COMPUTED TOMOGRAPHY PATTERN OF ANATOMICAL VARIANTS AMONG PATIENTS UNDERGOING TRANSNASAL TRANSSPHENOIDAL ENDOSCOPIC SURGERY FOR PITUITARY MACROADENOMA AT MUHIMBILI ORTHOPEDIC INSTITUTE

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Degree of Master of Medicine (Radiology) of
Muhimbili University of Health and Allied Sciences
October, 2021

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DEPARTMENT OF RADIOLOGY AND IMAGING

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By

Mwanaabas Sued (MD)

A Dissertation Submitted in (Partial) Fulfillment of the Requirement for the Degree of Master of Medicine (Radiology) of Muhimbili University of Health and Allied Sciences

October, 2021

CERTIFICATION

The undersigned certify that he has read and hereby recommend for acceptance by Muhimbili University of Health and Allied Sciences a dissertation entitled **"Computed Tomography pattern of anatomical variants among patients undergoing Transnasal Transsphenoidal Endoscopic Surgery for pituitary macroadenoma at Muhimbili Orthopedic Institute",** in (Partial) Fulfillment of the requirements for the degree of Master of Medicine (Radiology) of Muhimbili University of Health and Allied Sciences.

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DECLARATION AND COPYRIGHT

I, **Mwanaabas Sued**, declare that this dissertation is my own 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.

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DEDICATION

This work is dedicated to

My beloved husband Abbas J. Simkoko for the love, care and support.

Our adorable daughters Alyssa & Amelya for their unconditional love and understanding

My dearest mother Amina Kilasa for her endless love, care and support.

My guardian parents Mr and Mrs Idrisa Mwaisaka for the love, support and encouragement.

My mother in law, Mrs Suby Simkoko and her family for their endless love and support

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LIST OF ABBREVIATIONS:

BMI	-	Body Mass Index
CSF	-	Cerebrospinal fluid
CT	-	Computed Tomography
EETA	-	Endoscopic Endonasal Transphenoidal Approach
ICA	-	Internal carotid artery
ISS	-	Intersphenoid septum
LT	-	Left
MAMC	-	Muhimbili Academic Medical Centre
MOI	-	Muhimbili Orthopedic Institute
MUHAS	-	Muhimbili University of Health and Allied Sciences
MR	-	Magnetic Resonance
MRI	-	Magnetic Resonance Imaging
RT	-	Right
SS	-	Sphenoid sinus
SPSS	-	Statistical Package for Social Sciences
TTES	-	Transnasal transsphenoidal endoscopic surgery

ABSTRACT

Background

Transnasal Transsphenoidal Endoscopic Surgery has become the most common choice to treat skull base lesions including pituitary macroadenoma. Its suitability depends on anatomical variants such as sinonasal variants, the extent of sphenoid sinus pneumatization and bone coverage of cavernous portion of ICA. CT scans have proven to be vital and sufficient in imaging of the paranasal sinuses since it provides excellent contrast as well as sinonasal anatomic details. Hence it is important to careful evaluate these variants preoperatively by CT scan for lesser intra and postoperative complications.

Objective

The study was conducted in particular to assess anatomic variants among adult patients with pituitary macroadenoma planned for TTES at MOI from October 2020 to April 2021.

Methodology

This was a hospital based descriptive prospective cross-sectional study of all adult patients who were diagnosed with pituitary macroadenoma by both CT and MRI. It was done at MOI in the Neurosurgical and Radiology Departments using a structured questionnaire/checklist data collection tool. Information included socio-demographics and CT Head findings of sinonasal variants, sphenoid sinus pneumatization types and bony coverage of cavernous portion of ICA in relation to TTES. CT scan imaging was done using Siemens CT Somatom Definition 128slices, manufactured by Siemens in Germany. Data analysis was done using SPSS version 23 and summarized using tables and figures. The observed differences were considered significant at p value < 0.05.

Results

A total of 103 patients diagnosed with pituitary macroadenoma by CT/MRI were enrolled, males were 46 (44.66%) and females were 57 (55.34%). Age ranged between 18-95 years with mean age of 48.11 years. Among the sinonasal variants studied, majority of the patients had deviated intersphenoid septum (ISS) accounting for 60 patients (58.25%) and the least was

Onodi cells observed among 4 patients (3.88%). The commonest type of sphenoid sinus pneumatization was sellar observed among 92 patients (90.3%). Bilateral partial bony coverage of cavernous ICA was observed among 22 patients (21.4%).

Conclusion

CT scan plays an important role in the assessment of anatomic variants in the nasal cavity and the SS as far as TTES is concerned so as to make preoperative imaging evaluation not only crucial for diagnosis but also valuable for surgical mapping to ensure safe access and improved surgical outcomes. Therefore, the role of both the radiologists and neurosurgeons is to carefully evaluate them for a desirable outcome.

Recommendation

CT scan is mandatory and a necessary tool for evaluation of anatomical variants prior to undergoing TTES. Hence it is a role of every radiologist to report these variants in all patients with pituitary macroadenoma.

CHAPTER ONE

1.0 INTRODUCTION

Definition of key terms

Anatomic variants in relation to Transnasal Transsphenoidal Endoscopic Surgery refers to the deviation from the normal anatomic structure which may hinder instrumentation through the nostrils towards the sphenoid sinus for the purpose of excising sellar tumors.[1]

Bony dehiscence of ICA is similar to partial bony coverage [32]

Concha bullosa refers to pneumatization of middle turbinate[2]

Endoscopic surgery is a minimally invasive procedure which is performed with a thin, flexible tube with a video camera through a small incision or a natural orifice. It allows a surgeon to see inside the patient's body without making major incisions, allowing for easier recovery time, less pain and discomfort.[3]

Pituitary adenomas are primary neuroendocrine tumors arising from the pituitary gland. [4]

Pituitary macroadenomas are pituitary adenomas greater than 10 mm in size [4]

Sphenoid sinus is a mucosa-lined, variably pneumatized posterior extension of the paranasal sinuses located within the middle cranial fossa at the sphenoid bone [5]

Sphenoid sinus pneumatization refers to the extent of how the sphenoid sinus is aerated being the three patterns according to Hammer, Radberg and Hamberger: type I concha, type II presellar and type III sellar type. The sellar type is further subdivided into incomplete and complete pattern [6][7]

Transnasal means through the nose

Transnasal Transsphenoidal Endoscopic Surgery is an endoscopic surgery which involves excision of pituitary tumors by passing through the nasal cavity through the sphenoid sinus and finally into the sellar region. [7]

1.1 BACKGROUND

Ever since the first report of successful endonasal endoscopic resection of pituitary adenomas, this type of surgery has become the most common choice to neurosurgeons and otolaryngologists in treating skull base lesions [8]–[12]. The use of an endoscope in Transsphenoidal approaches represents a substantial advantage in management of skull base lesions, endoscopic surgery of the cadaver head, and use of image guidance during surgery [13][14].

Fluoroscopy was formerly used as the primary image-guidance technique, but currently Computed Tomography or Magnetic Resonance Imaging with multiplanar reconstructions is used preoperatively because of higher anatomic resolution[15]. CT Scan have proven to be vital and sufficient in imaging of the paranasal sinuses as it provides excellent contrast as well as sinonasal anatomic details [16]. CT is also useful in detecting and delineating bone landmarks and anatomic variants that facilitate safe access into the sphenoidal sinus for the surgeon [1]. Moreover, use of a soft-tissue window, especially when a contrast agent is used, permits identification of vascular structures and tumor delimitation [1].

Essentially, the Transnasal Transsphenoidal route has become the standard endoscopic approach for surgical treatment of most intrasellar tumors. This approach is the least traumatic nasal route to the sellar turcica as it avoids the need for brain retraction and offers improved visualization of the surgical field. As a result, this approach has lower morbidity and mortality rates when compared with transcranial procedures[17]. It is especially suggested for treatment of lesions in children, where it is essential to retain anatomic and functional integrity to ensure normal growth and nasosphenoidal ventilation[18].

Initially, pituitary macroadenoma were removed transcranially but there were detrimental effects to the approach hence surgeons needed an alternative method to reduce complications [19][20]. Transsanal transsphenoidal endoscopic surgery has gained popularity since the 20th century when it was successfully introduced [21]. Various approaches are widely available for

its success including the endonasal rhinoseptoplastic, transnasal septal displacement, transnasal endoscopic, and sublabial transseptal approaches[21][22].

There are observed challenges in transsphenoidal surgery which comprise of lesion extension and specific characteristics such as substantial suprasellar extension with a small hiatus of diaphragma sellae, lateral and retrosellar extension, brain invasion with edema, firm tumor consistency, vasospasm of circle of Willis arteries, and encasement or invasion of the optic pathways, optic foramina and internal carotid artery [23][1].

Transnasal Transphenoidal Endoscopic Surgery depends highly on various sinonasal variants for its success and to avoid complications. It is important to be aware of the pattern of intersphenoid sinus septum, Onodi cells, concha bullosa, nasal septal deviation, Agger nasi cells etc [24]–[26]. Moreover, majority of these variants can be seen using CT scan and hence makes a surgeon to be well prepared and sometimes will require to be corrected surgically prior to removal of pituitary macroadenoma [25].

More generally, the suitability of the endonasal transsphenoidal approach depends on the extension of pneumatization and specific anatomic variants in the sphenoid bone, thus radiologists are required to report these variants to limit intra and postoperative complications. The traditional classification described three types of sphenoid sinus pneumatization in adults, which are sellar, presellar and concha type [6][7].

The concha type, pneumatization does not extend into the body of the sphenoid bone since its anterior wall is separated from the sella turcica by approximately 10 mm of cancellous bone [27]. The presellar type, pneumatization is situated in the anterior sphenoid bone and does not penetrate beyond the anterior sellar wall [27]. The sellar type which comprise of incomplete sellar where the posterior margin of pneumatization lies beneath the sella but anterior to the posterior wall of sella and complete sellar where the posterior margin of pneumatization lies posterior to the posterior wall of the sellar [27]. The sellar pneumatization is the most common

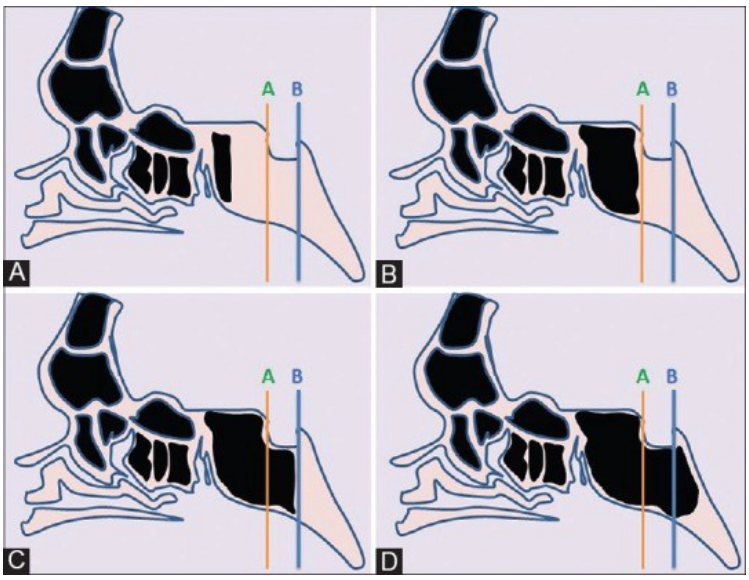
type in adults as it appears in majority of the population while the presellar and concha types are less common and would require drilling of the bone to reach the sellar floor [28]–[31].

The cavernous portion of internal carotid artery is an important structure to consider while performing Transnasal Transspehnoidal Endoscopic Surgery for pitutary macroadenoma. Failure to identify its visibility may cause catastrophic effects. Some studies have highlighted on the protrusion of the internal carotid artery into the sphenoid sinus and others have highlighted on the dehiscent nature of the ICA[16][32][33].

In majority of the studies regarding understanding the anatomical variants among patients who are to undergo Transnasal Transspehnoidal Endoscopic Surgery, female proportion was highly affected [22][23][25][26]. The common age group to be affected turned out to be between 50-60 years of age. Consistent significant associations between anatomical variants with the studied population has been laid out by some studies [24].

It is has been reported that imaging findings after transsphenoidal surgery depend on numerous factors, including the surgical route; size and extension of the lesion before surgery; and type, volume, and timing of resorption of implanted materials, changes in anatomic conditions and blood products, as well as use of packing and hemostatic materials [34][16].

Figure 1: Pictorial representation with vertical lines drawn along the anterior (orange line) and posterior walls (blue line) of the sellar showing the types of sphenoid sinus peumatization [27]



a) Concha type
b) Presellar type
c) Incomplete sellar
d) Complete sellar

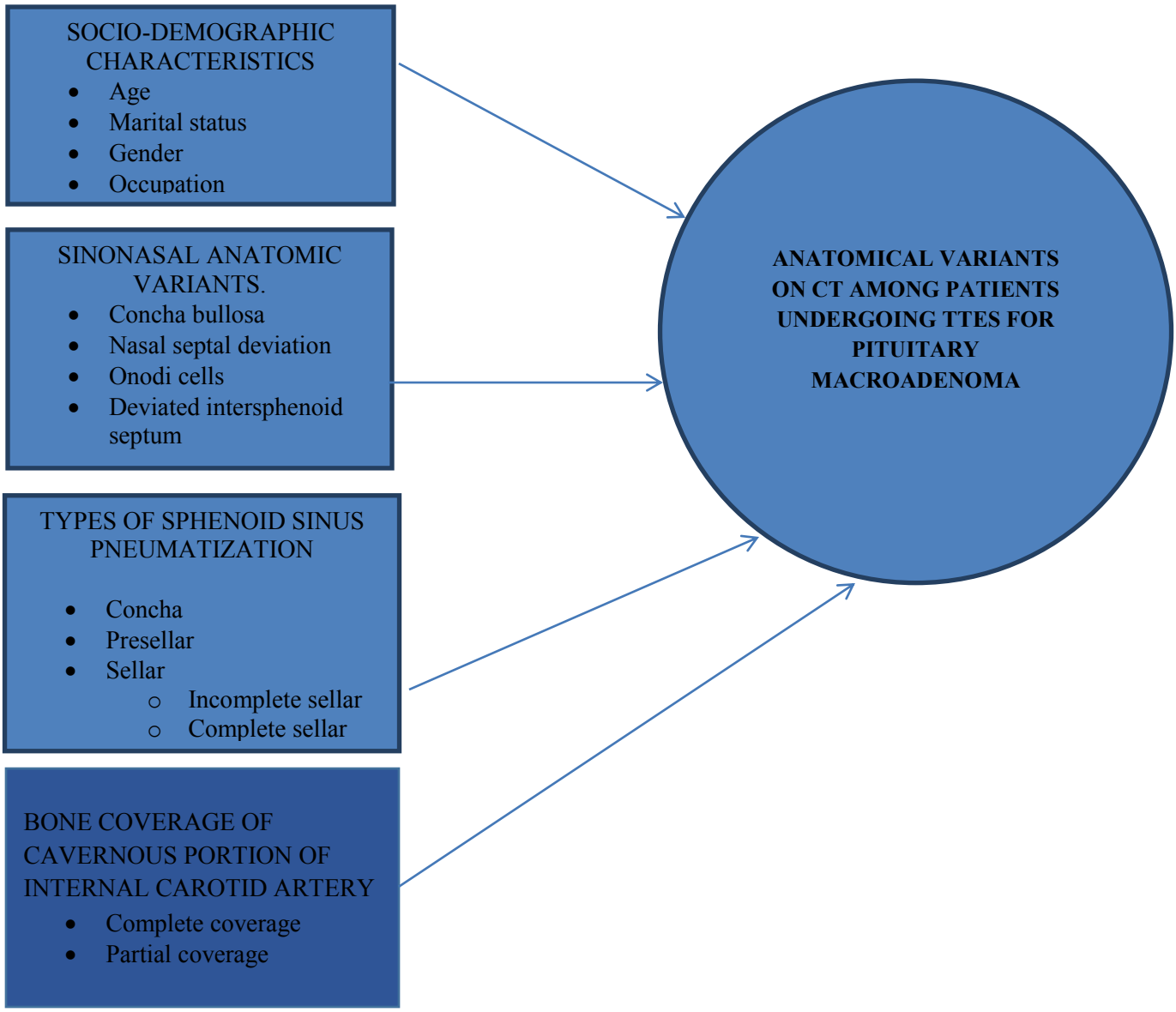
1.2 PROBLEM STATEMENT

The use of TTES for resection of pituitary macroadenoma has recently been introduced in our country and is still gaining popularity in Tanzania. So far, there is no established data in terms of the anatomic variants pre operatively, as they can predict management outcome.

However, this procedure has some observed complications such as perioperative mortalities, cerebrospinal fluid leak, new neurological deficit, perioperative myocardial infarction and more frequently endocrine complications including transient diabetes insipidus and symptomatic hyponatremia [35][36].

Hence, this study will help in detecting various anatomic variants for patients undergoing TTES for pituitary macroadenoma and thus will aid in selecting the most suitable route for accessing the pituitary fossa.

1.3 Conceptual framework



Explanation of the framework

The framework involved the dependent and independent variables in this study. The dependent variable was Transnasal Transsphenoidal Endoscopic Surgery of which its successfulness depended on the patients' socio demographic characteristics, sinonasal anatomic variants, the types of sphenoid sinus pneumatization and bone coverage of cavernous portion of internal carotid artery.

1.4 RATIONALE

The study aimed at assessing the anatomical variants among patients undergoing TTES for pituitary macroadenoma. Thus it will contribute to the body of existing knowledge regarding issues of anatomical variants in Tanzania's experience of which it will be of a great use in proper carrying out of TTES services with no or even less complications to the surgeons and the patients as well. The study has also become an eye opener for further more studies.

1.5 OBJECTIVES

1.5.1 Broad objective

To determine Computed Tomography pattern of anatomical variants among patients undergoing Transnasal Transsphenoidal Endoscopic Surgery for pituitary macroadenoma at MOI from October 2020 to April 2021.

1.5.2 Specific objectives

I. To determine the proportion of sinonasal anatomical variants among patients undergoing TTES surgery for pituitary macroadenoma at MOI
II. To determine common types of sphenoid sinus pneumatization among patients undergoing TTES for pituitary macroadenoma at MOI.
III. To determine the proportion of various types of bone coverage of cavernous portion of ICA among patients undergoing TTES at MOI
IV. To determine association between sphenoid sinus pneumatization and gender
V. To determine association between types of bony coverage of cavernous ICA and sphenoid sinus pneumatization

1.6 RESEARCH QUESTIONS

i. What is the proportion of adult patients with sinonasal anatomical variants?

ii. What is the proportion of adult patients with different types of sphenoid sinus pneumatization?

iii. What is the proportion of adult patients with various types of bone coverage of cavernous portion of internal carotid artery?

iv. What is the association between sphenoid sinus pneumatization and gender?

v. What is the association between types of bony coverage of cavernous ICA and sphenoid sinus pneumatization?

1.7 LITERATURE REVIEW

In majority of the studies regarding understanding the anatomical variants among patients who are to undergo Transnasal Transspehnoidal Endoscopic Surgery, female proportion was highly affected [22][23][25][26]. The common age group to be affected turned out to be between 50-60 years of age. Consistent significant associations between anatomical variants with the studied population has been laid out by some studies [24].

In a prospective cohort study of 185 consecutive patients receiving an EETA through a binostril approach was performed. All anatomical endonasal variations were noted whereby 48% of patients showed anatomical variations, majority of which were spinae septi and septum deviations [25].

In a retrospective study of 53patients which included observational and control groups. Majority of the patients in both groups had nasal septal deviations [24].

In a retrospective cross-sectional study which was done in Nigeria with a total of 320patients, 150 patients (46.9%) had single intersphenoid septum as major finding. Onodi cells were observed among 59 patients (18.4%) [31]

Different types of sphenoid sinus pneumatization have been reported including concha, presellar and sellar in accordance to the commonest classification widely used with the commonest being the sellar type [6][7]. However, in some studies, a fourth type has been added known as the postsellar [31][30]

In a study which was conducted among the Turkish population with a sample size of 616, it showed that majority of the patients (83%) had sellar type of sphenoid sinus pneumatization, the presellar type accounted for 16.6% and the concha type accounted for 0.5% [28].

A study which was conducted in India with a sample size of 500 patients who were assessed by CT, it revealed none of the patient had concha type. Those who had presellar type were 1.2%, those with incomplete sella type were 22.2% and those with complete sellar were 76.6% [27].

In a study which was conducted in Egypt, among the 182 patients, 3 cases (1.6%) had concha type of pneumatization, 23 cases (12.6%) had presellar type of pneumatization and 156 cases (85.7%) had sellar type of pneumatization [5].

In another study which was conducted in Egypt which assessed 296 patients retrospectively who underwent surgery for pituitary adenoma. Six cases (2%) had concha type of pneumatization, 62 patients (21%) had presellar type of pneumatization, 162 patients (54.7%) had sellar type and 66 patients (22.3%) had post sellar type [30].

A study conducted in Nigeria assessed 320 patients who underwent CT scan to determine sphenoid sinus pneumatization variation. Sellar type was the commonest accounted for 181 patients (56.6%) which was followed by postsellar, 129 patients (40.3%). Concha and presellar types accounted for 6 patients (1.9%) and 4 patients (1.2%) respectively [31].

Different studies show an existing correlation between sphenoid sinus pneumatization and gender. In a study which was conducted in Romania which evaluated CT scans of 50 patients, it revealed no statistical significance association between SS pneumatization and gender [37].

Another study which was done among 58 Nepalese, it showed that there was a statistical significance association between SS pneumatization and gender, where males were associated with more complete sellar type and females with more presellar and incomplete sellar type [38].

A study conducted in Nigeria with a sample size of 320, no significant association was found between sphenoid sinus pneumatization and gender [31].

Reviewed studies have highlighted on the importance of understanding the internal carotid artery as it courses through the sphenoid bone in relation to the respective sinus.

In a case control study which was done in China, a total of 53 patients underwent CT scan to evaluate anatomical abnormalities prior to TTES. Only 1 patient (3.7%) had bony defect covering the ICA which was observed among the cases [24]

In a study done in Turkey in 92 patients, dehiscence of the bony wall of ICA was seen in 21 (22.8%) of which 9 (9.8%) were on the right, 12 (13%) were on the left side, and 7 (7.6%) were bilateral [39].

A study done in Libya which had a sample size of 300 patients, 90 patients had ICA bony dehiscence. Thirty patients (10.3%) had bilateral bony dehiscence, 43 patients (14.3%) had right side bony dehiscence and 16 patients (.3%) had left side bony dehiscence [32].

In a Brazilian study with a sample size of 90patients, it showed a statistical significant association between sphenoid sinus pneumatization and internal carotid artery [23].

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study area

The study was conducted at Muhimbili Orthopedic Institute (MOI) in Dar es Salaam city, Tanzania. There are five municipal councils in the city (Kinondoni in the North, Ilala in the center, Ubungo, Temeke in the South, and Kigamboni in the East) and is the largest city in Tanzania.

MOI is in Ilala municipal of Dar es Salaam city. It serves as an institution for the Eastern zone and the national referral hospital for all neurosurgical cases. It also serves as a teaching hospital for MUHAS which has two campuses currently. One is located at Upanga Muhimbili National Hospital and another one is located at Kibamba 3 km off Dar-es-Salaam Morogoro highway (MAMC).

The study was conducted in the Neurosurgery and Radiology departments. MOI receives around 200brain tumor cases in a year. Among them, pituitary tumors are about 10-20cases in a month. Before the shift from craniotomy to TTES, 30 cases of pituitary macroadenoma were being operated in a year. The need to shift from craniotomy to TTES was due to lesser complications attributed by the TTES as compared to craniotomy and the popularity of the latter.

2.2 Study design

A hospital based descriptive prospective cross-sectional study was undertaken among patients with pituitary macroadenoma diagnosed by CT/MRI who had indications for undergoing TTES to determine their socio-demographic factors, sinonasal variations, variations of the sphenoid sinus pneumatization types and bony coverage of cavernous part of internal carotid artery among eligible patients.

2.3 Study duration

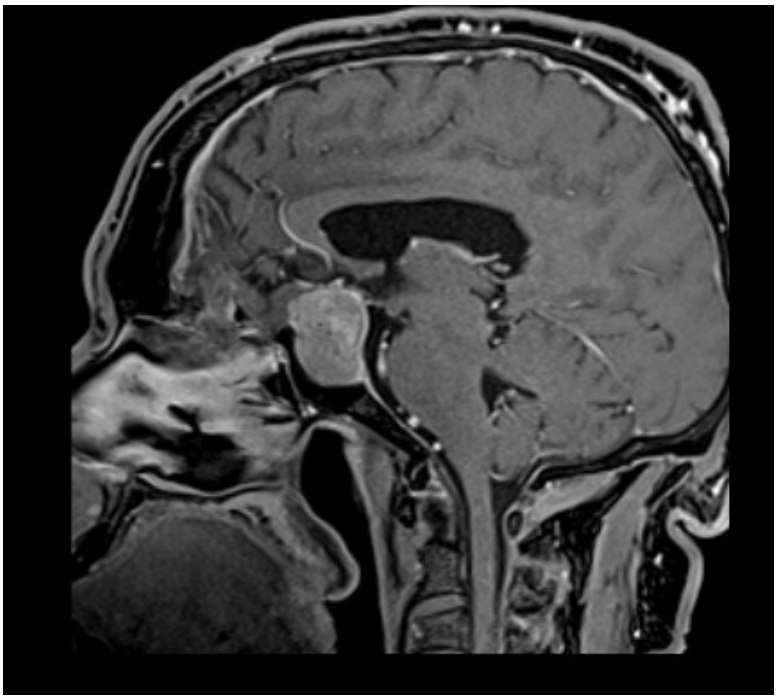
The study was conducted from October 2020 to April 2021

2.4 Targeted population

The study was done among all adult patients with pituitary macroadenoma diagnosed by CT/MRI who had indications for Transnasal Transsphenoidal Endoscopic Surgical intervention at MOI neurosurgery department. The indications of TTES at MOI are:

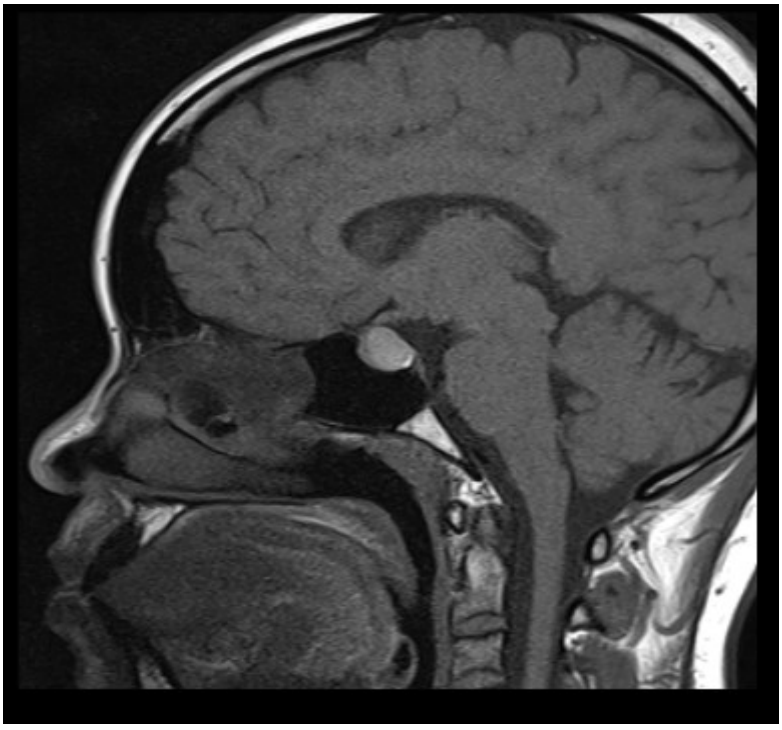
1. Pituitary tumors which are confined to the sellar region
2. Pituitary tumors that have eroded the sella towards the sphenoid sinus and further to the nasopharyngeal space
3. Pituitary tumors with upward extension showing a snowman appearance
4. For cosmetic purpose
5. Patients with comorbidities

Figure 2: MRI images showing some of the indications for TTES



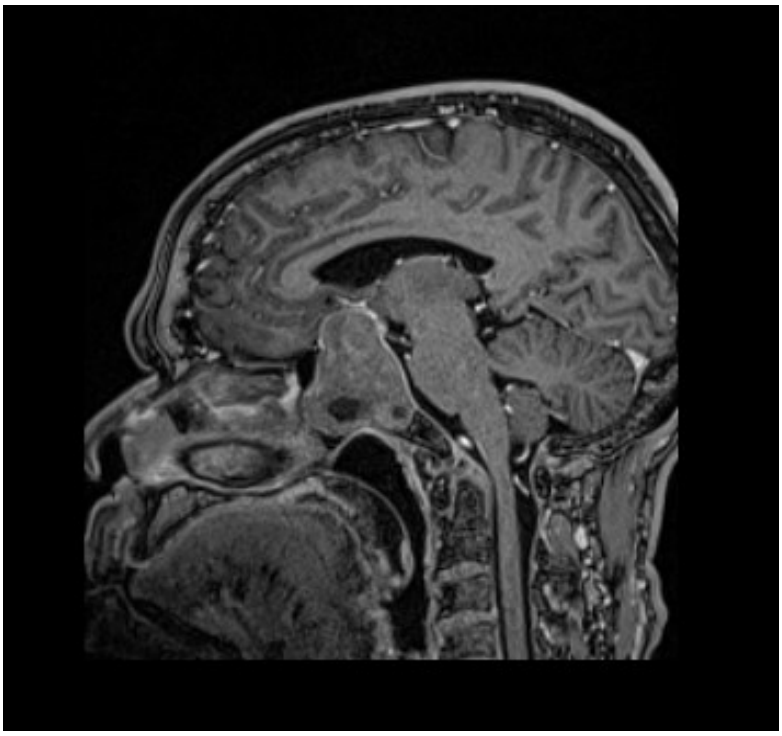
a): MRI image sagittal view T1 contrasted

A 49-year-old male with heterogeneous enhancing pituitary macroadenoma showing a snowman appearance



b): MRI image sagittal view T1 precontrasted

A 32-year-old female with a hyperintense pituitary macroadenoma confined to the sellar



c): MRI image sagittal view T1 contrasted

A 67-year-old male with heterogeneous enhancing pituitary macroadenoma that has eroded the sella with extension into the sphenoid sinus and compressing the nasal turbinates

2.5 Inclusion criteria

All adult patients with pituitary macroadenoma with indications for Transnasal Transsphenoidal Endoscopic Surgical interventions who attended MOI neurosurgery and/radiology departments during the study period were included in the study after consenting.

2.6 Exclusion criteria

All patients who met inclusion criteria but did not consent were not included in the study.

2.7 Sampling and sampling procedures.

All eligible patients who attended during the study duration were included in the study. Based on the monthly attendance, we had enrolled 103 clients during the study period.

2.8 Sample size estimation

The sample size was estimated with help of Yamane (1967) formula because a given sample size provided proportionately more information for small population than for large population. The formula was given by:

$$n = \frac{N}{1 + N\ (e)^2}$$

Where n is the required minimum sample size,

N is the population size in 140 (during research period)

e is the level of precision = 5% (the precision level given a 95% power of the study)

Therefore;

$n = \frac{140}{1+140(0.05^2)} \approx 103$

A 10% was added for the non-responses; minimum sample size of (103*10%) =93 Patients

2.9 Data collection tools

Data was collected using a structured questionnaire. CT scan imaging was done using Siemens CT Somatom Definition AS VA48A 128slices which was manufactured by Siemens healthcare GmBH in Germany. It was operated by a radiographer at MOI radiology department and all the images were read by principal investigator and confirmed by a radiologist.

2.10 Variables

2.10.1 Independent variables

Age, sex, marital status and employment status

2.10.2. Dependent variables

CT pattern of anatomical variants: sinonasal variants, sphenoid sinus pneumatization and bony coverage of cavernous portion of ICA.

2.11 Pre testing Piloting tool.

The structured checklist was used. The specific questions related with study were included in order to consider the availability of data and if available information were going to answer our research questions.

2.12 Data collection procedures

All patients with pituitary macroadenoma scheduled for TTES, underwent CT scan for preoperative evaluation. A checklist was made and the patients were evaluated against the objective of the study. Retrieved images from the available database (RADIANT DICOM/SYNGOVIA) at MOI were reviewed by an investigator and confirmed by the radiologist(s) on duty after consensus was reached.

2.13 Data management and analysis

Data entry and cleaning was done using SPSS version 23. Data was entered twice then compared to ensure accuracy. Continuous data were summarized using measures of central tendency with their respective measures of dispersion. Categorical data were summarized using frequencies and percentages. Data quality was checked repeatedly by checking frequencies. Descriptive analysis was used for continuous and categorically variables. Pearson Chi-square and Fisher's exact test was used to compare proportions. Statistical significance was considered when the p-value was< 0.05.

2.14 Descriptive data analysis

Mean and standard deviation was computed for numerical variables to summarize the characteristics of adult patients. Socio-demographic characteristics of adult patients undergoing TTES were analyzed using frequencies and percentages

2.15 Inferential statistics

Determination of the proportion of patients with sinonasal anatomical variations, proportion of adult patients with different types of sphenoid sinus pneumatization and proportion of patients with bony coverage portion of ICA, the Chi-square test was used to analyze the degree of association between each of the independent categorical variables and dependent categorical. It compared variables in contingency table to see if they were related therefore, Pearson's Chi-square test was used to determine the association between independent and dependent categorical variables. Chi square test for independence was used to calculate the proportions and compared using a 95% level of significance. P-value was used to determine statistical significance whereby p-value of less than 0.05 was taken as significant.

2.16 Reliability

Intra examiner consistency on imaging findings was based on imaging findings from 15 randomly selected participants. Measures of each finding were compared to and reported using Kappa statistics.

2.17 Ethical consideration

Informed consent was obtained from study participants. The preoperative CT images for all patients eligible to undergo Transnasal Transsphenoidal Endoscopic Surgery were read by the investigator in the reporting room. Data obtained was handled confidentially by investigator and stored in a secured place.

2.18 Ethical clearance

The proposal was presented to the Radiology department and ethical clearance was sought from Senate of Research and Publication committee of Muhimbili University of Health and Allied Sciences (MUHAS) and Muhimbili Orthopedic Institute

CHAPTER THREE

3.0 RESULTS

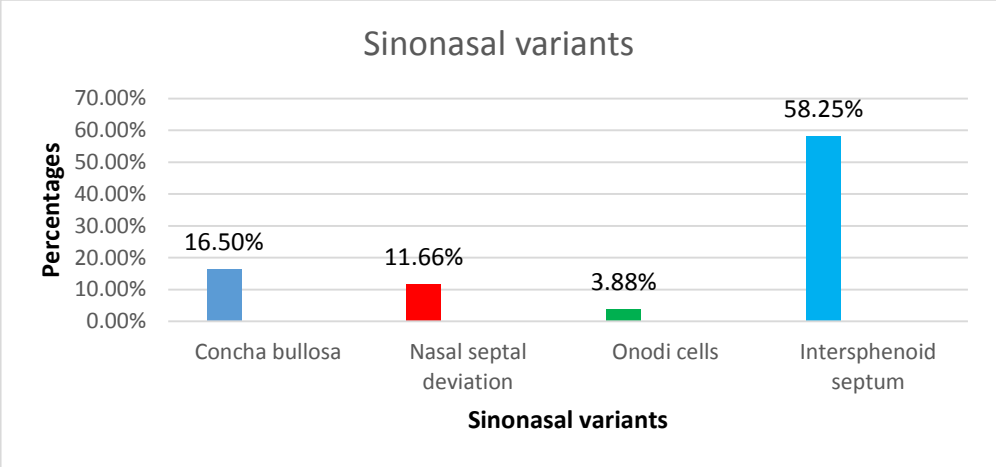
Table 1: Socio-demographics data

		Frequency (n)	**Percentage (%)**
Gender	Male	46	44.66
	Female	57	55.34
	Total	103	100
		Frequency (n)	**Percentage (%)**
Age groups	18-29	13	12.62
	30-39	13	12.62
	40-49	26	25.24
	50-59	32	31.07
	60+	19	18.45
	Total	103	100

A total of 103 study units were enrolled in this study, among them males were 46 (44.66%) and females were 57 (55.34%).

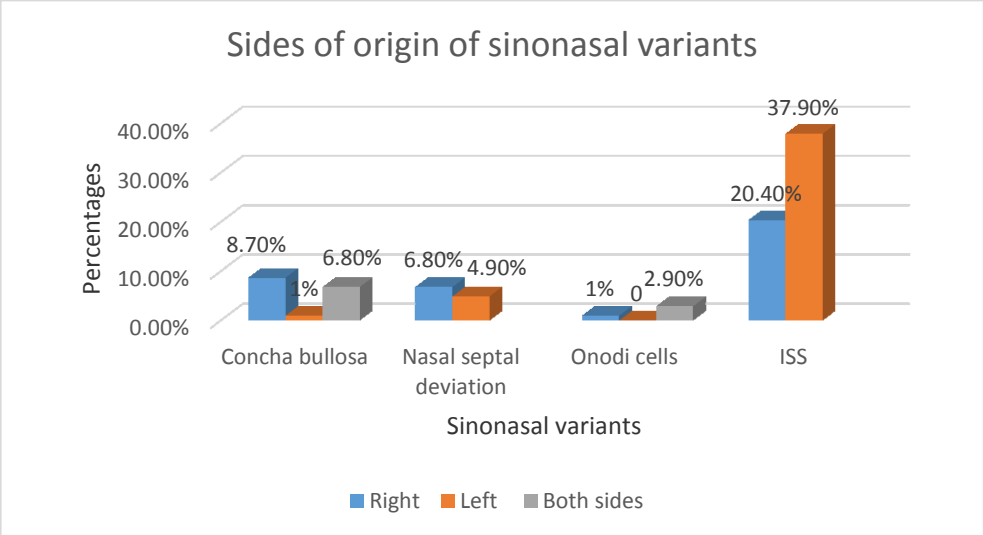
Participants' age ranged between 18-95 years with majority of the study population falling between 50-59 age group. The mean age was 48.11 with standard deviation of 14.27.

Figure 3: Distribution of studied sinonasal variants



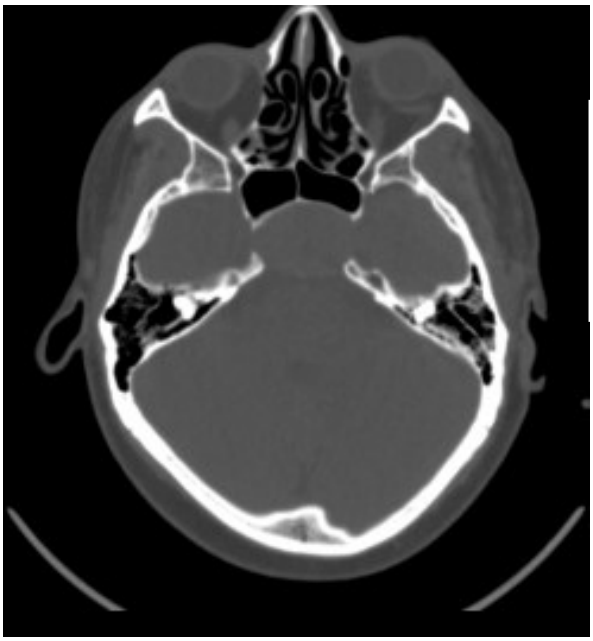
Among 103 participants, those who had concha bullosa were 17 (16.5%), nasal septal deviation 12 (11.66%), Onodi cells were 4 (3.88%) and those who had deviated intersphenoid septum were 60 (58.25%).

Figure 4: Distribution of sinonasal variants in relation to sides of origin

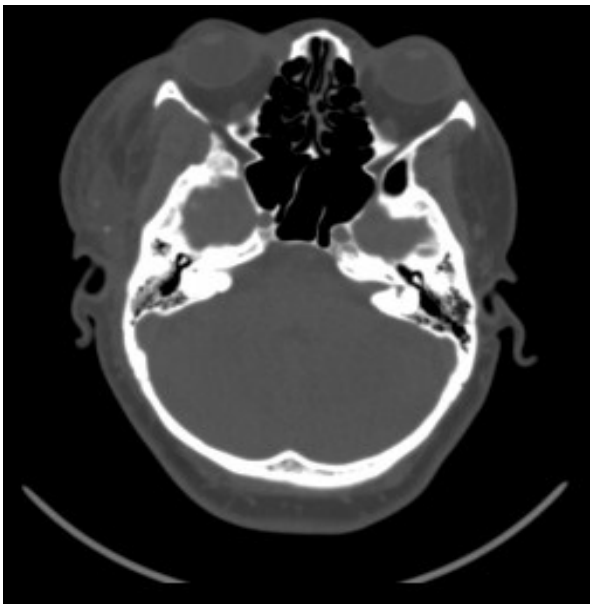


The sinonasal variants were further studied to understand the sides of origin or deviation. Majority of the study population had left sided deviation of the intersphenoid septum which accounted for 39 patients (65%). It was followed by concha bullosa in which majority of them had concha bullosa on the right-side accounting for 9 patients (52.94%).

Figure 5: Figures to show the studied sinonasal variants with their sides of origin:



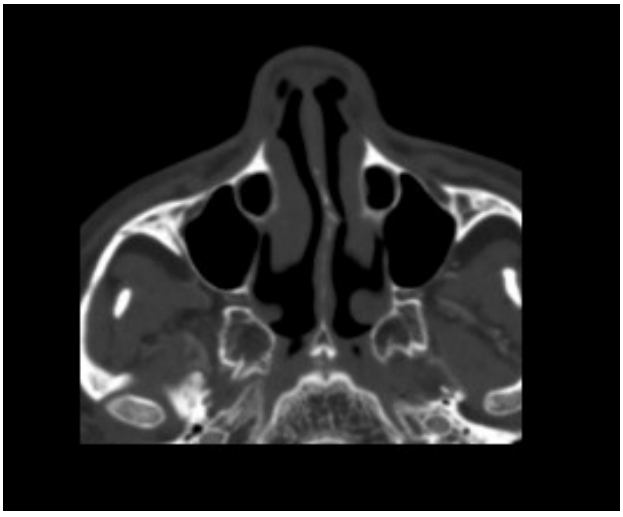
a) CT head bone window axial view of a 57-year old male showing bilateral pneumatization of middle turbinates in keeping with concha bullosa



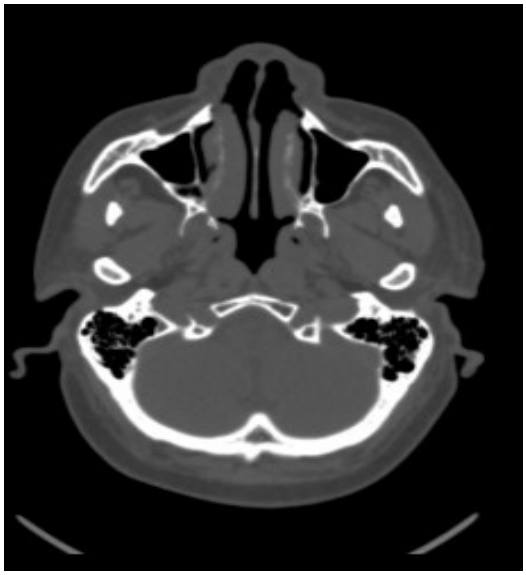
b) CT head bone window axial view of a 46-year old female with bilateral Onodi cells

c) CT head bone window axial view of a 33-year old female with left sided deviated ISS

d) CT head bone window axial view of a 30-year old male with right sided deviated ISS

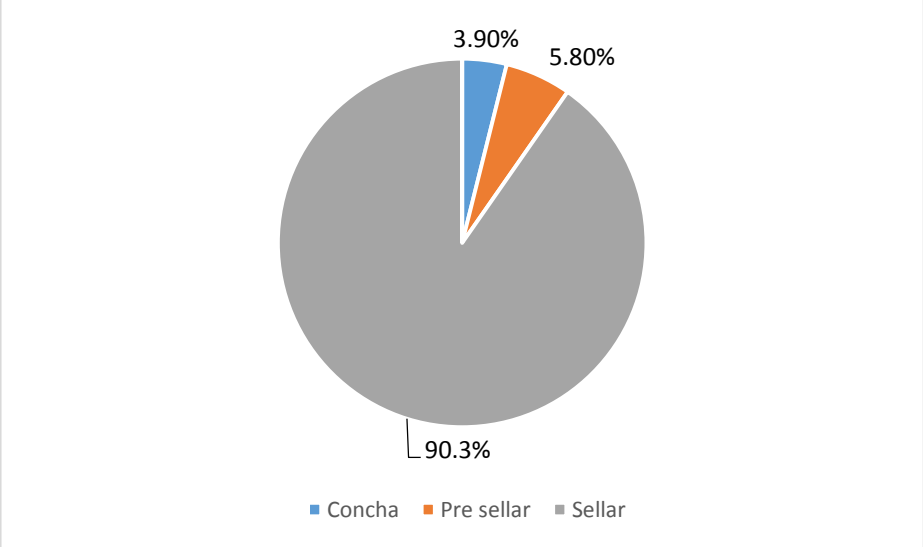


e) CT head bone window axial view of a 46-year-old male with left side nasal septal deviation



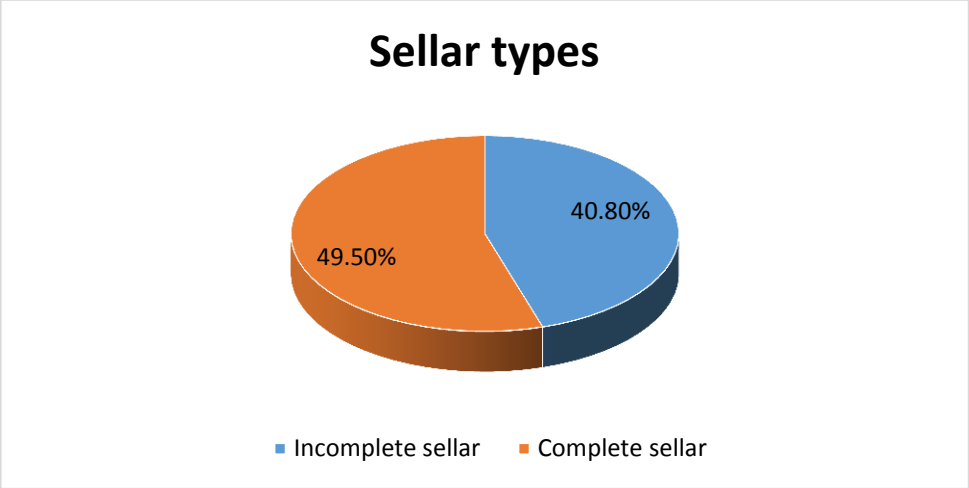
f) CT head bone window axial view of a 57-year old male with right side nasal septal deviation

Figure 6: Distribution of the types of sphenoid sinus pneumatization



Three types of sphenoid sinus pneumatization were studied. These were concha, presellar and sellar types. Majority of the patients had sellar type which accounted for 92 patients (90.3%), followed by presellar which accounted for 6 patients (5.8%). Concha type had the least number,4 patients (3.9%).

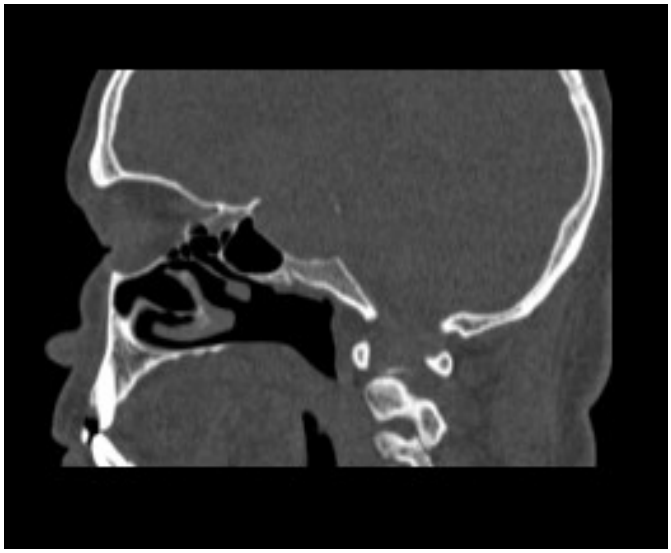
Figure 7: Distribution of the sellar types of sphenoid sinus pneumatization



The sellar type was classified into incomplete and complete sellar which accounted for 42 patients (40.8%) and 51 patients (49.5%) respectively.

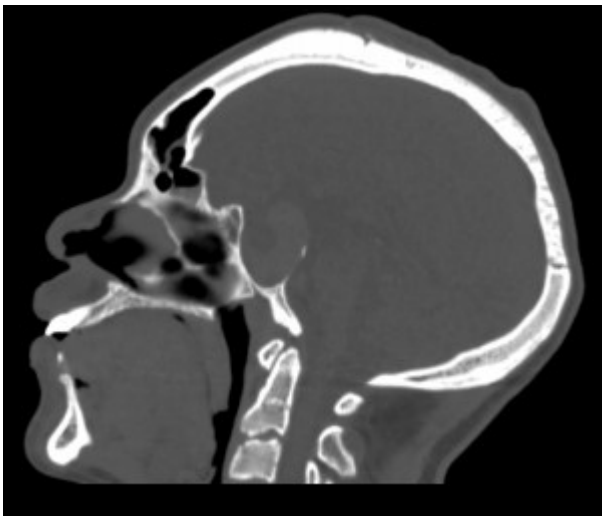
Figure 8: Figures to show the types of sphenoid sinus pneumatization:

a) CT head bone window sagittal view of a 53-year old female with complete sellar type



b) CT head bone window sagittal view of a 58-year old female with incomplete sellar type

c) CT head bone window sagittal view of a 28-year old female with presellar type



d) CT head bone window sagittal view of a 22-year old male with concha type

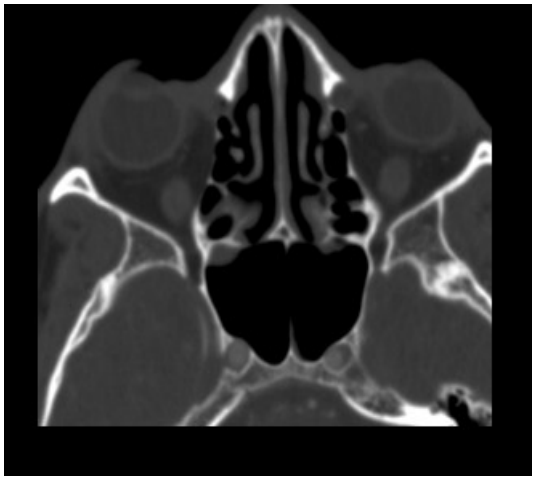
Table 2: Types of sphenoid sinus pneumatization in relation to gender

Sphenoid sinus pneumatization	**Gender**			
	Male	**Female**	**Total**	
Sellar	39 (84.8%)	54 (94.7%)	93 (90.3)	p-value 0.07
Presellar	3 (6.5%)	3 (5.3%)	6 (5.8%)	
Concha	4 (8.7%)	0	4 (3.9%)	x^2 5.31
Total	46 (100%)	57 (100%)	103 (100%)	

Out of 103 study population, majority of the participants had sellar type of sphenoid pneumatization accounting for 93 patients (90.3%), males were 39 (84.8%) and females were 54 (94.7%). The least type was concha which was observed among 4 patients (3.9%), all were males accounting for 8.7%. The p-value was 0.07 which showed no statistical significance between sphenoid sinus pneumatization and gender**.**

Figure 9: Figures to show bony coverage of cavernous portion of ICA as shown by CT head bone windows axial views

a) CT head bone window axial view of a 28-year-old female with complete bony coverage of cavernous ICA bilaterally



b) CT head bone window axial view of a 46-year-old male with partial bony coverage of cavernous ICA bilaterally

Table 3: Bony coverage of cavernous portion of internal carotid artery in relation to sphenoid sinus pneumatization

Bony coverage of cavernous ICA	Sphenoid sinus pneumatization				
	Sellar	Presellar	Concha	Total	
Complete	56 (60.2%)	5 (83.3%)	4 (100%)	65 (63.1%)	p-value 0.396 x^2 4.077
Partial	21 (22.6%)	1 (16.7%)	0	22 (21.4%)	
Either side	16 (17.2%)	0	0	16 (15.5%)	
Total	93 (100%)	6 (100%)	4 (100%)	103 (100%)	

This study also investigated the association between bony coverage of cavernous ICA and SS pneumatization. Out of 65 patients (63.1%) who had complete bony coverage, 56 patients (60.2%) had sellar, 5 patients (83.3%) had presellar type and 4 patients (100%) had concha type. Those who had partial coverage were 22 patients (21.4%), 21 (22.6%) had sellar, 1 patient (16.7%) had presellar and none of the patient had concha type. And those patients who had either one side complete and another side partial coverage were 16 (15.5%), all had sellar type accounting for 17.2%. The p-value was 0.396 which revealed no statistical significance between bony coverage of cavernous ICA and SS pneumatization.

CHAPTER FOUR

4.0 DISCUSSION

Endoscopic endonasal surgery has become the most common choice of neurosurgeons and otolaryngologists to treat lesions of the skull base [8]–[12]. Transnasal Transsphenoidal route has become the standard endoscopic approach for surgical treatment of most intrasellar tumors. However, understanding the various anatomical variants preoperatively are of crucial importance to prevent complications which might arise during surgery. Fluoroscopy was formerly used as the primary image-guidance technique, but currently Computed Tomography or Magnetic Resonance Imaging with multiplanar reconstructions is used preoperatively because of higher anatomic resolution [16]. This study aimed at evaluating CT patterns of anatomical variants among patients undergoing TTES for pituitary macroadenoma at MOI.

A total of 103 patients who were diagnosed with pituitary macroadenoma by CT scan and MRI were studied to assess their anatomical variants preoperatively. In this study, a higher proportion of anatomical variants in pituitary macroadenoma patients was observed among females, 56 (55.34%). This observation is similar to other studies done elsewhere [25][31][28][5] but differs with another study done in Egypt [30]. Differences can be due to a large sample size in the counterpart side.

Regarding age, participants' age ranged between 18-95 years with majority of the group falling between 50-59 group (31.07%). The mean age was 48.11 with standard deviation of 14.27. Results show that majority of study participants were 60 years and below. These results are congruent to other studies [27][28][31].

Among the sinonasal variants studied, majority of the patients had deviated intersphenoid septum accounting for 60 patients (58.25%), with the least of them being Onodi cells accounting for 4 patients (3.88%). Similarities are seen with other studies [31][30]. This can be attributed by same geographic pattern. However, the results differ from a study done in Netherlands [25] in which the commonest sinonasal variant was nasal septal deviation

accounting for 56 patients (30.3%). Differences can be contributed by ethnoracial variations, geographic pattern and environmental exposure.

In relation to types of sphenoid sinus pneumatization, the classification used was that of Hammer and Radberg [6] and Hamberger [7]. Majority of the patients had sellar type which accounted for 90.3% (93 patients). It was followed by presellar which accounted for 6 patients (5.8%). Concha type had the least number accounting for 4 patients 3.9%. The sellar type had 2types: incomplete and complete sellar which accounted for 42 patients (40.8%) and 51 patients (49.5%) respectively. These results resemble works done by others [23][27][28][31][30]. Resemblances can be due to similar classification of SS pneumatization used.

Relationship between types of sphenoid sinus pneumatization and gender was studied. Sellar type of sphenoid pneumatization accounted for 90.3% (93 patients), females were 54 (94.7%) and males were 39 (84.8%). Presellar accounted for 6 patients (5.8%), females were 3(5.3%) and males were 3 (6.5%). All 4 patients (3.9%) with concha type were males (8.7%). The p-value was 0.07 which showed no statistical significance association between sphenoid sinus pneumatization and gender. This finding concur with a study in Romania [37] but differs with a study in Nepal [38]. Differences can be due to inclusion of pediatrics and adults in the latter study.

The bony coverage of cavernous portion of ICA is of paramount significance so as to avoid intraoperative complications. Our study showed that among 103 patients, 65 patients (63.1%) had complete bony coverage on both sides, whereas 22 patients (21.4%) had partial coverage on both sides. Those who had one side complete and another side incomplete coverage accounted for about 16 patients (15.5%). Results concur with a study done in Libya[32]. The probability can be due to same geographical pattern and environmental exposure. However a study in China[24] showed only 1 patient (3.7%) had bony defect of the ICA. Differences in results can be explained by small sample size used and case control study design in the aforementioned study.

Relationship between bony coverage of cavernous ICA and sphenoid sinus pneumatization was also studied. Out of 65 patients (63.1%) who had complete bony coverage, 56 patients (60.2%) had sellar sphenoid pneumatization, 5 patients (83.3%) had presellar type and 4 patients (100%) had concha type. Those who had partial coverage were 22 patients (21.4%), 21 (22.6%) had sellar type, 1 patient (16.7%) had presellar type and none of the patient had concha type. And those patients who had either one side complete and another side partial coverage were 16 patients (15.5%) and all 16 patients (17.2%) had sellar type. The p-value was 0.396 in which there was no statistical significance association between bony coverage of cavernous ICA and SS pneumatization. Contrary to a study which was done in Brazil [23] which had a p-value of 0.001 which was statistically significance. Incongruences can be due to, in the counterpart study, they used lateral extension of SS pneumatization in relation to ICA.

CHAPTER FIVE

5.0 CONCLUSION

In this study, anatomical variants in pituitary macroadenoma patients are more common in females as compared to males. The age range of 50-59 years is the most affected. The commonest sinonasal variant observed was deviated intersphenoid septum with the least one being Onodi cells. Majority of the patients had complete sellar type of sphenoid sinus pneumatization Less than one third of patients had partial bony coverage of cavernous ICA. This study has shown that, knowing the Computed Tomography pattern of various anatomical variants among patients who are undergoing TTES for pituitary macroadenoma is of paramount importance so as to avoid intraoperative complications and to improve operative quality of surgery. The role of both the radiologists and neurosurgeons is to understand these anatomical variants for a desirable outcome.

5.1 STUDY LIMITATIONS

1. Transnasal Transsphenoidal Endoscopic Surgery for pituitary macroadenoma has recently been introduced in our country hence no enough data was available for comparisons which resulted into studying fewer variations.
2. During the current study, there was a global pandemic of COVID-19 which caused scarcity of patients.
3. On and off network stability caused difficulties in accessing MOI image database archive storage.

5.2 RECOMMENDATIONS

Transnasal Transsphenoidal Endoscopic Surgery for excision of pituitary macroadenoma is gaining popularity in our country. From the results of our study and discussion above, the following are the recommendations for its success and prevention of complications:

1. Further studies are needed in our country to explore more variants such as:
    a. Lateral extension of sphenoid sinus pneumatization into other structures like lesser and greater wings of sphenoid, pterygoid plates and the clivus.
    b. Insertion of intersphenoid septum into the bone covering the ICA and/or optic nerve.
    c. Presence of multiple intersphenoid septums and highlight the dominant septum
    d. Protrusion of the ICA into the sphenoid sinus
2. Every radiologist should look for these variants and include them in a report of every patient with pituitary macroadenoma
3. All patients with pituitary macroadenoma should undergo CT scan so as to understand various anatomical variants pertaining to TTES in excision of pituitary macroadenoma for desirable outcome and lesser complications
4. Comparative study on pre and post-operative changes should be conducted to properly evaluate the significance of the variations.

5.3 DISSEMINATION PLAN

The dissertation report will be submitted to Muhimbili University for partial fulfillment of Master of Medicine in Radiology. The results will also be disseminated to the Teaching, Research, and Consultancy Coordination Unit of MOI and thereafter disseminated to the Dean School of Medicine and to the Director of Postgraduate Studies. The University and the principal author will hold the copyright of the research findings and they will be published in the local and/or international journals**.**

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APPENDICES

CHECKLIST FOR PRE-OPERATIVE ASSESSMENT OF ANATOMICAL VARIANTS AMONG PATIENTS UNDERGOING TRANSNASAL TRANSSPHENOIDAL ENDOSCOPIC SURGERY FOR PITUITARY MACROADENOMA AT MOI

Identity number …….

Associated factors assessment

1. Age ..... years

2. Sex 1. Male 2. Female

3. Maritual status. 1. Married 2. unmarried

4. occupation: 1. Employed 2. Unemployed

5. History of Hypertension 1. Yes 2. No

6. Any hisrory of using anthypertensive medication 1.Yes 2. No

7. Duration of hypertension .....

8. History of Diabetes 1.Yes 2. No

9. Any history of using hypoglycemic medication 1. Yes 2. No

10. Duration of diabetes .....

11. History of using tobacco or smoking ciggarete at least one piece per day for preceding three month or more

1.Yes 2.No

12. History of consuming alcohol at least any kind of alcohol for preceding three month or more

1.Yes 2.No

TABLE 1:

TYPES OF SPHENOID SINUS PNEUMATIZATION	YES	NO
CONCHA		
PRE SELLAR		
SELLA		

TABLE 2:

SINONASAL VARIANTS	YES	NO
CONCHA BULLOSA		
NASAL SEPTAL DEVIATION		
ONODI CELLS		
DEVIATED INTERSPHENOD SEPTUM		

TABLE 3:

BONY COVERAGE OF CAVERNOUS PORTION OF INTERNAL CAROTID ARTERY	YES	NO
COMPLETE COVERAGE		
PARTIAL COVERGAE		
NO COVERAGE		

Informed consent Form (English Version)
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DIRECTORATE OF RESEARCH AND PUBLICATIONS, MUHAS

ID-N0.....

Introduction:

My name is Dr Mwanaabas Sued. Am a second year resident undertaking masters in radiology and Imaging. I am conducting a research entitled, "Preoperative assessment of anatomical variants among patients undergoing Transnasal Transsphenoidal endoscopic surgery for pituitary macroadenoma at Muhimbili Orthopedic Institute".

Purpose of the study

This study has the purpose of the partial fulfilment for attaining of the degree of Masters of Medicine in Radiology from the Muhimbili University of Health and Allied Sciences. Moreover, the study aims at adding more knowledge in the neuroradiology field for better improvement on diagnosis and care for the patients with pituitary macroadenoma.

Participant involvement

Once a patient agrees to be involved in the study and informed consent has been signed, a series of questions will be asked, then preoperative images which will be taken by CT scan machine will be read and interpreted and categorized into various anatomic variations.

Confidentiality

Information obtained from each study participant will be kept confidentially. Interviews will be done as discreet as the environment allows. No name will appear on any document of the study and identification numbers shall be used instead.

Participant rights

The decision for participating in the study is voluntary. Refusal or withdrawal from the study will not have interference with your management at the hospital and no penalty will be given.

Benefits

Your participation will help us in the medical field with more knowledge on various anatomic variants among patients with pituitary macroadenoma who are to undergo transnasal transsphenoidal surgery. And in so doing, it will assist in better management of these patients

Risks

Your participation in this study would not compromise your disease outcome nor influence your health service provision at the hospital. Also, all your personal medical information will not be disclosed to the public and will be always be kept confidential except to those involved in undertaking the study.

Who to contact

If you have questions about this study, you can contact:

Principal Investigator, Dr. Mwanaabas Sued, through my mobile number +255715975335/+255684975331, or P.O Box 8146 Dar es salaam, or

Dr .Mechris Mango (Mobile number +255754022576) who is the supervisor of this study, a honorary lecturer at MUHAS in the department of Radiology and Imaging.

In case you need more information on your participation rights you may contact:

Dr. Bruno Sunguya, Director of Research and Publications, P. O. Box 65001 Dar es Salaam

Dr. Joyce Masalu, Chairperson of the Senate of Research and Publications Committee, P. O. Box 65001 Dar es Salaam. Telephone**:** +255 022 2152489

I ……. have read and understood the contents of this form. I have agreed/not agreed to participate in this study.

Signature of Participant ……..Date……..……

Signature of Researcher ……..Date…….

Fomu Ya Ridhaa (Informed Consent Swahili version)
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DIRECTORATE OF RESEARCH AND PUBLICATIONS

Namba ya utambulisho _____

Utangulizi

Jina langu ni Dr. Mwanaabas Sued. Mimi ni mwanafunzi wa mwaka wa pili katika kitengo cha Radiolojia. Ninafanya utafiti kwa lengo la kufahamu, Tathmini ya kiufanisi ya anuwai ya anatomiki kayi ya wagonjwa wanaofanyiwa upasuaji kupitia njia ya pua na njia ya hewa kwenye ubongo kwa ajili ya kuondoa uvimbe kwenye tezi ya pituitary katika hospitali ya MOI.

Malengo ya utafiti

Utafiti unaofanywa ni kwa ajili ya ukamilisho wa shahada ya uzamili (Degree of Master of Medicine in Radiology) kutoka Chuo Kikuu cha Muhimbili. Zaidi zaidi utafiti huo unakusudia kuongeza maarifa zaidi katika uwanja wa radiolojia na kuboresha ubora wa utambuzi wa anuwai ya anatomiki itakayosaidia kutoa matibabu husika.

Ushiriki

Mara tu mgonjwa akikubali kushiriki katika utafiti na fomu ya ridhaa kuwa imesainiwa, mfululizo wa maswali yataulizwa, uchunguzi wa anuwai ya anatomiki utafanyika kwa kuangalia picha zilizopigwa na mashine ya CT scan na taarifa za kijamii zitaulizwa kwa mgonjwa husika.

Usiri

Taarifa zitakazopatikana kutoka kwa kila mshiriki wa utafiti huu zitahifadhiwa kwa siri. Mahojiano yatafanywa kwa busara kama mazingira yatakavyoruhusu. Hakuna jina litakaloonekana kwenye hati yoyote ya utafiti na badala yake namba zitatumika.

Haki ya mshiriki

Uamuzi wa kushiriki katika utafiti ni wa hiari. Kukataa/kujiondoa kwenye utafiti hakutoathiri upatikanaji wa huduma na hakuna adhabu yoyote itakayotolewa.

Manufaaa

Ushiriki wako utatusaidia katika uwanja wa matibabu na kujua zaidi juu ya anuwai za anatomiki mbalimbali na kuweza kuzilinganisha na za tafiti zingine zilizofanyika ndani na nje ya bara la Africa. Na kwa kufanya hivyo kutasaidia utoaji wa huduma bora na msaada kwa wagonjwa wenye uvimbe katika tezi ya pituitary.

Madhara

Ushiriki wako kwenye utafiti huu hautoathiri matokeo ya ugonjwa wako, pia hautoathiri kupata huduma hospitalini. Pia taarifa zako binafsi zihusuzo ugonjwa/matibabu hazitofichuliwa kwa umma na zitahifadhiwa kwa siri isipokuwa kwa wale wanaohusika katika kufanya utafiti.

Mawasiliano

Endapo una shaka, ama utahitaji maelezo zaidi juu ya utafiti huu, wasiliana na:

Dr Mwanaabas Sued, mtafiti mkuu kwa namba ya simu +255 715975335/+255684975331, ama sanduku la posta (SLP) 8146 Dar es Salaam. Ama wasiliana na

Dr. Mechris Mango (kwa namba +255754022576), ambaye ni mshauri na msimamizi wa mtafiti mkuu Dr. Mwanaabas.

Dr. Mechris Mango ni mkufunzi/mwalimu wa kitengo cha Radiolojia katika Chuu Kikuu cha Sayansi ya Tiba Muhimbili.

Endapo utahitaji taarifa zaidi kuhusu haki ya ushiriki wako katika utafiti huu wasiliana na:

Dr. Bruno Sunguya, mkurugenzi wa utafiti na uchapaji, SLP 65001 Dar es Salaam

Dr. Joyce Masalu, ambaye ni mwenyekiti wa bodi ya utafiti na uchapaji SLP 65001 Dar es Salaam kwa namba ya simu +255 022 2152489.

Mimi _____ nimesoma / nimeelewa yaliyomo katika fomu hii. Maswali yangu wamejibu. Mimi nimekubali kushiriki katika utafiti huu.

Sahihi ya mshiriki ……..Tarehe…….……

Sahihi ya mtafiti ……..Tarehe……..