for award of a degree in any university.

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DEDICATION

To my mother, the reason I studied ENT Surgery

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LIST OF ABBREVIATIONS

ACP-	Anterior Clinoid Process
CT -	Computed tomography
GWS-	Greater Wing of Sphenoid
ICA-	Internal Carotid Artery
MN-	Maxillary Nerve
ON-	Optic Nerve
PP-	Pterygoid Plate
SS-	Sphenoid sinus
VN-	Vidian nerve

ABSTRACT

Background: The anatomy of the sphenoid sinus is of great utility to otorhinolaryngologists and neurosurgeons. It is an important landmark in minimal access surgery of the anterior and middle cranial fossa. Knowledge of the variant anatomy is important to reduce surgery related complications. Computed tomography (CT) scan of the paranasal sinuses is the imaging modality of choice used in assessing this anatomy.

Objective: To determine the variant anatomy of the sphenoid sinus in patients undergoing paranasal CT scan evaluation at The Nairobi Hospital

Study Design: This was a descriptive cross-sectional study.

Study Setting: This study took place at The Nairobi Hospital Radiology Department

Methodology: This study involved 123 participants aged 16 years and above who were recruited through consecutive sampling from all the patients sent for paranasal CT scan imaging at The Nairobi Hospital Radiology Department. The axial CT scan slices were standardized to 0.67mm cuts and coronal and sagittal orientations generated by computer reconfiguration. The variant anatomy was studied and characterized.

Study Duration: This study was conducted from January 2022 to September 2023.

Data Management and Analysis: Data was collected using a questionnaire and analyzed using SPSS version 22. Analysis of variance was carried out to determine the association between the anatomical variations and age distribution. Fischer's exact test was used to compare between right, left and bilateral variations. A cut-off statistical significance was set at a P value of <0.05 for a 95% confidence interval.

Results: the study included 55 males and 68 females with ages ranging from 18 years to 80 years. The mean age was 43.9 years +/- 14.3 years. The most common type of sellar pneumatization was the sellar variant (87.8%) with presellar variant representing 12.2% and no conchal variant seen in this study. The most common sellar variant was the complete one (65.7%) with the complete variant being more common in males (53.52%) than it was in females (46.48%). The sphenoid sinus invariably (97.6%) had septa. The most common type of Optic nerve protrusion was type 0 (left 30.1%, right 31.7%) and type 1 (left 43.9%, right 40.7%).

Conclusion: This study confirms the variant anatomy of the sphenoid sinus. The complete. Sellar variant was more common in males. There was no internal carotid dehiscence.

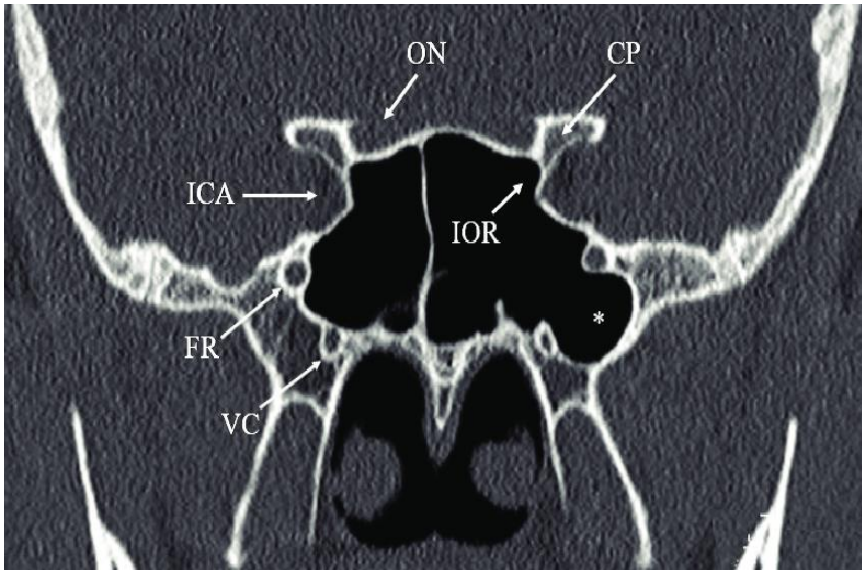
Recommendations: understanding the anatomy if the sphenoid sinus is important in performing safe surgery.

1.0 CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Introduction

The sphenoid sinus has diverse anatomical variants. Familiarity of the anatomy of the sphenoid sinus is of importance during sinus surgery. Furthermore, its proximity to the middle cranial fossa has great utility in endoscopic access of structures in the middle cranial fossa such as the hypophysis cerebri. Computed tomography (CT) scan imaging has been very instrumental in giving healthcare providers a three-dimensional orientation of the anatomical structures related to this sinus. This is particularly so when considering the fact that the sinus presents great difficulty in clinical examination. It then follows that proper understanding of the orientation of the sphenoid sinus, its relations and its variant anatomy is mandatory in performing safe sphenoid sinus and transsphenoidal surgery.

The sphenoid sinus is situated in the sphenoid bone. It is bordered superiorly by the hypophysis cerebri, anteriorly by the ethmoidal air cells, the nasopharynx inferiorly, laterally by the cavernous sinuses and the brainstem posteriorly (1). The sphenoid sinus is adjacent to crucial neurovascular structures. These include the Optic nerve on the superolateral border, the cavernous section of the internal carotid artery on the lateral border of the sinus, the maxillary and vidian nerves on the lateral border. The locations of these structures may vary depending on the pneumatization pattern of the sphenoid sinus.



ON- optic nerve
ICA- Internal carotid artery
CP- anterior clinoid process
FR- Foramen rotundum
VC- Vidian canal
IOR- Infra-optic recess

Figure 1:Neurovascular relations of the sphenoid sinus (12)

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Embryology

The sphenoid bone has a complex development pattern with 15 separate ossification centers (1). The lateral part of the greater wing and the lateral pterygoid plates develop from intramembranous ossification while the remainder of the sphenoid bone structures develop from endochondral sources. These cartilaginous portions then fuse to form the complete sphenoid bone. The table below demonstrates the cartilaginous precursors vis a vis their resultant structures and their contribution to the sphenoid body.

Table 1:The embryological origins of the parts of the sphenoid sinus (1)

Part of sphenoid body	Cartilaginous precursors	Resultant structures
Pre-sphenoid	Orbitosphenoid (lesser wing)	Sphenoid body anterior to the tuberculum sellae
Post-sphenoid	Alisphenoid (medial portion of the greater wing), pterygoid plates	Sella turcica, dorsum sellae, basisphenoid.

The sphenoid sinus is completely formed by the 16th year of life (1). This understanding is the basis of the lower age limit of the participants included in this study.

2.2 Sphenoid Sinus Pneumatization

The characterization of the pattern of the sphenoid sinus pneumatization is based on the extent of its pneumatization. As a result, there are three recognized patterns of pneumatization: conchal, pre-sellar and sellar (2,3,4). The conchal type of pneumatization (also known as the fetal type) has no air cell and it appears as a block of bone. (The triangle shows the sphenoid sinus while the star shows the Sella turcica)

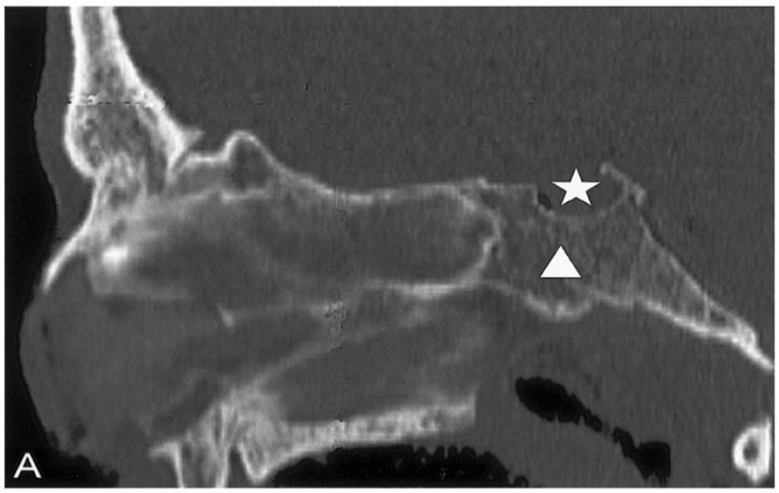


Figure 2:Conchal type of sphenoid sinus pneumatization (3).

In the pre-sellar type (also known as the juvenile type), the pneumatization does not exceed the anterior border of the Sella turcica. (The triangle shows the sphenoid sinus while the star shows the Sella turcica)

Figure 3:Pre-sellar type of pneumatization (3)

The sellar type can further be subdivided into the complete and incomplete type. The incomplete type is manifested by pneumatization that exceeds the anterior border of the Sella turcica but does not extend to the clivus. This is further defined as having a clivus thickness of more than two millimeters. (The triangle shows the sphenoid sinus while the star shows the Sella turcica)

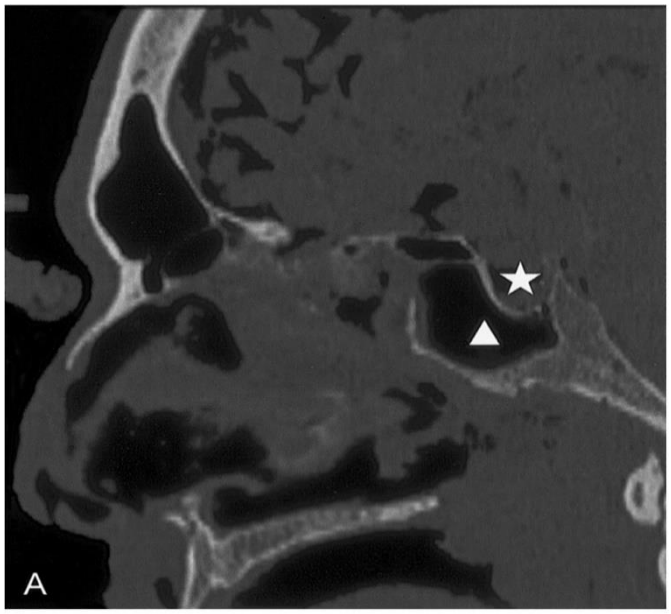


Figure 4:Incomplete sellar type (3)

The complete sellar pneumatization variant extends to the clivus. This is further defined as having a clivus thickness of less than two millimeters. (The triangle shows the sphenoid sinus while the star shows the Sella turcica)

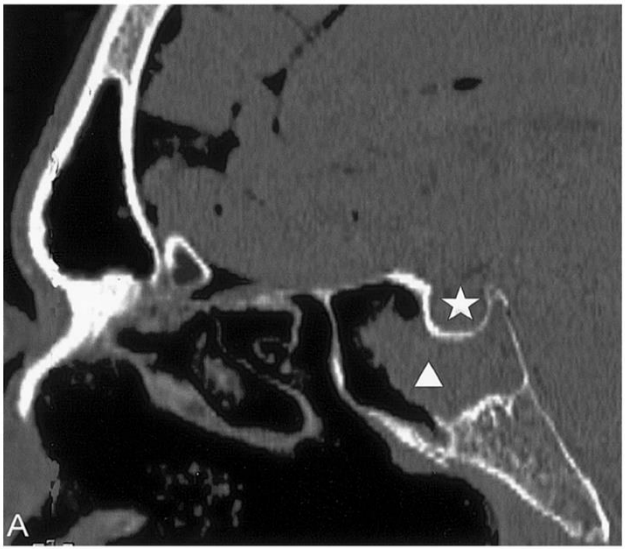


Figure 5:Complete sellar type (3)

One of the earliest studies done on the sphenoid sinus was by Hammer G and Radberg C in 1961 (4). In their study, they used both radiological (120 cases) and cadaveric (103) examinations of the sphenoid sinus. This study set the stage for the recognized pneumatization patterns of the sphenoid sinus as conchal, pre-sellar and sellar. Their study revealed that the most prevalent type of pneumatization was the sellar type (86%). It also revealed that the thickness of the anterior wall of the Sella turcica corresponds to the type of the pneumatization; being thickest in the conchal type and thinnest in the sellar type. As a result, they made recommendations that the conchal type of pneumatization is a contraindication for transsphenoidal surgery.

The sphenoid sinus has the potential to extend into any of the constituent parts of the sphenoid bone namely the greater wing, the lesser wing, the anterior clinoid process, the posterior clinoid process, and the pterygoid recess. This pneumatization has the potential to encroach on the adjacent neuro-vascular structures that may traverse these areas (5,6,7).

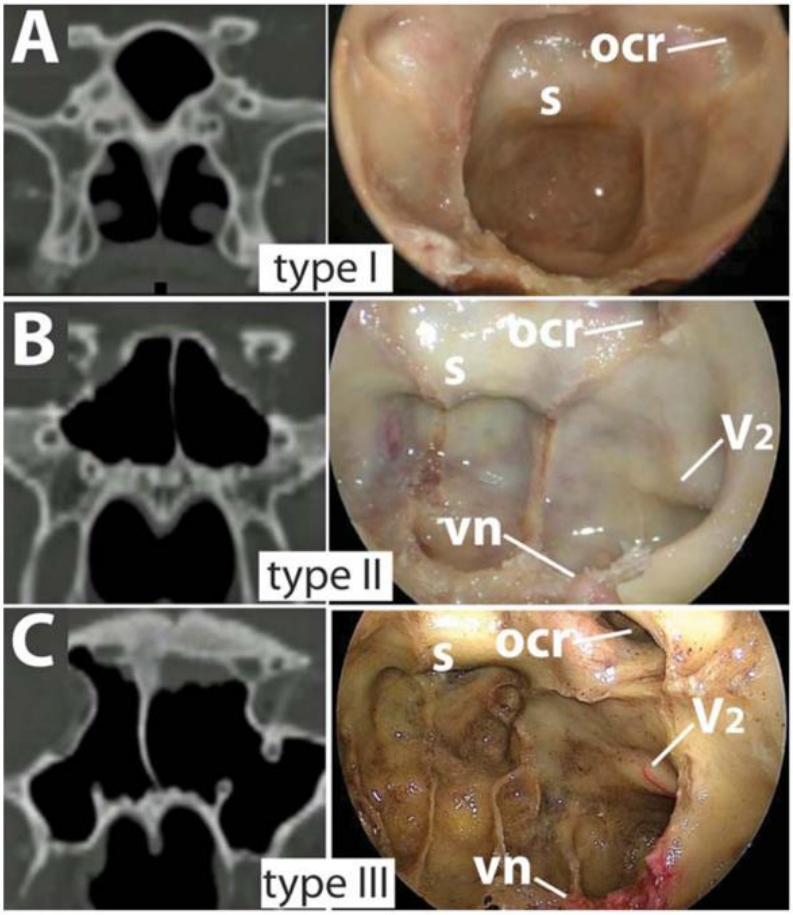
Attempts have been made to classify this pattern of lateral pneumatization (8,9). In 2014, Vaezi A. et al described the lateral extent of the sphenoid sinus pneumatization according to three types (8). These three types were based on the extent of the pneumatization in relation to the vidian canal and foramen rotundum as seen on coronal CT scans. In type I, the pneumatization is from the midline to the medial edge of the vidian canal (pre-vidian). In type II, pre-rotundum, the pneumatization is from the sphenoid sinus midline to the lateral edge of foramen rotundum.

Type III, post-rotundum, the sphenoid sinus pneumatization is from the midline to beyond the lateral edge of foramen rotundum.

Kazkayasi M et al in their study demonstrated that the lateral extent of pneumatization of the sphenoid sinus encroached on adjacent neuro-vascular structures (10). They found that when the sphenoid sinus was pneumatized towards the pterygoid plates there was resultant projection of the Vidian canal in 36.7% of the patients and projection of the Foramen Rotundum in 12.7%. Their study showed that pneumatization of the anterior clinoid process was associated with projection of the optic canal into the sphenoid sinus (4.1%). However, they noted that the relationship between optic canal projection and anterior clinoid process pneumatization was lower in their study when compared to other studies owing to the differences in definition of optic canal protrusion. The patients recruited in this study are those who had sinus-disease-related complaints. The ones who had no complaints pertaining their sinuses were excluded from the study.

A study amongst Libyan patients was conducted by Hewaidi G and Omami G (6). This study mirrors what majority of the other studies already reveal; the pneumatization of the constituent parts of the sphenoid bone is associated with projection of the relations of the sphenoid sinus into the sinus cavity (3,5,7,8). In their study, pneumatization of the pterygoid plate was recognized as that extending beyond the horizontal plane crossing the Vidian canal. This correlated with 29% of the patients. While they found a lesser percentage of anterior clinoid process pneumatization in their study in comparison to the studies they looked at, they argued that thicker slices used in CT scan evaluation could have underestimated the prevalence of anterior clinoid process pneumatization rather than it being a difference in the populations being studied.

In the study by Vaezi A and colleagues they proposed the method of classification of the pneumatization of the sphenoid sinus in relation to the Vidian canal and foramen Rotundum (8). In their study, they found that type I existed in 25% of their subjects, type II in 39% and type III in 37% of their subjects. They further state that the classification is significant in planning for access to the middle cranial fossa. They note that there is increasing difficulty in accessing the middle cranial fossa in the order of type III, type II and type I respectively. They also noted that during the endonasal endoscopic approach of the middle cranial fossa in type I pneumatization, the Vidian nerve is sacrificed. This classification by Vaezi and colleagues could be adapted as a routine step in pre-operative analysis of patients undergoing sphenoid sinus and trans-sphenoidal surgery. This would also be helpful in preoperative counseling of patients in whom sacrifice of the Vidian nerve is anticipated.



Key

ocr- Optic-carotid recess

s- Sella turcica floor

V_2 – maxillary nerve

vn- **Vidian nerve**

Figure 6:Pattern of lateral pneumatization of the sphenoid sinus (8)

The table below shows the neuro-vascular structures closely related to the constituent parts of the sphenoid bone (6).

Table 2:The Neuro-vascular relations of the constituent parts of the sphenoid sinus

Sphenoid bone structure	Neuro-vascular structure
Anterior clinoid process	Optic nerve (optic canal), Internal carotid artery
Greater sphenoid wing	Maxillary nerve
Pterygoid recess	Internal carotid artery, Vidian nerve

Considering the neurovascular relations of the sinus, the potential complications arising from surgery involving the sphenoid sinus include intractable hemorrhage, blindness and neurological deficits resulting from injury to the Maxillary nerve and Vidian nerve (9).

A microsurgical study carried out on adult cadavers by Fujii and his associates showed that the narrowest portion of the sphenoid sinus wall was the anterior sellar wall (0.4mm) (13). The depth of the sinus was found to be 17.1mm (range of 12.0-23.0mm) and was defined as the

length from the sphenoid ostium to the closest part of the Sella. These dimensions bear significance during trans-sphenoidal endoscopic surgery.

2.3 Sphenoid Sinus Septation

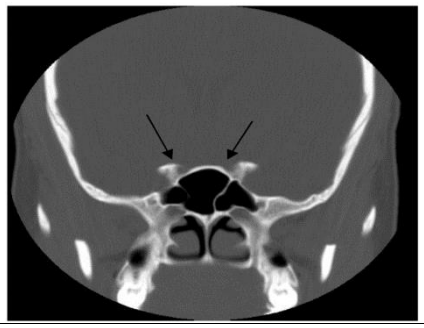
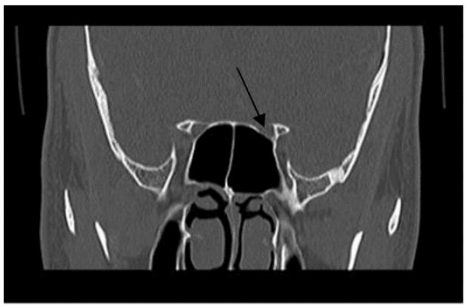
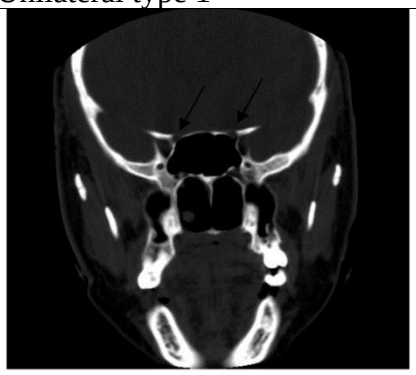
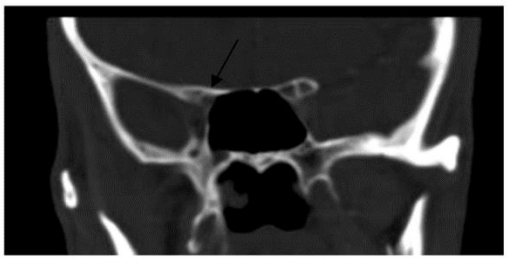
The sphenoid sinus invariably has a bony septum dividing it into a distinctive right and left compartment (10,11). There could be accessory septa (10,11). The septum can be attached to the sellar floor or the optic nerve (canal) or the internal carotid artery or the Vidian canal (12). A local study by Maalim F found sphenoid septation in 14% of his patients (14). The study, however, does not give further information as to the nature of sphenoid septation. The study also does not give details on the attachments of the septa. While the information regarding the sphenoid sinus in this study is limited, it is the only one available locally. No further studies have been done locally on the anatomy of the sphenoid sinus per se.

2.4 The Optic Nerve and the Sphenoid Sinus

DeLano et al described varied types of relations of the optic nerve to the sphenoid sinus. In their paper they characterized them into four types (20). In type I, the optic nerve passes adjacent to the superior or lateral wall of the sphenoid sinus without any indentation of the sphenoid sinus wall. Type II describes the course of the optic nerve causing an indentation on the lateral wall of the sinus. In type III the optic nerve traverses the sinus as opposed to running adjacent to it. Finally, in type IV, the nerve runs immediately lateral to the posterior ethmoidal sinus and the sphenoid sinus within the spheno-ethmoidal junction. In their study, majority of the patients had type I at 76% followed by type II at 15%, type III at 6% and type IV at 3% (20). Optic nerve dehiscence was most prevalent in type III optic nerves (100%) followed by type II (82%), then type I (7%) and finally type IV nerves. From these numbers, there seems to be a relationship between dehiscence of the optic nerve in relation to the type of DeLano classification of the optic nerve.

Batra P.S et al later modified the DeLano classification and its relation to the spheno-ethmoidal air cells (23). They described the relation of the optic nerve vis a vis the spheno-ethmoidal air cells as follows:

Table 3:Relation of the optic nerve vis a vis the spheno-ethmoidal air cell

Classification	Description	Image (21)
Type 0	The optic nerve does not border the sphepno-ethmoidal air cells	Bilateral type 0 
Type 1	Adjacent to the spheno-ethmoidal air cells	 Unilateral type 1
Type 2	Indenting the spheno-ethmoidal air cells	 Right-sided type 2 and left type 3
Type 3	Less than 50% exposure of optic nerve into the spheno-ethmoidal air cells	 Unilateral type 3
Type 4	Optic nerve traversing the spheno-ethmoidal air cells	 Bilateral type 4

In a study carried out on a Nigerian population, the optic nerve was defined as per the modified DeLano classification (21). Type 0 was found in 30%, type 1 in 31.8%, type 2 in 19.1%, type 3 in 13.6% and type 4 in 5.5% of the study population. When this is compared against the study by Batra P.S. et al, type 0 was found in 5.6%, type 1 in 58.3%, type 2 in 25%, type 3 in 2.8% and type 4 in 8.3% of the study population. This suggests that there could be some ethnic variations in the description of the optic nerve in relation to the sphenoid sinus.

2.5 Radiological Imaging of the Sphenoid Sinus

The earlier studies done on the sphenoid sinus were done by evaluating plain radiograph images of the paranasal sinuses (4). There is a limited role of plain radiographic imaging of the paranasal sinuses. This imaging modality can delineate the anatomy of the maxillary sinus, posterior ethmoid sinuses, sphenoid sinus, and the frontal sinus albeit without showing the adjacent neurovascular structures. This imaging modality also falls short in showing the anterior ethmoidal air cells and the upper nasal cavity (22).

The CT scan is the gold standard imaging modality for the visualization of the paranasal sinuses (14). Current developments in medical imaging technology allow for sagittal and coronal views to be reconfigured from axial slices alone. This helps in reducing radiation exposure to the patient undergoing evaluation. The various views of the sphenoid sinus allow to better visualize specific aspects of the sinus.

Coronal views give information regarding the lateral pneumatization of the sinus, the protrusion of the internal carotid artery, the maxillary nerve, the vidian canal and the optic nerve. The axial slices allow for visualization of the pattern of sphenoid sinus septation and the dehiscence of the ICA and optic nerve. The sagittal views are essential in characterizing the type of sphenoid sinus pneumatization in relation to the Sella turcica.

While various studies on the paranasal sinuses have used different slice thicknesses, the consensus is that for proper visualization of the sinuses, cuts less than 5mm thick should be taken (14,15,16). However, for greater detail appreciation, 3mm slices or less are recommended. The slices are taken on a plane that is parallel to the inferior orbito-meatal line (The Line of Frankfurt).

Magnetic resonance imaging (MRI) has some utility in visualization of the paranasal sinuses. It has excellent soft tissue delineation that is applicable in fungal rhinosinusitis and neoplastic diseases of the nose and the paranasal sinuses. The MRI also offers excellent visualization of neurovascular structures. The downside to this imaging is that it has poor visualization of bony structures, has limited availability and cost could be prohibitive in some settings (15, 22).

2.6 Ethnic Variation in The Anatomy of The Sphenoid Sinus

Ethnic variations in the anatomy of the sphenoid sinus have been shown from various studies involving different ethnic backgrounds. The ethnic variations of the sphenoid sinus anatomy have aptly been described by Anusha B et al in a study review (18). Their study revealed variation in the pneumatization patterns of the sphenoid sinus between Egyptian (76% pre-sellar, 24% sellar), Asian (pre-sellar 17%, sellar 55%) and Korean populations (conchal 1%, pre-sellar 9%, sellar 90%). When assessing optic nerve projection, they demonstrated that the Asian population had a significantly higher optic nerve projection into the sphenoid sinus (69%) compared to the Turkish population (31%). It is important to note, however, that the differences in the rates of optic nerve protrusion could be because of differences in definitions of optic nerve protrusion. In the Turkish population, protrusion was defined as bulging of more than 50% of the circumference of a neurovascular structure into the sphenoid sinus cavity. No specific definition was offered for the Asian population study.

Sareen D et al studied the anatomic variants of the sphenoid sinus and its relations in the Indian population (sample size 20 cadaveric specimen) (11). Their study suggested that there exist racial differences in the location of the relations of the sphenoid sinus. Of note, their research showed a variation in the location of the internal carotid artery. They noted that there was internal carotid artery dehiscence in 5% of their study population. However, their study does not mention internal carotid artery non-dehiscent bulges on the lateral sphenoid sinus wall. Their study seems to imply that the dehiscent internal carotid artery is synonymous with lateral wall impression of the carotid artery. Their study also notes that there was no optic nerve impression on the sphenoid sinuses among their study population.

2.7 Study Justification

With increasing endoscopic sinus surgery in the country and its utility in minimal access surgery of the anterior and middle cranial fossa, a firm understanding of the sphenoid sinus anatomy in the Kenyan population is important. There is an established ethnic variation in the sphenoid sinus anatomy. As a result, local data on the anatomy of the sphenoid sinus is needed for our local demography. This local data is limited. This study aims to provide that data and to describe the sphenoid sinus anatomy in the Kenyan population. The information derived from this study would add to the growing data on the variant anatomy of the sphenoid sinus vis a vis race. This data will in turn aid in safe sphenoid and trans-sphenoidal sinus surgery. The study will give the demographic characteristics of the patients with the various radiological variants of the sphenoid sinus.

2.8 Objectives

2.8.1 Broad Objective

To determine the variant anatomy of the sphenoid sinus as seen in patients above the age of 16 years undergoing paranasal CT scan evaluation at The Nairobi Hospital.

2.8.2 Specific Objectives

a) To determine the anatomical variants of the sphenoid sinus and its relations among patients undergoing paranasal sinus CT scan evaluation.
b) To determine the demographic characteristics (age distribution and sex) of patients undergoing paranasal sinus CT scan evaluation.
c) To determine the distribution of anatomical variants in relation to the demographic characteristics of patients undergoing paranasal CT scan evaluation (determine the variants present vis a vis the age and/or sex of the patients undergoing paranasal CT scan evaluation).

3.0 CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Design

This study was a descriptive cross-sectional study.

3.2 Study Setting

The study was carried out at the radiology department of The Nairobi hospital located on Argwings Kodhek road in Nairobi, Kenya. This facility is a private healthcare facility that predominantly serves the Kenyan population but also serves patients from other countries in Africa and the world. This center carries out an average of 120 CT scans of the paranasal sinuses per month.

3.3 Study Population

The study population was drawn from all the patients who were undergoing CT scan evaluation of the paranasal sinuses at the Radiology Department of The Nairobi Hospital. The definition of adult population included patients 18 years and above.

3.4 Inclusion Criteria

a) All patients above the age of 16 years undergoing paranasal CT scan evaluation at the Radiology department of The Nairobi Hospital.
b) Patients or patients whose guardians gave consent/assent to be included in the study.
c) Paranasal sinus CT scan images with 0.67-millimeter slice cuts

3.5 Exclusion Criteria

a) Patients with CT scan imaging evidence of endonasal endoscopic surgery involving the sphenoid sinus.
b) Patients with CT scan imaging evidence of facial and/or skull base fractures involving the sphenoid sinus.
c) Patients with CT scan imaging revealing masses involving the sphenoid sinus.

3.6 Sample Size

The sample size was calculated using the Cochrane's formula (16)

$$N = \frac{Z^2 P(1-P)}{d^2}$$

N=sample size

Z= statistic value for a desired level of confidence=1.96 for 90% power.

P=expected prevalence or proportion. From a previous study in Libya, ON protrusion was found in 9.5% of the population.

d=Precision, set at 0.05

substituting in the formula gives a sample size of 117 participants. This was rounded off to 123 participants.

3.7 Sampling Method

This study used consecutive sampling technique to recruit the study subjects.

3.8 Study Recruitment Procedure

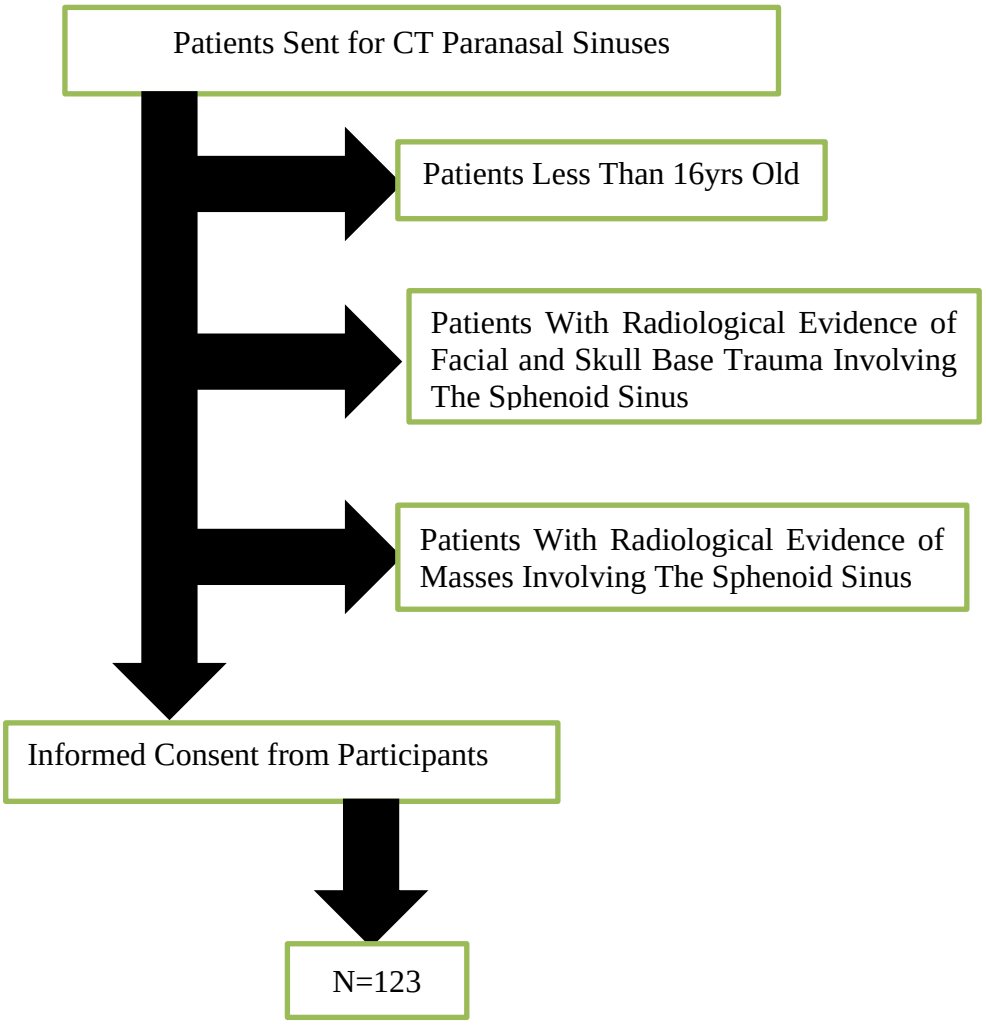


Figure 7:Study Recruitment Procedure

3.9 Study Period

The study was carried out over one year following ethics committee approval.

3.10 Data Management and Analysis

Data collected was checked, cleaned, categorized, and logged using the statistical analysis software package, SPSS version 22. The data was saved in a password-protected folder and uploaded to a cloud storage drive and backup was done daily to prevent missing entries. Measures of central tendency for example standard deviation and mean were used to describe variables with normal distribution while skewed distributions were described in terms of inter quartile ranges and medians.

Descriptive statistics such as frequencies and percentages were used to describe demographic characteristics like age and sex. Classification of the type of pneumatization of the sphenoid sinus in relation to the Sella turcica into: conchal, presellar and sellar were expressed as percentages. Frequencies and percentages were used to express classification of the extensions of sellar-type pneumatization into lateral and posterior.

Two types of posterior extension were considered according to the width between the posterior boundary of the sphenoid sinus and the clivus identified on the sagittal slices. The types were defined as complete for thickness < 2 mm and incomplete for clivus thickness ≥ 2 mm. The chi-square test was used for establishing associations between anatomical variants and gender, presence of septations with or without posterior extension and relationship between ON protrusion and ON dehiscence. Analysis of variance (ANOVA) was used to establish associations between anatomical variants and age. Comparison between right, left and bilateral types was done using the Fisher's exact test. Cut off for statistical significance was set at a P value of < 0.05 for a 95% confidence interval.

3.11 Materials and Equipment

The equipment that was used was:

a) Phillips Brilliance computed tomography scanner 64 slice. Model B64. Year of manufacture; 2009

3.12 Study Procedure

Patients were recruited from the Radiology department at The Nairobi Hospital. The patients were those who have been sent for CT scan evaluation of their paranasal sinuses. Prior to undergoing CT scan evaluation, the principal investigator explained the study to the patients

who meet the inclusion criteria of the study and took written consent (appendix I) to include the patients in the study. The study subjects were placed to lie supine in the CT scan machine. Axial cuts of the paranasal sinuses were taken with 0.67mm thickness from the roof of the Frontal sinus to the maxillary alveoli. Coronal and Sagittal views were then constructed by reformatting the axial scans for complete three-dimensional evaluation of the sphenoid sinus. The principal investigator and the same radiologist then reviewed the images using Picture Archiving Communication system (PACS) computer software. A data extraction questionnaire (Appendix II) was then be filled. There are no protocol modifications that were made in the imaging process for the purposes of this study.

3.13 Quality Control

The principal investigator recruited all the patients undergoing the study. Standard cuts of 1mm were obtained for the CT scan of the paranasal sinuses. The CT scan images were reviewed by the principal investigator and the same radiologist.

3.14 Ethical Considerations

The study was carried out after the approval of the Kenyatta National Hospital, University of Nairobi KNH-UoN ERC), and The Nairobi Hospital ethics committees. Only patients who had given written informed consent were included in the study after being given detailed information on the scope of the study. No extra financial costs were incurred by the patients who were recruited into the study. Patient confidentiality was maintained through coded data and secure storage of patient data. There was no monetary gain by the principal investigator from this study. There was no penalty incurred by the patients who declined to be included into the study. The study results shall be published in peer review journals and presented at various scientific fora to benefit the scientific community and the public.

4.0 CHAPTER FOUR: RESULTS

4.1 Demographics

A total of 123 patients were recruited into this study. Males constituted 44.7% (55) and females 55.3% (68). Mean age of the patients was 43.9 years ± 14.3 years and ranged from 18 years to 80 years.

Table 4:Age distribution of patients undergoing CT scan of the paranasal sinuses

Age (in yrs.)	Frequency (N)	Percentage
≤30	23	18.7
31-40	29	23.6
41-50	31	25.2
51-60	20	16.3
61-70	14	11.4
≥71	6	4.9
Total	123	100.0

4.2 Pneumatization

The most common (87.8%) type of sphenoid sinus pneumatization was sellar with the most common (65.7%) being the complete sellar variant as represented below. There was no conchal variant of sphenoid pneumatization that was seen in the study population.

Table 5:Variation of the sphenoid sinus pneumatization in relation to the sellar turcica

Variable	Categories	Frequency(N)	Percentage (%)
Variant type	Presellar	15	12.2
	Sellar	108	87.8
Sellar variant	Incomplete	37	34.3
	Complete	71	65.7

The complete sellar variant was more common in the male patients (P value = 0.03).

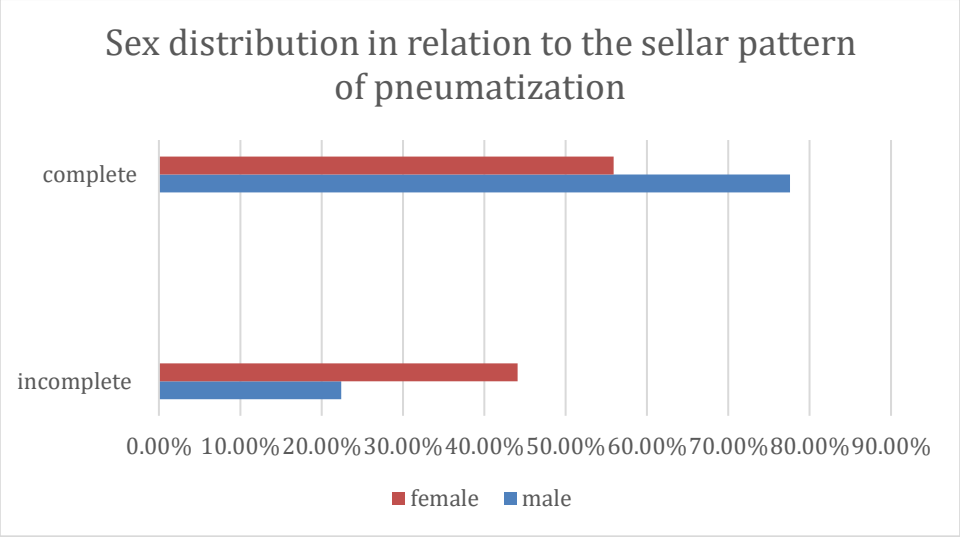


Figure 8::Sex distribution in relation to the sellar pattern of pneumatization

When the pattern of pneumatization into the greater wing of sphenoid was assessed, it was noted that there was an almost equal distribution among type 1, type 2 and type 3. There was no pneumatization into the anterior clinoid process and the pterygoid plates in 78.9% and 74.8% of the study subjects respectively.

Table 6:Sphenoid sinus pneumatization into the constituent parts of the sphenoid bone

Pneumatization			
Variable	**Categories**	**Frequency(N)**	**Percentage (%)**
Anterior clinoid process	None	97	78.9
	Left	6	4.9
	Right	10	8.1
	Bilateral	10	8.1
Right side pneumatization of greater wing of sphenoid type	None	2	1.6
	Type 1	40	32.5
	Type 2	41	33.3
	Type 3	40	32.5
left side pneumatization of greater wing of sphenoid type	None	2	1.6
	Type 1	42	34.1
	Type 2	39	31.7
	Type 3	40	32.5
Pterygoid process pneumatization	None	92	74.8
	Left	8	6.5
	Right	8	6.5
	Bilateral	15	12.2

The mean distance between sphenoid sinus and clivus was 4.2±6.0 and ranged from 0.34 to 45.4.

4.3 Septation of the Sphenoid Sinus

Out of the 123 sphenoid sinuses studied, 120 (97.6%) were found to have septation while 3 (2.4%) were found to have no septation. Out of the 120 sphenoid sinuses that had septa, 26.8% were attached to the optic nerve and 44.5% were attached to the Carotid artery prominence.

Table 7:Attachment of septa to neurovascular structures

Attachment of septa to neuro-vascular structures			
Variable	**Categories**	**Frequency(N)**	**Percentage (%)**
Optic nerve	No	90	73.2
	Yes	33	26.8
Carotid artery	No	67	55.5
	Yes	56	44.5

Out of the sinuses that had septation attached to the optic nerve, 18 (54.54%) of the sinuses were from female patients and 15 (45.45) were from male patients (P=1.00).

Table 8:Sex distribution of attachment of septa to optic nerve

		Attachment To Optic Nerve		**Total**	**P value**
		Absent	Present		
Gender	Female	50	18	68	1.00
	Male	40	15	55	
Total		90	33	123	

Out of the 56 sinuses that had septation attached to the Carotid artery, 32 (57.14%) were from females and 24 (42.86%) were from males (p value= 0.14).

4.4 Protrusion of Neurovascular Structures into the Sphenoid Sinus

The protrusion of neurovascular structures adjacent to the sphenoid sinus was assessed. There was no protrusion of the internal carotid artery in 52.8% of the sphenoid sinuses studied. Of the remaining 47.2% that had protrusion, 8.9% had only left-sided protrusion, 13% had only right-sided protrusion and 25.2% had bilateral protrusion. There was bilateral paraclival ICA protrusion in 12.2%, only left-sided in 6.5%, only right-sided in 2.4% and no paraclival protrusion in 78.9% of the sphenoid sinuses. The parasellar ICA exhibited protrusion on the left side only, right side only and bilaterally in 9.8%, 13% and 21.1% respectively with no protrusion in 56.1% of the sphenoid sinuses.

Table 9: Protrusion of the ICA into the sphenoid sinus

Variable	Protrusion		
	Categories	Frequency	Percentage
Internal carotid artery	None	65	52.8
	Left	11	8.9
	Right	16	13.0
	Bilateral	31	25.2
Paraclival internal carotid artery	None	97	78.9
	Left	8	6.5
	Right	3	2.4
	Bilateral	15	12.2
Parasellar ICA	None	69	56.1
	Left	12	9.8
	Right	16	13.0
	Bilateral	26	21.1

When the sex distribution of ICA protrusion was studied, it was noted that out of the 58 sinuses (47.15%) that had ICA protrusion, 32 (55.17%) of the sinuses were from the male population while 26 (44.83%) were from the female population (P=0.14).

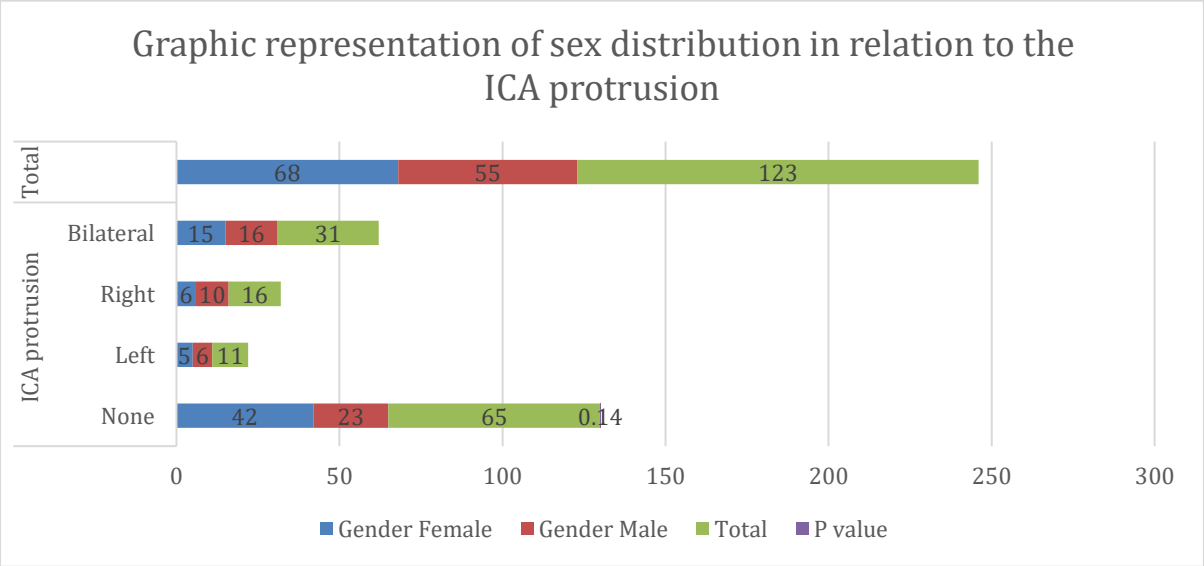


Figure 9:Graphic representation of sex distribution in relation to the ICA protrusion

Optic nerve protrusion was noted in 121 of the sphenoid sinuses studied. This represented 98.4% of the sphenoid sinuses studied. The most common type of protrusion of the optic nerve was type 1 with 43.9% on the left and 40.7% on the right. The other types of optic nerve protrusion were represented as below.

Table 10:Types of Optic nerve protrusion into the sphenoid sinus

Variable	Optic nerve protrusion types		
	Categories	**Frequency**	**Percentage**
Optic nerve protrusion type on the left	Type 0	37	30.1
	Type 1	54	43.9
	Type 2	16	13.0
	Type 3	10	8.1
	Type 4	6	4.9
Optic nerve protrusion type on the right	Type 0	39	31.7
	Type 1	50	40.7
	Type 2	18	14.6
	Type 3	14	11.4
	Type 4	2	1.6

Maxillary nerve protrusion was noted in 38.1% of the sphenoid sinuses. Protrusion was noted on the left in 9 (7.3%) sphenoid sinuses, on the right in 7 (5.7%) sphenoid sinuses and bilateral in 22 (17.9%) sphenoid sinuses. Majority of the sphenoid sinuses were noted not to have protrusion of the maxillary nerve into the sinus accounting for 61.9% of the sinuses studied.

Table 11:Maxillary nerve protrusion into the sphenoid sinus

Variable	**Categories**	**Frequency**	**Percentage**
Maxillary nerve	None	85	61.9
	Left	9	7.3
	Right	7	5.7
	Bilateral	22	17.9

Vidian canal protrusion was noted in 60 sphenoid sinuses. Majority of the ones that exhibited protrusion of the Vidian canal had bilateral protrusion (44) with 6 sinuses showing protrusion on the left and 10 on the right.

Table 12:Vidian nerve protrusion into the sphenoid sinus

Variable	**Categories**	**Frequency**	**Percentage**
Vidian nerve	None	63	51.2
	Left	6	4.9
	Right	10	8.1
	Bilateral	44	35.8

4.5 Dehiscence of Adjacent Neurovascular Structures

Dehiscence of the optic nerve was noted in 13 (10.6%) sphenoid sinuses with 7 (5.7%) being bilateral, 4 (3.3%) on the right and 2 (1.6%) on the left. 89.4% of the sinuses studied did not exhibit dehiscence of the optic nerve.

Table 13:Optic nerve dehiscence in relation to Optic nerve protrusion

		Dehiscence				Total	P-Value
		None	Left	Right	Bilateral		
Optic Nerve Protrusion	None	2	0	0	0	2	1.00
	Bilateral	108	2	4	7	121	
Total		110	2	4	7	123	

From the table above, 108 sphenoid sinuses had optic nerve protrusion but only 13 (12.04%) sinuses exhibited optic nerve dehiscence (p= 1.00).

Maxillary nerve dehiscence was noted in 7 (5.69%) of the sphenoid sinuses studied with 2 (1.63%) showing dehiscence on the left, 4 (3.25%) on the right and 1 (0.81%) having bilateral dehiscence. Vidian nerve dehiscence was seen in 5 (4.07) of the sphenoid sinuses studied with 2 (1.63) on the right and 3 (2.44%) showing bilateral Vidian nerve dehiscence.

Table 14:Vidian nerve dehiscence

Variable	**Dehiscence**		
	Categories	**Frequency**	**Percentage**
Maxillary nerve	None	116	94.3
	Left	2	1.6
	Right	4	3.3
	Bilateral	1	0.8
Vidian nerve	None	118	95.9
	Left	00	00
	Right	2	1.6
	Bilateral	3	2.4

There was no ICA dehiscence demonstrated in this study.

5.0 CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Demographics

Majority (55.3%) of the patients recruited in this study were female. This might not be of significant value considering that the sampling technique was convenient sampling. The sample population varied from 18 years to 80 years, however, most (48.8%) of the patients recruited in the study had ages ranging from 31 years to 50 years.

5.1.2 Septation

The sphenoid sinus invariably (97.6%) has septa. This is true when compared to other studies done worldwide (10,11). There, however, seems to be a great disparity between this study and that done by Maalim F where only 14% of the patients he studied had sphenoid sinus septation (14). There is no clear explanation to the great variation considering the demographics of the patients being studied were similar. It is important, however, to note that this study used 0.67mm-cuts CT scans while that of Maalim used 3mm cuts. Thin imaging slices give greater detail compared to thick slices. This study looked at the sphenoid sinus in detail while that by Maalim included 100 subjects and looked at the variant anatomy of the paranasal sinuses in general. Both studies were radiological studies.

Majority of the subjects did not have the sphenoid sinus septa attached to the ON (73.2%) or the ICA (55.5%). There also appears to be no sex predilection in relation to attachment of the sphenoid sinus septa to the internal carotid artery and the optic nerve. This is contrasted against the study done by Batra P.S et al which was a radiological study done on cadavers where the results showed that 37.5% of the sinuses, they studied had attachment of septa to the ICA (3). The study by Batra P.S et al used 1mm-CT scan cuts while this study used 0.67mm cuts.

5.1.3 Pneumatization

This study greatly aligns with that done by Hammer G and Radberg C that showed majority (59%) of their population had sellar variant type of pneumatization (4). The study by Hammer G et al was a cadaveric study that was conducted by both anatomic dissection of the sphenoid sinus and radiological study using roentgenograms on 120 specimens.

The findings of this study mirror those of a review done by Anusha B. et al that encompassed the Egyptian and Korean communities: the review included both cadaveric dissections and

radiological studies (18). The findings in this study mirror that of the Korean population (conchal 1%, pre-sellar 9%, sellar 90%) as demonstrated by Anusha B et al but widely varies from that of the Egyptian (76% pre-sellar, 24% sellar) population which found the most prevalent type of pneumatization to be the pre-sellar variant. While this study was conducted amongst the Kenyan population, it did not consider the race or ethnicity of the patients. This study has further shown that the complete sellar variant is more common in males (77.6%) than it is in females (55.9%) among the patients studied.

A radiological study done by Vaezi et al on 204 hemi-sinuses described a classification of the lateral pneumatization of the sphenoid sinuses (8). They found an almost equal distribution of the pattern of lateral pneumatization of the sphenoid bone into the greater wing of the sphenoid. In their study, they found that 25% of the subjects had type I, 39% had type II and 37% had type III. The results of our study do not vary widely from the one by Vaezi et al with 32.5% of the subjects having type I on the right sphenoid sinus, 33.3% had type II and type III in 32.5% and in the left type I was seen in 34.1%., type II in 31.7% and type III in 32.5% of the subjects. Our study differs from a radiological study done amongst the Libyan population that found Pterygoid plate pneumatization in 29% of their study population (n=300) (6). This is contrasted against 12.2% of our study population. This points towards another ethnic variation in the anatomy of the sphenoid sinus. However, it is important to consider that the Libyan study used 2mm-cut CT scans compared to 0.67mm cuts used in this study.

5.1.4 Sphenoid Sinus and Its Relation to Adjacent Neurovascular Structures

The most common types of ON protrusion into the sphenoid sinus found in this study were type 0 (left-30.1%, right 31.7%) and type 1 (left 43.9%, right 40.7%). This compares to the study done in the Nigerian population (type 0-30.8%, type 1-31.8%) and varies from that done by Batra P.S et al (21,23). In the study by Batra P.S et al, the most common types of ON protrusion were type I (58.3%) and type II (25%). Our study used CT scans with 0.67 mm-cuts while that by Batra P. S et al and that done on the Nigerian population used 1mm and 3mm-cut CT scans respectively.

Dehiscence of the adjacent neurovascular structures was an uncommon finding in this study. There was dehiscence of the optic nerve in 10.6%, maxillary nerve dehiscence in 5.7% and vidian nerve dehiscence in 4.1% of the sphenoid sinuses with no dehiscence of the ICA. This differs from the study done by Sareen D et al that showed ICA dehiscence in 5% of their study population (11). The study by Saren D et al was a cadaveric dissection study involving 20 cadavers. Furthermore, this study does not show a significant correlation between ON protrusion and ON dehiscence (p=1.00).

5.2 Conclusion

This study demonstrates that there exists variant anatomy of the sphenoid sinus. The most common type of sellar variant in the studied population is the complete sellar variant. The complete sellar variant is more common in males than it is in females. Understanding this anatomy then becomes paramount in performing safe surgery of the sphenoid sinus and transsphenoidal sinus surgery. Particularly, understanding the anatomy of the two most crucial structures adjacent to the sphenoid sinus, the Optic nerve and the Internal Carotid artery, allows for safe surgery.

5.3 Recommendation

The variant anatomy of the sphenoid sinus should be studied in detail, preoperatively. This would be important in guiding the otorhinolaryngologists, neurosurgeons and any other healthcare practitioners performing surgery in and around the sphenoid sinus. By identifying the variant anatomy, one can offer safe surgery by avoiding potential adverse effects like blindness and severe hemorrhage.

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APPENDICES

Appendix I: Participant Information and Consent Form

CONSENT FOR ENROLLMENT IN THE STUDY

Title of Study: **THE VARIANT ANATOMY OF THE SPHENOID SINUS AS SEEN IN PATIENTS UNDERGOING PARANASAL SINUS COMPUTED TOMOGRAPHY IMAGING AT THE NAIROBI HOSPITAL**

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Introduction:

I would like to tell you about a study being conducted by the above listed researchers. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide to be in the

study or not. This process is called 'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in medical research:

i) Your decision to participate is entirely voluntary

ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal

iii) Refusal to participate in the research will not affect the services you are entitled to in this health facility or other facilities. We will give you a copy of this form for your records.

May I continue? YES / NO

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No. _____

What Is This Study About?

The researchers listed above are interviewing individuals who undergo CT scan evaluation of the paranasal sinuses. The purpose of the study is to find out the differences in the sphenoid sinuses of the various participants who will be recruited in this study. Participants in this research study will have their CT scans examined and data from their CT scans will be extracted regarding the anatomy of the sphenoid sinus.

There will be approximately 117 participants in this study randomly chosen. We are asking for your consent to consider participating in this study.

What Will Happen If You Decide to Be in This Research Study?

If you agree to participate in this study, the following things will happen:

Your CT scan images of your paranasal sinuses will be studied by the principal investigator with the help of one of the co-investigators (radiologist). The images will be evaluated for the type of the sphenoid sinus pneumatization and the relations of the sphenoid sinus. We will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include clarifying details of your past medical history.

Are There Any Risks, Harms Discomforts Associated with This Study?

Medical research has the potential to introduce psychological, social, emotional and physical risks. Effort should always be put in place to minimize the risks. One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify you in a password-protected computer database and will

keep all our paper records in a locked file cabinet. However, no system of protecting your confidentiality can be secure, so it is still possible that someone could find out you were in this study and could find out information about you.

Also, answering questions in the interview may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

Furthermore, all study staff and interviewers are professionals with special training in these examinations. In case of an injury, illness or complications related to this study, contact the study staff right away at the number provided at the end of this document. The study staff will treat you for minor conditions or refer you when necessary.

Are There Any Benefits Being in This Study?

We will refer you to a hospital for care and support where necessary. Also, the information you provide will help us better understand the anatomy of the Sphenoid sinus. This information is a contribution to science and medicine.

Will Being in This Study Cost You Anything?

No additional costs will be incurred because of being recruited in this study

Will You Get Refund for Any Money Spent as Part of This Study?

There shall be no refunds because of being recruited in this study

What If You Have Questions in Future?

If you have further questions or concerns about participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. (020) 318262 Ext. 28250 email principal-cae@uonbi.ac.ke or P.O Box 30197-00100 Nairobi, Kenya.

The study staff will pay you back for your charges to these numbers if the call is for study-related communication.

What Are Your Other Choices?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without injustice or loss of any benefits.

Consent Form (Statement of Consent)

Participant's statement

I have read this consent form or had the information read to me. I have had the chance to discuss this research study with a study counsellor. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study.

I understand that all efforts will be made to keep information regarding my personal identity confidential.

By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: Yes No

I agree to have CT scan images preserved for later study: I agree to provide contact: Yes, No information for follow-up: Yes No

Participant printed name: _____

Participant signature / Thumb stamp _____ Date _____

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Researcher 's Name: _____ Date: _____

Signature

_____

Role in the study: _____

For more information contact **Dr. Allan Gray Mukuzi on 0727386138 or drgraymukuzi@gmail.com.**

Witness Printed Name (If witness is necessary, A witness is a person mutually acceptable to both the researcher and participant)

Name _____

Contact information _____ Signature /Thumb stamp: _____

Date; _____

Idhini Kwa Kiswahili

Fomu Ya Idhini

Fomu hili lina sehemu tatu

I. Maelezo ya Mtafiti Mkuu na utafiti

II. Fomu ya Idhini

III. Kiapo cha Mtafiti

(i) Sehemu ya kwanza –Maelezo ya Mtafiti Mkuu na utafiti.

Mimi ni Dkt. Allan Gray Mukuzi, kutoka chuo kikuu cha Nairobi, Shule ya Utabibu, Idara ya upasuaji, sehemu ya ENT. Ninafanya utafiti wa kubainisha "THE VARIANT ANATOMY OF THE SPHENOID SINUS AS SEEN ON PARANASAL SINUS COMPUTED TOMOGRAPHY IMAGING AT THE NAIROBI HOSPITAL" yani, kubainasha maumbile zisio za kawaida katika mfupa wa pua kulingana na picha spesheli aina ya CT scan. Utafiti huu unaangalia umbo la mfupa wa pua na kudhibitisha tofauti zinazopatikana katika mfupa huu bila tofauti hizi kuwa na magonjwa haswa. Tofauti hizi mara nyingi hufanya upasuaji wa mfupa huu wa pua na ubongo kuwa mgumu zaidi. Kujua tofauti hizi kutasaidia katika kupanga upasuaji wa mfupa huu na kupunguza madhara ya upasuaji ambayo yanaweza kuletwa na tofauti hizi.

Ningependa kukuchagua / kuchagua mtoto wako katika utafiti huu. Kukubali kwako ni kwa hiari yako. Kukataa kwako hakutadhuru matibabu unayopata/ mtoto wako anafaa kupata, hautakatazwa matibabu kwa sababu ya kukataa kushiriki utafiti huu.

Kushiriki utafiti huu hakutakudhuru au kudhuru mtoto wako kwa njia yoyote kwani kile kinachohitajika ni picha ya CT scan ya mfupa wa pua ambao umefanywa au utafanywa kulingana na maagizo ya daktari wako.

Habari zozote zitakazokusanywa kutoka kwako zitashughulikiwa kwa usiri na hazitasambazwa kwa yeyote ila tu kwa ruhusa kutoka kwa kamiti kuu ya utafiti ya chuo kikuu cha Nairobi, hospitali kuu ya Kenyatta (KNH/UON ERC) na Nairobi Hospital.

(ii) Sehemu ya pili– Idhini ya mgonjwa

Mimi (Jina)..... / Mzazi

wa..... kwa hiari yangu, nimekubali kushiriki/

kushirikisha mtoto wangu katika utafiti huu ambao unafanywa na Daktari Allan Gray Mukuzi. Nimeelezewa manufaa na madhara ya utafiti huu kwa undani na nimeyaelewa.

Jina la Mgonjwa/ Mzazi.....

Sahihi.....

Tarehe.....

Siku/Mwezi/Mwaka

Nambari ya utafiti.....

Nambari ya picha.....

Jina la Shahidi.....

Sahihi.....

Tarehe.....

(Siku/Mwezi/Mwaka)

Unaweza kupata uchambuzi wa utafiti huu na maelezo zaidi kutoka kwa:

Katibu wa utafiti,

Hospitali kuu ya Kenyatta na Chuo kikuu cha Nairobi (KNH/UON ERC).

Sanduku la Posta 30197 00100.

KNH, Nairobi, Kenya

Nambari ya simu: 254721257746, (020) 318262 Ext 28250

Barua pepe principal-cae@uonbi@ac.ke.

Dkt. Allan Gray Mukuzi

Nambari ya simu: 0727386138

Barua pepe: drgraymukuzi@gmail.com

Appendix II: Assent form (English)

I ……. voluntarily assent to the participation by my minor in the study conducted by the principal investigator **DR. ALLAN GRAY MUKUZI**, whose nature has been clearly explained to me. I understand that participation is entirely of my own free will. I understand that if I wish, I may freely withdraw my minor from this study and this will not have any effect on the care offered to him/her. I understand that the study results can directly benefit me, my kin and/or other patients.

Signature/ Left thumb print (self)……
Witness Name…….
Signature…….. Date……..

Appendix III: Assent form (Swahili)/ Fomu ya Makubaliano

Mimi…….
ninathibitisha ya kwamba nimeelewa habari kuhusu utafiti kama ilivyotolewa na mtafiti mkuu, **DKT. ALLAN GRAY MUKUZI** na ninakubali kushiriki kwa mtoto wangu kwa hiari yangu. Ninathibitisha ya kwamba nimepata nafasi ya kuuliza maswali ambayo mtafiti amejibu kwa kuridhika kwangu. Ninaelewa kuwa ushiriki huu ni wa hiari yangu na kwamba ninaweza kumuondoa mshiriki kutoka kwa utafiti wakati wowote bila kulazimika kutoa sababu. Ninaelewa kuwa matokeo ya utafiti yanaweza kumfaidi mshiriki au wagonjwa wengine.

Jina la mshirika…….
Sahihi ya mshirika…….
Tarehe……

Appendix IV: Data Collection Tool

Serial Number	

Age

Gender

Sphenoid sinus variant

Conchal	
Presellar	
Sellar	

Complete	incomplete

Septation

Present	
Absent	

Attachment to septa and neurovascular structures

Optic Nerve	

Carotid artery's prominence	

Pneumatization

Anterior clinoid Process

Left		Right		Bilateral	

Greater wing of the sphenoid

Left		Right		Bilateral	

Pterygoid process

Left		Right		Bilateral	

Lesser wing of the sphenoid

Left		Right		Bilateral	

Posterior extension

Distance between sphenoid sinus and clivus(mm) |

Protrusion

Internal carotid artery

Left		Right		Bilateral	

Paraclival ICA

Left		Right		Bilateral	

Parasellar ICA

Left		Right		Bilateral	

Optic Nerve

Left		Right		Bilateral	

Maxillary nerve

Left		Right		Bilateral	

Vidian Nerve

Left		Right		Bilateral	

Dehiscence

Internal carotid artery

Left		Right		Bilateral	

Optic Nerve

Left		Right		Bilateral	

Maxillary nerve

Left		Right		Bilateral	

Vidian Nerve

Left		Right		Bilateral	

Appendix V: Nairobi Hospital -ERC Approval

THE NAIROBI HOSPITAL

REF: TNH/DCS/DMSR/ERC/15/11/22

15th November 2022

TO: Dr. Allan Gray Mukuzi
Principal Investigator

Dear Dr Mukuzi,

RE: THE VARIANT ANATOMY OF THE SPHENOID SINUS AS SEEN IN PATIENTS ABOVE THE AGE OF 16 YEARS UNDERGOING PARANASAL SINUS COMPUTED TOMOGRAPHY IMAGING AT THE NAIROBI HOSPITAL

This is to inform you that *The Nairobi Hospital Ethics & Research Committee* has reviewed and approved your above research proposal. Your application approval number is *TNH-ERC/DMSR/ RP/046/22*. The approval period is *15th November 2022 – 15th November 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 *The Nairobi Hospital Ethics & Research Committee*
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 *The Nairobi Hospital Ethics & Research Committee* within 24 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 *The Nairobi Hospital Ethics & Research Committee* 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 *The Nairobi Hospital Ethics & Research Committee.*
viii. Compliance with the guidelines and regulations stipulated by the study site authorization

Healthcare with a difference!

P.O. Box 30026 - 00100 Nairobi, Kenya | Tel: +254 020 2845000 | Fax: +254 020 2728003
Email: hosp@nbihosp.org | Website: www.nairobihospital.org

Appendix VI: KNH/UoN -ERC Letter of 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/350

16th September, 2022

Dr. Allan Gray Mukuzi
Reg. No.H58/11663/2018
Dept. of Surgery
Faculty of Health Sciences
University of Nairobi

Dear Dr. Mukuzi

RESEARCH PROPOSAL: THE VARIANT ANATOMY OF THE SPHENOID SINUS AS SEEN IN PATIENTS ABOVE THE AGE OF 16 YEARS UNDERGOING PARANASAL SINUS COMPUTED TOMOGRAPHY IMAGING AT THE NAIROBI HOSPITAL (P37/01/2022)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P37/01/2022.** The approval period is 16th September 2022 – 15th September 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.

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 Assistant Director, Health Information Dept., KNH
The Chairperson, KNH- UoN ERC
The Chair, Dept. of Surgery, UoN
Supervisors: Dr. Peter Mugwe, Dept. of Surgery, UoN
Dr. Catherine Irungu, Dept. of Surgery, UoN
Dr. Jennifer Nabaweesi Batuka, Radiology Department, The Nairobi Hospital

Appendix VII: Certificate of Plagiarism

The Variant Anatomy Of The Sphenoid Sinus As Seen In Patients Undergoing Paranasal Sinus Computed Tomography Imaging At The Nairobi Hospital

ORIGINALITY REPORT

11%	2%	9%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	B. Anusha, A. Baharudin, R. Philip, S. Harvinder, B. Mohd Shaffie. "Anatomical variations of the sphenoid sinus and its adjacent structures: a review of existing literature", Surgical and Radiologic Anatomy, 2013 Publication	1%
2	erepository.uonbi.ac.ke Internet Source	1%
3	Albert L. Rhoton. "The Sellar Region", Neurosurgery, 2002 Publication	1%
4	Guldner, C., S. M. Pistorius, I. Diogo, S. Bien, A. Sesterhenn, and J. A. Werner. "Analysis of pneumatization and neurovascular structures of the sphenoid sinus using cone-beam tomography (CBT)", Acta Radiologica, 2012. Publication	1%
5	www.mdpi.com	