Sudan University of Science and Technology

College of Graduate studies

A Study of Anatomical Variation of Paranasal Sinuses among Adults Residing in Saudi Arabia with Rhinosinusitis using Computed Tomography

دراسة التباين التشريحي للجيوب الانفية لدى البالغين المقيمين في المملكة العربية السعودية والمصابين بالتهاب الأنف والحنجرة باستخدام التصوير بالأشعة المقطعية المحوسبة

A thesis Submitted for fulfillment for the Requirement of PhD Degree in Diagnostic Radiologic Imaging

By

Ohood El-Husain Mohammed El-basheer

Supervisor

Dr. Mohammed Omer Mohammed Yousef

Co-supervisor

Ahmed Mostafa Mohammed Abukonna

2020

الاية

قال تعالى:

{قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ}

صدق الله العظيم

(٣٢البقرة)

Dedication

To my parents

To my partner who supports me a lot

To my children

Acknowledgement

First and above all, thanks and praises to Allah, the almighty for providing me this opportunity and granting me the capability to proceed successfully, and the prayers and peace be upon the merciful prophet Mohammed.

I want to express my sincere thanks and deep graduate to my faithful supervisor Dr. Mohammed Omer for guidance throughout this thesis and sharing his knowledge through the entire study.

I would also like to pass my special thanks to my Co Supervisor Dr. Ahmed Abukonna, to Dr. Nasraldeen Alnaeem my friends and colleagues whom help me in my thesis.

I'm sincerely thanking the participants without whom the study would not have been feasible. The Sudan University of Science and Technology, Consultant Radiologists Diagnostic Center are thankfully acknowledged

Abstract

Anatomical variations are very important to be identified when planning a paranasal sinus (PNS) surgery. Conventional radiology does not permit a detailed study of anatomical variations of the nose and paranasal sinuses; there is lack of studies in Saudi Arabia resident in this entity to Study Anatomical Variations of Para nasal sinus (PNS) using Multi slice Computed Tomography (CT) in Rhino sinusitis**.**

A cross-sectional hospital-based study of 392 patients (272 males, and 120 females) referred for CT scan of PNS was conducted from 2017 to 2020 in Riyadh Hospitals, Saudi Arabia, mostly from Consultant Radiologists Diagnostic Center. All subjects complaining from rhino sinusitis and scanned with GE high speed CTE dual CT scanner. The images were evaluated for the presence of any anatomical variants in paranasal sinuses, Candidates those have rhino sinusitis were selected and those who have, trauma or surgery that disturbed their normal anatomy were excluded.

The results of this study revealed that the absolute frequency of anatomical variations among 392 were as follows; 91.3% were deviated nasal septum, concha bullosa seen in 50.77%, Basal lamella pneumatization found in 5.36 %. The superior turbinates were pneumatized in 20.15%, The crista galli was pneumatized in 19.39%. Frontal sinus was hyperpneumatized in 8.67% and non-pneumatized in 4.85%, the middle turbinate found to be paradoxical in shape in 10.71 %, lamina papyrecia dehiscence in 1.79%, inferior turbinate was pneumatized in 1.28%. The frontal air-cell was not present in our studied group. The supraorbital air-cell was present in 16.07%,the Onodi air-cell found to be present in 12.24%, the Haller air-cell found to be present in

30.10%, the sphenoid sinus is laterally pneumatized in 7.65%, the depth of cribriform plate (Keros classification) was in 0.51%, the agger cells found to be presented in 51.02%, the infraorbital air-cell was present in 10.20%,nasal septum spur was presented in 29.34%, prominent ethmoidal bulla was presented in 29.85%, uncinate process was pneumatized in 12.76%,sphenoid sinus extension into posterior nasal septum is presented in 36.22%, posterior floor of cellaturcica was pneumatized in 30.87%, the pterygoid process was pneumatized in 7.91%,anterior clinoid process was pneumatized in 10.97%, hard palate was pneumatized in 9.18% and lastly sphenoid septum change the direction in 8.16%. and we compared our results with previous study.

Anatomical variations of paranasal sinuses are best depicted on MDCT scan of PNS. The deviated nasal septum was the commonest anatomical variation (93.11%) followed by agger cell (51.02%) and Concha bullosa(50.77%).

المستخلص

دراسة الاختلافات التشريحية مهمة جدا عند التخطيط لجراحة الجيوب الانفيه. لاتسمح الاشعة العادية باجراء دراسة مفصلة للتغيرات التشريحية للأنف والجيوب الأنفية ؛هناك نقص في الدراسات على المقيمين في المملكة العربية السعودية في هذا الكيان لدراسة الاختلافات التشريحية للجيوب الأنفية باستخدام التصوير المقطعي متعدد الطبقات في التهاب الأنف والجيوب الأنفية.

أجريت دراسة باستخدام التصوير الطبقي المحوري علي 392مريضاً(272 من الذكور و120 من الاناث)محالون للتصوير المقطعي للجيوب الأنفية في الفترة من2017 الى 2020 , وقد اجريت هذة الدراسة في مستشفيات الرياض بالمملكة العربية السعودية , ومعظمها من مركز الاستشاريون للأشعة التشخيصية. الفئة المختارة كانت تشكو من التهاب الأنف والحنجرة حيث أخضعوا للتصوير باستخدام جهاز جي اي . تم تقييم الصور لوجود أي اختلافات تشريحية في الجيوب الأنفية تم اختيار المرضي المصابين بالتهاب الأنف والجيوب الأنفية واستبعاد أولئك الذين تعرضوا لحادث أو عملية جراحية غيرت التشريح الطبيعي لديهم .

كشفت نتائج هذة الدراسة أن الترددالمطلق للتغيرات التشريحية بين 392 هو 91.3% انحراف الحاجز الأنفي , والحجيرات الهوائية شوهدت في 50.77% , تم العثور على الحجيرات الهوائية في الجزء الداخلي للجيوب الغربالية 5.36% المحارة لأنفية العلوية بها حجيرات هوائية بنسبة 20.15% الجيب الجبهي بة تضخم في الحجيرات الهوائية بنسبة 8.67% وغير موجودة بنسبة 4.85% , ووجدت المحارة المتوسطة متناقضة في الشكل في 10.71% وجدتالتصاق اللامينا بابريشيا بنسبة 1.79% , المحارة السفلى بها حجيرات هوائية بنسبة 1.28% .الخلايا الهوائية الجبهية لاتوجد في مجموعة الدراسة . الخلايا الهوائية فوق الحجاج وجدت بنسبة 16.07% خلايا الهوائية (اونودي) بنسبة 12.24% خلايا هالر الهوائية وجدت بنسبة 30.10% , التهوية الطرفية للجيب الوتدي بنسبة 7.65% , عمق الصفيحة المصفوية (تصنيف كيروس) كان في 0.51% , خلايا نابرة الانف وجدت في 51.02% الخلايا الهوائية تحت الحجاج وجدت في 10.20% مهماز الفاصل الانفي وجد في 29.34% الفقاعة الغربالية البارزة وجدت في 29.85% الناتئ الشصي المملوء بالهواء وجد في 12.76% , امتداد الجيب الوتدي للخلف الي الحاجز الأنفي وجد في 36.22% القاع الخلفي للسرج التركي مملوء بالهواء بنسبة 30.87%

الناتئ الجناحي مملوءة بالهواء بنسبة 7.91% الناتئ السريري الامامي المملوء بالهواء 10.97% , الحنك الصلب امتلئ بالهواء في 9.18 , واخيرا الفاصل الوتدي غير اتجاهة في 8.16%. وقد قارنا نتائجنا بالدراسة السابقة.

خلصت الدراسة إلى أن افضل الوسائل لتصوير الاختلافات التشريحية للجيوب الأنفية هو التصوير الطبقي المحوري متعدد الكواشفو أن الحاجز الأنفي المنحرف هو أكثر الاختلافات التشريحية شيوعا (93.11%) تليها خلايا نابره الانف 51.02%ثم الحجيرات الهوائيه بنسبه 50.77%

List of contents

List of tables

List of figures

List of abbreviations

Abbreviation	Full name
CT	Computed tomography
MPR	Multi planar reformation
PNS	Para nasal sinuses
OMU	Osteo meatal unit
AIDS	Acquired immunodeficiency syndrome
MRI	Magnetic resonance imaging
IV	Intravenous
ARS	Acute rhinositis
SARS	Sub acute Rhinositis
CRS	Chronic rhinositis
AECRS	Acute exacerbartion Rhinositis
DNS	Deviated nasal septum
SCCT	Screening sinuses computed tomography
HU	Hounsfield units
NP	Nasal polyp
DICOM	Digital Imaging and Communications in Medicine
MSCT	Multi slice computed tomography
MDCT	Multi detector computed tomography
GE	General electric
SPSS	Statistical Package for Social Sciences
MAS	Milli ampere second
sec	Second
3D	3 dimension
MA	Milli ampere
FOS	First order of statistic
KSA	Kingdom of Saudi Arabia
SNR	Signal to noise ratio
AV	Anatomical variation
RT	Right
LT	Left

Abbreviation	Full name
PT	Patient
IDL	Inter active data language
FESS	Functional endoscopic Sinuses surgery
ML	Milli litter
mm	Millli meter
V1	Ophthalmic nerve
cm	Centimeter
V2	Infra orbital nerve
IV	Intra venous
CRSNP	Chronic rhino sinus without nasal polyp
CRSWNP	Chronic rhino sinus with nasal polyp
AFS	Allergic fungal sinusitis
FOS	First order of statistic
XI	Intensity value of pixel
I	Pixel
N	Total number of pixel
V	Maximum intensity value with in a patch
CM CRDC	Contrast media Consultant radiologic diagnostic center
HI	Histogram of an image patch
STD	Standard deviation
Þ	Probability of certain pixel values
CI	Confidence interval
µ	Mean 2
б	Standard deviation 2

Chapter one

Introduction

1.1Introduction:

Paranasal sinuses are a group of air-filled spaces developed as an expansion of the nasal cavities, eroding the adjacent bone structures. According to the literature, some of such regions present a high risk for injuries and consequential intra operative complications; with the ethmoid and frontal sinuses being most frequently affected (Sobiesk and Munakomi, 2020).

Sino nasal diseases, especially rhino-sinusitis, are commonly encountered health problems in otorhino-laryngology practice. Variations in sinonasal anatomy such as the deviated nasal septum, enlarged turbinates, etc. are common in the population (Sobiesk and Munakomi, 2020).Chronic rhino sinusitis is a common condition in which the paranasal sinuses (PNS) become inflamed and swollen for at least eight weeks despite treatment attempts(Sobiesk and Munakomi, 2020). It is also known that chronic rhino sinusitis interferes with drainage and causes mucus to build up. It is one of the most common illness of our times, and it is increasing in epidemic proportions throughout the world (Sobiesk and Munakomi, 2020). Chronic or recurrent sinusitis has been known to negatively impact health-related quality of life (Alkire and Bhattacharyya, 2010).

The prevalence of these variations differs in various ethnic populations (Badia et al., 2005). Role of sinonasal anatomical variations in the causation of chronic rhinosinusitis is still debated though it cannot be ruled out altogether (Sobiesk and Munakomi, 2020). Although sinusitis is a clinically diagnosed condition, imaging studies are used to assess the disease and demonstrate the sinonasal anatomy (Sobiesk and Munakomi, 2020). Computed tomography (CT) scan plays a fundamental role in the diagnosis of anatomical variations as well as of sinonasal diseases for better guidance in the decision making about clinical, therapeutic and surgical approaches. Spiral CT provides axial and coronal images that facilitate a good appreciation of the size and relationship of the paranasal sinuses. It is currently the gold standard to study the imaging modality of choice for evaluating paranasal sinuses and adjacent structures (Kaygusuz et al., 2014; Mamatha et al., 2010). MSCT with its capability of displaying bone and soft tissues is the current diagnostic modality of choice for evaluating the ostiomeatal complex. MSCT is used both as a diagnostic tool to identify anatomical anomalies and mucosal pathology and as a preoperative map to guide the surgeon through the challengingly convoluted and variable anatomy of the area (Shpilberg et al., 2015; Alkire and Bhattacharyya, 2010).

The present study is aimed atdemonstrating the main anatomical variations that may be detected in paranasal sinuses by means of multislice computed tomography.

1.2Problem of the study:

The problem of this study that most of residents live in Saudi more than 6 months started complaining from headache and heaviness when they come to the hospital the doctor directly as routine test ask them to do PNS CT scan. Also Anatomical variations are very important to be identified when planning a paranasal sinus (PNS) surgery. Conventional radiology does not permit a detailed study of anatomical variations of the nose and paranasal sinuses; there is lack of studies in Saudi Arabia resident in this entity to Study Anatomical Variations of Para nasal sinus (PNS) using Multislice Computed Tomography (MSCT) in Rhinosinusitis

1.3 Objectives:

1.3.1General objective

The aim of this study was to characterize the most common anatomical variation of PNS in Saudi resident subject whom have rihanosinusitis.

1.3.2 Specific objectives

- To characterize the most common anatomical variation of PNS in Saudi resident
- To detect the most pathological finding.
- To characterize the common lesion of PNS in Saudi resident.
- To detect the reasons that causes the PNS lesion.
- To classify the most age groups affecting by the lesion.
- To correlate between the disease and patient demographic data.
- To correlate the age to pathological findings

1.4 Overview of this study:

This study consists of five chapters, chapter one consist of an introduction; introduce briefly this thesis and it was containing general introduction about CT scan of Para nasal sinuses, problem of the study, general and specific objectives in addition to the over view of the study. Chapter two was the literature review which contains the general theoretical background and previous study about detection of these diseases during CT scan for PNS. Chapter three describe the methodology (material and method) that used in this study. Chapter four was including result of presentation of the final finding of the study.

Chapter five was including discussion, conclusion and recommendations for future scope in addition to references and appendices.

Chapter two

Literature review and theoretical background

2.1 Anatomy and physiology:

The paranasal sinuses are connected system of hollow air field cavities in the skull which communicate with the nasal cavity and lined by ciliated mucous membrane. They develop as out Pouching from the nasal passages and are sufficiently will developed to be demonstrable in radiographs at four or five years of age and do not stop growing until age 18 years old (Sobiesk and Munakomi, 2020)

In all, there are eight sinuses they are divided into two groups; the anterior and posterior groups the anterior group consist of the two maxillary sinuses (antra), the two frontal sinuses and the two anterior and middle ethmoidal sinuses. The posterior group comprises the two posterior ethmoidal sinuses and the two sphenoidal sinuses (Figure2.1) (Sobiesk and Munakomi, 2020).

The anterior group drainage into middle meatus which is bordered by the middle turbinate bone and the posterior group drainage into superior meatus (which is a space defined by superior turbinate bone) and the sphenoethmoidal recess (Figure2.1) (Sobiesk and Munakomi, 2020).Although in a minority of patients some of the sinuses do not fully form. These hypo plastic (incompletely formed) or a plastic sinus (completely unformed) are often an incidental finding, usually not associated with any increased sinus problems, although in some instances they should be addressed (Sobiesk and Munakomi, 2020).

The purpose of the sinuses is unclear but theories said that sinuses are- :

- Decreasing the relative weight of the front of the skull, and especially the bones of the face.

- Increasing resonance of the voice.
- Providing a buffer against blows to the face.
- Insulating sensitive structures like dental roots and eyes from rapid temperature fluctuations in the nasal cavity.
- Humidifying and heating of inhaled air because of slow air turnover in this region,
- Humidification and warming of inspired air are accomplished by the watery secretions of the serous glands, which can produce up to 1–2 liters of secretions per day (Sobiesk and Munakomi, 2020).

While the watery serous secretions play a role in humidification and warming, the secretions of the goblet cells and mucous glands facilitate the removal of particulate matter. This mucous is very effective, trapping up to 80% of particles larger than 3–5 microns. This includes not only inorganic pathogens but also up to 75% of the bacteria entering the nose. The mucous blanket of the nose is a very dynamic structure, continuously renewing itself every 10–20 minutes (Sobiesk and Munakomi, 2020).

The mucous blanket also defends the body against infection. Besides trapping organic pathogens, the blanket constitutes a rich immunologic barrier within the mucosa. When exposed to the trapped antigens, it can further enhance the response by stimulating the immune system. The ciliated epithelium continually beats, propelling the mucus in a synchronized fashion toward the natural opening or ostium of each sinus.

These ostia drain into the nasal cavity. The mucus is then propelled to the nasopharynx to be swallowed. At this point the acid secretions of the stomach can help destroy the inhaled pathogens (Sobiesk and Munakomi, 2020).

The normal function of the sinuses depends on three essential components: thin normal mucus secretions, normally functioning microscopic hairs (called cilia) that move the mucus out of the sinuses, and open sinus drainage openings (called sinus ostium) (Sobiesk and Munakomi, 2020).

These components allow for the continuous clearance of secretions. Interference with any of these three components of the normal sinuses may predispose the patient to sinusitis. In other words, thick secretions malfunction of the microhairs, or blockage of the natural sinus openings may lead to symptoms of sinusitis. The microhairs move at a frequency of 10 strokes per second in a coordinated fashion. The action of these microhairs move any given mucus particle from the sinuses and out into the nose in about 10 minutes. Cilia function is most effective at a temperature above 18 °C and a relative humidity of about 50% (Sobiesk and Munakomi, 2020).

This may be a factor with common colds, which occur in the winter months. For the mucociliary system to clear the secretions from the sinuses, the natural sinus opening must be patent (Sobiesk and Munakomi, 2020)

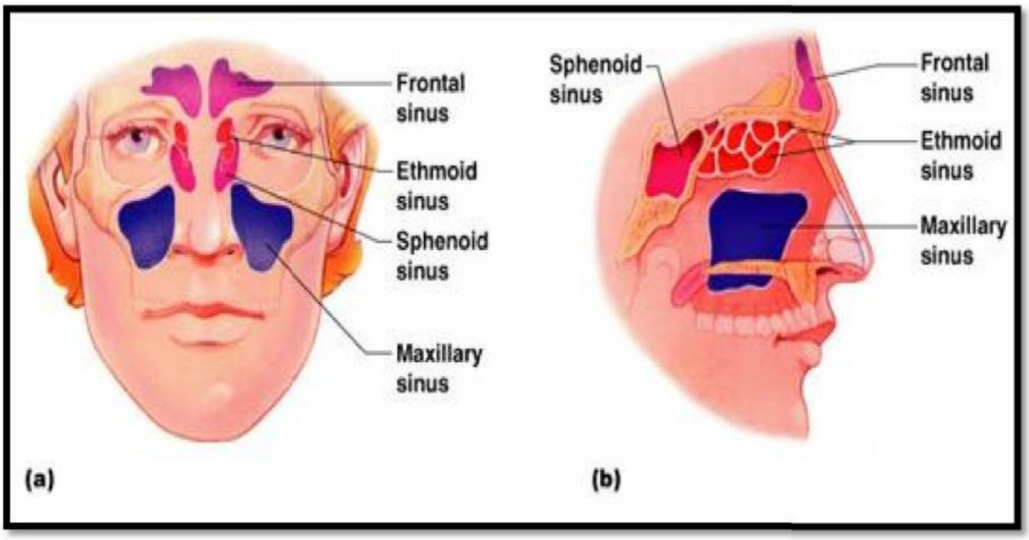


Figure (2.1): Anatomy of paranasalsinuses: (a) anterior view (b) side view (Marieb, 1998)

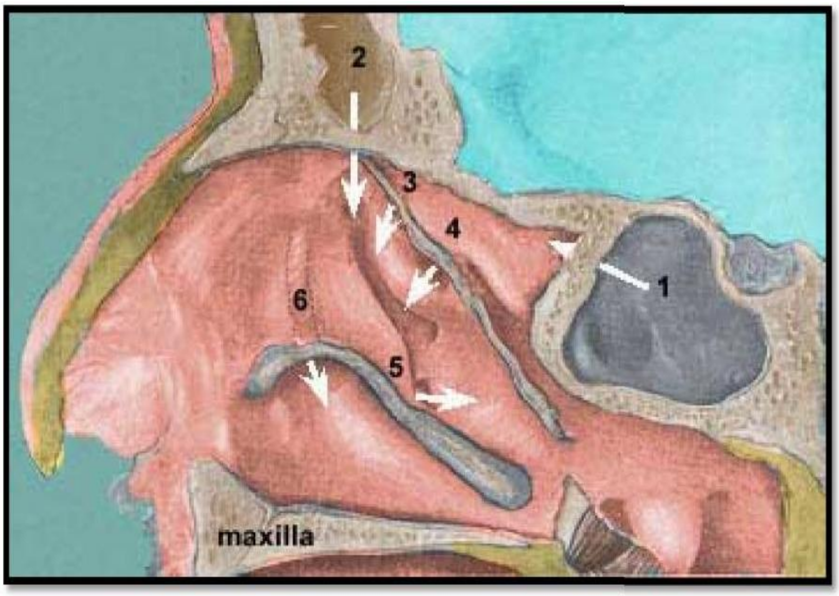


Figure (2.2): lateral view shows the anatomical parts of the sinuses (Marieb, 1998).

2.1.1The Maxillary sinus or(antra):

The maxillary sinus (antrum of Highmore) is the first to develop. These structures are usually fluid-filled at birth. The growth of these sinuses is biphasic with growth during years 0-3 and 7-12. During the later phase pneumatization spreads more inferiorly as the permanent Teeth take their place. Pneumatization can be so extensive as to expose tooth roots with only a thin layer of soft tissue covering them (Sobiesk and Munakomi, 2020).

2.1.1.1Structure:

The adult maxillary sinus is a pyramid which has a volume of approximately15 ml (34x33x23mm). The base of the pyramid is the nasal wall with the peak pointing toward the zygomatic process. The anterior wall has the infra orbital foramen located at the mid superior portion with the infra orbital nerve running over the roof of the sinus and exiting through the foramen. This nerve can be dehiscent (14%). The thinnest portion of the anterior wall is just above the canine tooth-the canine fossa (Sobiesk and Munakomi, 2020).

The roof is formed by the orbital floor and transected by the course of the infra orbital nerve. The posterior wall is unremarkable. Behind this wall is the pterygomaxillary fossa with the internal maxillary artery, spheno palatine ganglion and the Vidian canal, the greater palatine nerve and the foramen rotundum. The floor, as discussed above, varies in its level. From birth to age nine the floor of the sinus is above that of the nasal cavity. At age nine the floor is generally at the level of the nasal floor. The floor continues to sink as the maxillary sinus pneumatizes. Because of the close relationship with the dentition dental disease can cause maxillary infection, and tooth extraction can result in oral-antral fistulae (Sobiesk and Munakomi, 2020).

2.1.1.2Vascular supply

Branches of the internal maxillary artery supply this sinus. These include the infraorbital (as it runs with the infraorbital nerve), lateral branches of the sphenopalatine, greater palatine, and the alveolar arteries. Venous drainage- runs anteriorly into the facial vein and posteriorly into the maxillary vein and jugular vs. dural sinus systems (Sobiesk and Munakomi, 2020).

2.1.1.3Innervation

The maxillary sinus is innervated by branches of V2, Specifically, the greater palatine nerve and the branches of the infraorbital nerve [(Sobiesk and Munakomi, 2020).

2.1.1.3Related structures:

The naso lacrimal duct drains the lacrimal sac and runs from the lacrimal fossa in the orbit down the posterior aspect of the maxillary vertical buttress and empties in the anterior aspect of the inferior meatus. The duct lies very close to the maxillary ostium. On average it lies 4mm-9mm anterior to the ostium (Sobiesk and Munakomi, 2020).

The osteo-meatal unit (OMU) comprises the maxillary sinus ostium, the ethmoid infundibulum, anterior ethmoid cells and the frontal recess. The ethmoid infundibilum is bounded laterally by the inferomedial wall of the orbit, superiorly by the hiatus semilunaris and ethmoid bulla, and medially by the uncinate process. The maxillary sinus ostium and ethmoid infundibilum constitute the common drainage for the anterior paranasal sinuses. One of the aims of FESS is to re-establish the normal ventilation and the sinus drainage in the OMU (Sobiesk and Munakomi, 2020).

It is important to realize that the ethmoid infundibulum is a three-dimensional structure and not two-dimensional as depicted on CT. As the maxillary sinus ostium opens into the floor of the ethmoid infundibulum, it is not possible to see the ostium endoscopically without removing the uncinate process. If an ostium is seen endoscopically, it is most likely to represent an accessory ostium or fontanelle.

The hiatus semilunaris gains its name from the arched appearance in the sagittal plane. It runs obliquely in a posteroinferior direction between the uncinate process and the ethmoid bulla. It is best identified on parasagittal sections. On CT, it is bounded superiorly by the ethmoid bulla, laterally by the medial bony orbit, inferiorly by the uncinate process and medially by the middle meatus. The hiatus semilunaris, the final segment of the drainage pathway from the maxillary sinus and ethmoid infundibulum, communicates medially with the middle meatus (Figure 2.3) (Sobiesk and Munakomi, 2020).

The relations of the uncinate process is again different from the three-dimensional view through an endoscope and the two-dimensional view portrayed on CT. Anteriorly, it is attached to the naso lacrimal apparatus; inferiorly to the inferior turbinate; posteriorly it has a free margin; and superiorly, its attachment is variable.On CT, the uncinate process can be seen attached inferiorly to the inferior turbinate with the free edge representing the posterior free margin. Anteriorly, the uncinate process may be attached to the lamina papyracea, the skull base or the middle turbinate. This variable superior attachment results in different clinical implications If the uncinate Process inserts into the lamina papyracea, the ethmoid infundibulum would be effectively closed superiorly by a blind-ending pouch known as the recessus terminals. In this instance, the frontal recess and the ethmoid infundibulum are separated and this explains why ethmoid infundibular inflammation does not result in concomitant frontal sinusitis. However, if the uncinate process is attached superiorly to the skull base or the middle turbinate, the frontal sinus

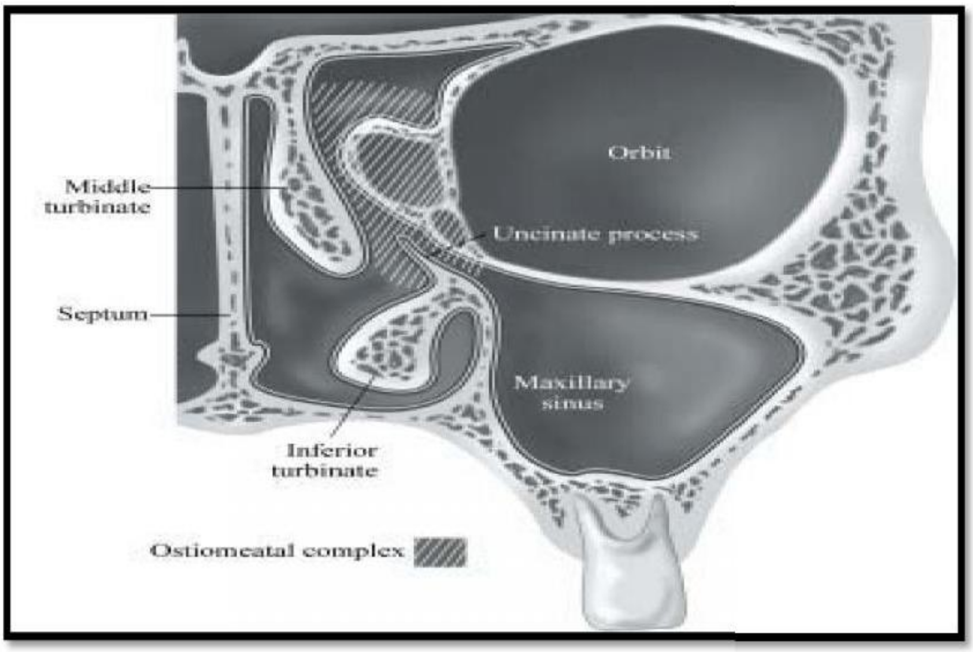


Figure (2.3): Anatomy of maxillary sinus and ostiomeatal complex (Maclennan, 1995).

opens into the ethmoid infundibulum and infection in the infundibulum may affect the frontal sinus, resulting in the involvement of the frontal, ethmoid and maxillary sinuses (Sobiesk and Munakomi, 2020).

2.1.2**The Frontal Sinus:**

2.1.2.1Development

The frontal sinus is likely formed by the upward movement of the anterior- most ethmoid cells. Since the frontal bone is membranous at birth there is seldom more than a recess until the bone begins to ossify around age two. Thus, radiographs seldom show this structure before that time. True growth begins at age five and continues into the late teens (Sobiesk and Munakomi, 2020).

2.1.2.2Structure

The volume of the sinus is approximately 6-7 ml (28x24x20mm). Frontal sinus anatomy is highly variable, but generally there are two sinuses which are funnel shaped and point upward. The depth of the sinus is the most surgically significant dimension as it determines the limitations of surgical approach. Both frontal sinuses have their ostia at the most dependent portion of the cavity (posteriomedial). Both the anterior and posterior walls of this sinus are composed of diploic bone. However, the posterior wall (separates the frontal sinus from the anterior cranial fossa) is much thinner. The floor of the sinus also functions as a portion of the orbital roof (Sobiesk and Munakomi, 2020).

2.1.2.3Vascular supply

The frontal sinus is supply via ophthalmic artery via the supraorbital and supratrocchlear arteries (Sobiesk and Munakomi, 2020).

2.1.2.4Innervation

The frontal sinus is innervated by branches of V1. Specifically, these nerves include the supra orbital and supratrochlear branches (Sobiesk and Munakomi, 2020).

2.1.2.5Related structures

The frontal recess is the space between the frontal sinus and the hiatus semilunaris into which the sinus drains. It is bounded anteriorly by the agger nasi cell and superiorly by the frontal sinus, medially by the middle turbinate, and laterally by the lamina papyracea. The cavity resembles a dumbbell as the frontal sinus narrows to the sinus ostium/channel and then opens again into the wider frontal recess (Figure 2.4) (Sobiesk and Munakomi, 2020).

2.1.3 The Ethmoidal cells:

2.1.3.1Development

The ethmoid sinuses are well-delineated, fluid-filled structures in a newborn child. During fetal development the anterior cells form first, followed by the posterior cells. The cells grow gradually and are adult size by age 12. Ethmoid cells are the most variable and can often be found above the orbit, lateral to the sphenoid, into the roof of the maxillary sinus, and anteriorly above the frontal sinus. These cells have been named. A cell above the orbit is called a supraorbital cell and is found in 15% of patients. Invasion of an ethmoid cell into the floor of the frontal sinus is called a frontal bulla. Extension into the middle turbinate is termed concha bullosa.Cells in the roof of the maxillary sinus (infraorbital) are called, "Haller's cells," and are found in 10% of the population. These cells can obstruct the maxillary ostia and narrow the infundibulum and result in disruption of normal sinus function. Finally, a cell which extends anteriolaterally to the sphenoid sinus is called an Onodi cell (10%) (Sobiesk and Munakomi, 2020).

2.1.3.2Structure

Posterior and anterior cells combined have a volume of 15ml(3.3x2.7x1.4cm). The ethmoids are shaped like a pyramid and are divided intomultiple cells by thin septa. Roof - The anterior 2/3 of the roof is thick and strong and is composed of the frontal bone and the foveolae ethmoidalis. The posterior 1/3 ishigher laterally and slopes down medially to the cribriform plate. The junction between the lateral dense bone and the plate is one-tenth as strong as the lateral roof. The difference in height between the lateral and medial roof is variable, but can be as much as 15-17mm. The posterior aspect of the ethmoid cells borders on the sphenoid sinus. The lateral wall is the lamina papyracea of the orbit (Sobiesk and Munakomi, 2020).

2.1.3.3Vascular supply

The ethmoid sinuses are supplied by both the external and internal carotid arteries. The Sphenopalatine artery and the ophthalmic artery (which branches into the anterior and posterior ethmoid arteries) supply the sinuses. Venous drainage -follows arterial supply and thus infection can track intracranially (Sobiesk and Munakomi, 2020).

2.1.3.4Innervation

Both V1 and V2 innervate this region. V1 supplies the more superior aspect with V2 innervating the inferior regions. Parasympathetic innervation is via the Vidian nerve. Sympathetic innervation is via the cervical sympathetic ganglion and follows the arterial vasculature to the mucosa of the sinuses (Sobiesk and Munakomi, 2020).

2.1.3.5Related structures

This structure forms the separation between the anterior and posterior ethmoid cells. It is the attachment of the middle turbinate and runs in three different planes in its course from anterior to posterior. The anterior most portions are vertical and inserts in the crista ethmoidalis and skull base. The middle third is oblique with insertion in the lamina papyracea. The final third runs horizontal with insertion in the lamina papyracea. The space under the middle turbinate is termed the middle meatus into which the anterior ethmoids, frontal sinus, and maxillary sinus drain. Surgical damage to the anterior or posterior portions of the middle turbinate may destabilize this structure and anteriorly risks disruption of the cribriform plate (Sobiesk and Munakomi, 2020).

The anterior cells are those anterior to the basal lamella. They drain into the middle meatus via the ethmoid infundibulum. They include the agger nasi cells, the ethmoid bulla and any other anterior cells. The posterior cells drain into the superior meatus and border on the sphenoid sinus. They are generally fewer in number and larger than the anterior cells (Figure 2.4) (Sobiesk and Munakomi, 2020).

The cell is found in the lacrimal bone anterior and superior to the junction of the middle turbinate with the nasal wall (often described as the bulge in the lateral nasal wall where the middle turbinate attaches). It is hidden behind the anterior most aspect of the uncinate process and drains into the hiatus semilunaris. It is the first cell to pneumatize in the newborn and is prominent through childhood. There can be from one to three cells. The posterior wall of the cell forms the anterior wall of the frontal recess. The roof of the agger nasi cell is the floor of the frontal sinus, and is therefore, an important landmark for frontal sinus surgery (Sobiesk and Munakomi, 2020).

This is the most constant landmark for surgery. It lies above the infundibulum and its lateral/inferior surface and the superior edge of the uncinate process forms the hiatus semilunaris. It is usually the largest of the anterior ethmoid cells. The anterior ethmoid artery usually courses across the roof of this cell. Suprabullar and retrobullar recesses may be formed when the ethmoid bulla does not extend to the skull base. The suprabullar recess is when there is a cleft between the roof of the ethmoid bulla and the fovea. The retrobullar space is formed when there is a cleft between the basal lamella and bulla. This retrobullar space opens into what is known as the "hiatus semilunaris superior." (Sobiesk and Munakomi, 2020).

The development of the infundibulum precedes that of the sinuses. This recess, into which the anterior ethmoid sinuses, maxillary sinus and frontal sinus drain, is formed by multiple structures. The anterior wall is formed by the uncinate process; the medial wall is the frontal process of the maxilla and the lamina papyracea. It runs anteriorly in continuity with the frontal recess to its posterior limit where the uncinate process attaches to the lamina. The opening above the recess is known as the hiatus semilunaris. The maxillary sinus is found in this area (Sobiesk and Munakomi, 2020).

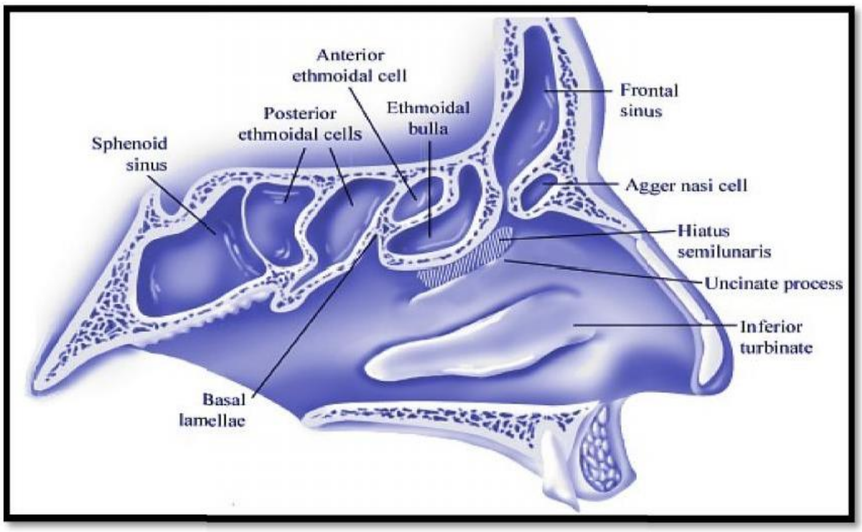


Figure (2.4): Anterior vs. posterior Ethmoid cells and related structures (Maclennan, 1995).

2.1.4The Sphenoidal sinuses:

2.1.4.1Development

The sphenoid sinuses are unique in that they do not arise from out pouchings of the nasal cavity. These sinuses arise from within the nasal capsule of the embryonic nose. They remain undeveloped until age three. By age seven the pneumatization has reached the sella turcica. By age 18 the sinuses have reached full size (Sobiesk and Munakomi, 2020).

Its volume is approximately 7.5 ml (23x20x17mm). Pneumatization of this sinus, like that of the frontal sinus, is very variable. Generally, these are bilateral structures located at the posterior superior aspect of the nasal cavity. Pneumatization can extend as far as the clivus, the sphenoid wings, and the foramen magnum (Sobiesk and Munakomi, 2020).

The walls of the sphenoid vary in thickness with the anterosuperior wall and roof being the thinnest (1 to 1.5 mm). The other walls are thicker. The thinnest part of the anterior wall is 1cm from the fovea ethmoidalis. The sinus can sit far anterior to, just anterior to, or immediately under the sella turcica (conchal, presellar, sellar/postsellar). The most posterior position can place the sinus just adjacent to vital structures such as the carotid arteries, optic nerves, maxillary branch of the trigeminal nerve, the Vidian nerve, the pons, sella turcica, and the cavernous sinus. These structures are often identified as indentions on the roof and walls of the sinus. A small percentage will have dehiscence of bone over such vital structures as the optic nerve and carotid arteries. Care must also be taken when removing sinus septa as these may be in continuity with the carotid and optic canal and can result in death and blindness (Sobiesk and Munakomi, 2020).

The sphenoid sinus ostium drains into the sphenoethmoidal recess. The ostium is very small (.5-4mm) and is located about 10mm above the sinus floor. A 30-degree angle drawn from the anterior nasal floor approximates the location of the ostium on the posteriosuperior nasal wall. It is noted to be close to the midline at the junction of the upper 1/3 and the lower 2/3 of the anterior sinus wall. It is generally medial to the supreme/superior turbinate, and is only a few millimeters from the cribriform plate. This ostium, like that of the maxillary sinus, has a much larger bony dehiscence which is narrowed by a membranous septum (Figure 2.4) (Sobiesk and Munakomi, 2020).

2.1.4.2Vascular supply

The posterior ethmoid artery supplies the roof of the sphenoid sinus. The rest of the sinus is supplied by the spheno palatine artery. Venous drainage is via the maxillary veins to the jugular and pterygoid plexus systems (Sobiesk and Munakomi, 2020).

2.1.4.3Innervation

The sphenoid sinus is supplied by branches from both V1 and V2. The nasociliary nerve (from V1) runs into the posterior ethmoid nerve and supplies the roof. The branches of the sphenopalatine nerve (V2) supply the floor (Sobiesk and Munakomi, 2020).

2.1.4.4Related structures

The spheno ethmoid recess is a space behind and above the most superior turbinate. The boundaries of this space are formed by multiple structures. The anterior wall of the sphenoid sinus forms the posterior aspect. The nasal septum and cribiform plate form the medial and superior aspects. The anterio lateral extent is determined by the most superior turbinate. The space opens into the nasal cavity inferiorly. The posterior ethmoid cells, empty into this region as well as the sphenoid sinus (Sobiesk and Munakomi, 2020).

Sphenoid rostrum structure is simply the midline projection of the anterior sphenoid sinus wall. It articulates with the perpendicular plate and the vomer**.** An Onodi cell is a posterior ethmoid cell that extends lateral and superior to the sphenoid sinus and abuts the optic nerve. Kainz and Stammberger defined an Onodi cell as a posterior ethmoid cell with an endoscopically visible bulge of the optic canal. The vulnerability of the optic nerve with or without the presence of an Onodi cell is further compounded by the thin lamina papyracea in the posterior ethmoid area (Sobiesk and Munakomi, 2020).

Haller Cells Haller cells or infraorbital ethmoidal air cells are pneumatized ethmoid air cells that project along the medial roof of the maxillary sinus and the most inferior portion of the lamina papyracea, below the ethmoid bulla and lateral to the uncinate process. This cell was first described by an anatomist Albert Haller in 1765 When enlarged, it can cause obstruction of the posterior aspect of the ethmoidal infundibulum and ostium leading to maxillary sinusitis, resulting in orofacial pain and sinusitis, nasal obstruction, impaired nasal breathing, headache, chronic cough, and mucoceles (Sobiesk and Munakomi, 2020).

2.2Pathology:

2.2.1Inflammatory conditions:

The term sinusitis refers to a group of disorders characterized by inflammation of the mucosa of the paranasal sinuses, because the inflammation nearly always also involves the nose, hence it is now generally accepted that rhinosinusitis is the preferred term to describe this inflammation of the nose and paranasal sinuses; refers to the inflammation of the mucous membranes of the paranasal sinuses. Any condition (Inflammation, neoplasm, foreign body) that interferes with drainage of a sinus renders it liable to infection. If the ostium of a sinus is blocked, the secretion or exudates accumulates behind the obstruction (Sobiesk and Munakomi, 2020)

Causative factors of sinusitis include Inflammatory factors include upper respiratory tract infections (example, the common cold), allergic rhinitis, vasomotor rhinitis, recent dental work, baro-trauma, and swimming. Systemic factors include immunodeficiency, ciliary dyskinesia syndrome, cystic fibrosis, rhinitis of pregnancy, and hypothyroidism.Mechanical factors include choanal atresia, sinonasal polyps, deviated septum, foreign body, trauma, tumor, nasogastric tube, turbinate hypertrophy, concha bullosa, adenoid hypertrophy. Medicative causes include beta blockers, birth control pills, anti-hypertensive, aspirin intolerance, rhinitis medicamentosa (overuse of topical decongestants), and cocaine abuse (Sobiesk and Munakomi, 2020).

2.2.1.1Acute sinusitis:

Acute sinusitis generally presents complication of acute infection of the nose (rhinitis) and rarely secondary to dental sepsis. The ostia are occluded due to inflammation and edema and the sinuses are full (Figure 2.5), (Figure 2.6) (Sobiesk and Munakomi, 2020)

2.2.1.2Chronic sinusitis:

Acute sinusitis may become chronic due to incomplete resolution of acute inflammation and from damage to the mucous membrane, inadequate drainage of the sinuses, nasal obstruction due to polyps, or enlargement of the nasopharyngeal lymphoid tissue (adenoids). Sinusitis acute or chronic may be followed by a number of complications which are; Osteomyelitis of orbit bone, Septal deviation of nasal septum and concha bullosa, or air filled middle turbinate, which impede drainage of the infundibulum on its own side of the nose or, in extreme circumstances, may push the septum to the opposite side of the nose and block drainage on that side (Sobiesk and Munakomi, 2020).

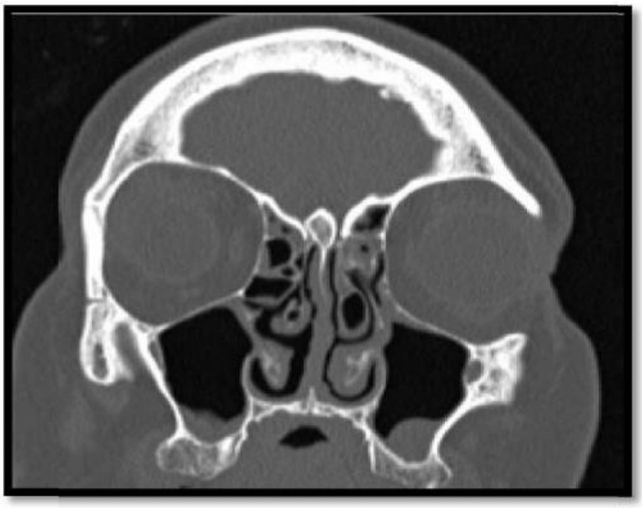


Figure (2.5): Coronal CT showing an air filled left sided middle turbinate (concha bullosa) pushes against the patient's nasal side wall and blocks the sinus drainage

Figure (2.6): X-RayPNS (Water's view) showing air fluid level in bot maxillary sinuses.

2.2.2Nasal Polyps:

Nasal polyps are usually bilateral multiple and freely movable protrusions of benign edematousmucosa. They are glistening, pale-grey smooth andsemi translucentin appearance. Polypoid lesions are mainly situated in the middle meatus and most of the polyps originate from the mucosa of the ostia, anterior and posterior ethmoidal clefts and frontal and sphenoethmoidal recesses but also from middle turbinate and septum (Sobiesk and Munakomi, 2020).

Polyps may occur in all paranasal sinuses too [Drake AB. (1987)], and could be visible in the middle meatus usually originate from the mucosa of the ostia, anterior ethmoidal cleft or frontal recess but polyps visible between the nasal septum and the middle or the superior turbinate either originate from recess (Sobiesk and Munakomi, 2020).

The olfactory ridge, posterior ethmoidal cleft or sphenoethmoidalAntrochoanal polyps arise in the maxillary antrum and prolapse through the ostium of the sinus in the middle meatus. They are seen in the nose or, if larger, in the posterior choana (Sobiesk and Munakomi, 2020).

Most frequently nasal polyps are found on the concave site of the deviated septum [Maran AGD and Lund VJ. (1990)]. There are 2 major types of nasal polyps according to the area of affected sinuses: antrochoanal polyp which is single, unilateral, originate from maxillary sinus and usually found in children. Ethmoidal polyp: This is bilaterally and usually found in adults (Figure 2.7), (Figure 2.8) (Sobiesk and Munakomi, 2020).

2.2.1Types of polyps:

2.2.1.1Allergic Polyps:

Recurrent allergic reactions cause chronic mucosal edema and enlargement of the turbinate (conchae) and that leading to localized bulging of the mucosa and the formation of polyps.Allergic polyps of the nose are usually multiple and appear as smooth, pale, movable, rounded tumors, which protrude in to the airway and cause symptoms of nasal obstruction. They may be sessile or pedunculated, and allergic polyps are lined externally by respiratory epithelium (Sobiesk and Munakomi, 2020).

2.2.1.2NonAllergic polyps:

These lesions arise in cases of chronic rhinitis and chronic sinusitis and are not related to allergic diseases of the nose (Sobiesk and Munakomi, 2020)

Figure (2.7) Anterior rhinoscopy showing multiple nasal polyps (Timmanagouda, 2008)

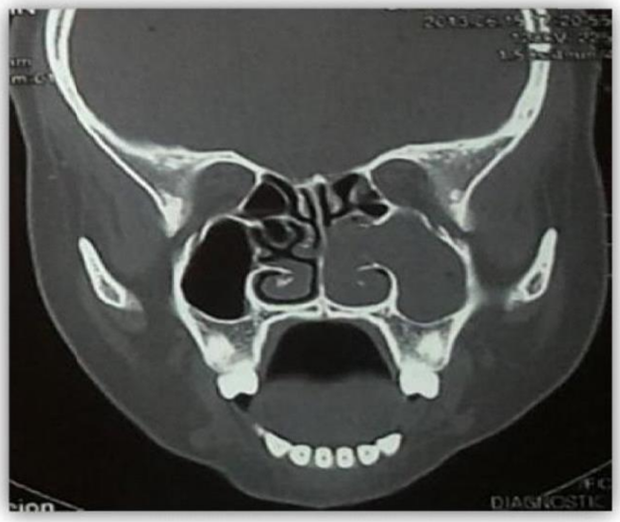


Figure (2.8) shows the coronal CT of a patient significant blockage of the nasal airway (Becker, 2003).

2.2.3Mucocele:

Mucoceles of the paranasal sinuses are benign, cyst-like, expansile lesions lined with a secretory respiratory mucosa of pseudostratified columnar epithelium. They are mucoid filled masses and develop after obstruction of the sinus ostium and drainage pattern, which is confirmed by the high incidence of mucoceles in the frontal sinus caused by the variations of the nasofrontal duct obstruction of paranasal sinus, causes the secretions to accumulate and to fill the sinus. Increased pressure results in expansion of the sinus and erosion or remodeling of its walls. There is a period preceding the remodeling/erosion when there is just accumulation of the secretions. These are most often found in the frontal sinuses (60%), due to vulnerability of the long fronto-nasal duct to obstruction by mucosal swelling (Figure 2.9) and (Figure 2.10).

Ethmoidal mucoeles are also common (25%). Maxillarymucoceles (10%) andsphenoidal mucoceles (1.2%) are less common. A mucocele can be thought of as the end stage of a chronically obstructed paranasal sinus (Sobiesk and Munakomi, 2020).

Figure (2.9) shows patient with mucocele; facial deformity, (swelling) abnormal protrusion of the eyeball(Timmanagouda, 2008).

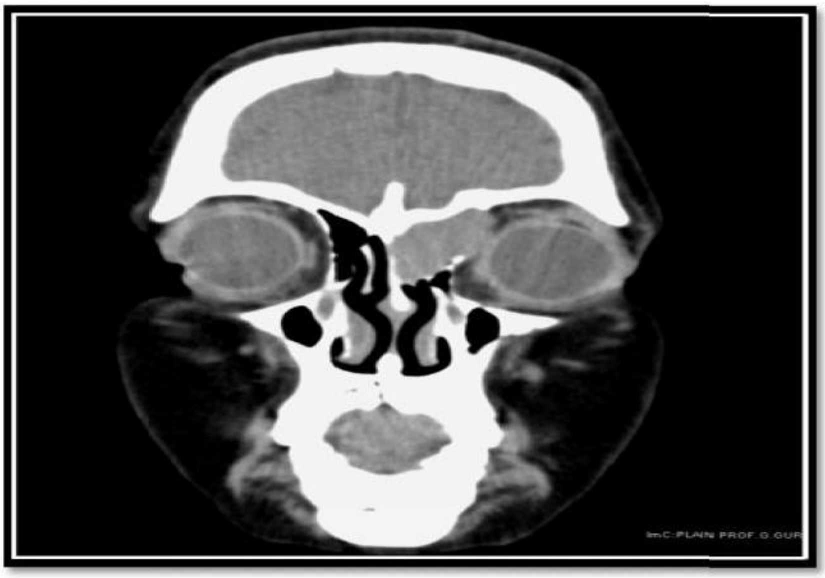


Figure (2.10) coronal CT showing mucocele; Lt. frontal and ethmoid sinuses opacity and expanded(Timmanagouda, 2008).

2.2.4 Fungal Sinusitis:

Fungi are plant-like organisms that thrive in warm and humid climates, which is why they easily colonize the sinuses which are dark, moist cavities in the skull bones. Fungal infections are usually opportunistic, meaning they occur when there is immune suppression in the body or the defense mechanism of the body is lowered. This happens with diabetes, AIDS, overuse of antibiotics, use of immunosuppressive drugs to prevent graft rejection and some chronic diseases (Gleeson, 2008).

However, it is now known that fungal sinusitis can also affect the immune competent or healthy individual. Fungal infections occurring in people without any immune deficiency are usually benign and non-invasive while those affecting the immune suppressed may be invasive. The most common organisms causing fungal sinusitis are Aspergillus and Mucor (Gleeson, 2008).

There are four types of fungal sinusitis; Allergic fungal sinusitis, Fungal ball or Mycetoma, Acute fulminant fungal sinusitis and Chronic invasive fungal sinusitis. The first two types occur in immunocompetent individuals. Allergic fungal sinusitis is an allergic or hypersensitivity reaction to fungal elements in the environment. The affected individual has nasal block and discharge and may develop nasal polyps, sometimes extensive(Gleeson, 2008).

Fungal ball or mycetoma is a condition where fungal colonies grow in the cavities of the sinuses and sometimes occupy them completely. They commonly grow in the maxillary or the sphenoid sinuses. These patients may experience nasal stuffiness and have other features of sinusitis like nasal blockage and discharge, usually one-sided. It may sometimes be an incidental finding in a CT scan. The other two varieties are invasive and can spread to neighboring structures like the eye and brain. While they usually occur in the immune compromised, they have been reported even in immune competent individuals (Gleeson, 2008).

Acute fungal sinusitis is a rapidly spreading infection. The patient may experience fever, severe headache, facial pain, nasal obstruction and nasal discharge which may be blackish or blood stained. Endoscopy may show the nasal tissues turning black and necrotic. This condition can be rapidly fatal if not treated immediately. The infection may spread to the eye causing blindness and the brain resulting in meningitis. Chronic invasive fungal sinusitis is similar but spreads more slowly giving rise to all the features of long standing chronic sinusitis with no response to antibiotic treatment. This infection may also spread to the eye but the acute and toxic symptoms of the acute fulminant variety are absent (Gleeson, 2008).

2.2.5Tumors:

The tumors of nose; nasal cavity and paranasal sinuses are uncommon. However benign and malignant tumors of epithelial as well can occur (Kumar et al, 1997).

2.2.5.1Benign Tumors:

Capillary Hemangioma is the common benign lesion in the septum of nose, and if the surface ulcerated and lesion contains inflammatory cells infiltrate, it resembles inflammatory granulation tissue and is called hemangioma of granulation tissue type (Kumar et al, 1997).

Papillomas may occur in the nasal vestibule, nasal cavity and paranasal sinuses. They are mainly of two types. Fungi form papilloma with exophatic growth, and inverted papilloma within irritated growth. Each of this may be lined with combination of epithelia: respiratory, squamous, and mucous types, which represent the commonest epithelial (Benign) tumors in the paranasal sinus and lateral wall of nasal cavity (Kumar et al, 1997).

Malignant tumors of Paranasal sinuses are rare, comprising about 3% of all head andnecktumors. Approximately50-65%of sinonasalmalignanciesarise within the maxillary sinuses,10-25% in ethmoid sinuses and 15-30% in the nasal cavity of all Paranasal sinuses cancers about 80% arise in maxillary antrum (Maclennan, 1995).

Olfactory neuroblastomaoccurs over the olfactory mucosa as a polypoid mass that may invade to the paranasal sinuses or skull. Usually a polypoid and highly vascular, and the tumors cells are larger than lymphocytes (Sobiesk and Munakomi, 2020).

More than half of carcinoma of the nasal cavity and paranasal sinuses:originate in the antrum of the maxillary sinus, one third in the nasal cavity, 10% in the ethmoid sinus, and 1% in the sphenoid and frontal sinuses (Sobiesk and Munakomi, 2020).

Most cancers of the nasal cavity and paranasal sinuses are squamous cell carcinomas. About 15% are adenocarcinomas, transitional cell carcinoma, or anaplastic carcinoma. The tumor extends locally to involve the surrounding bone and soft tissues and also metastasizes widely (Sobiesk and Munakomi, 2020).

2.3Diagnostic Testing

Clinical diagnosis (Signs & symptom) combined with history and physical examination is usuallysufficient to diagnose sinusitis in most cases of uncomplicated acute and subacuterhinosinusitis.The diagnosis of rhinosinusitis is based on clinical grounds. The emphasis on obtaining a patient history and performing a limited physical examination is based on thefact that most patientscan is effectively treated (medically andcost-wise) without thenecessity of nasal endoscopy, radiographic studies or bacterial cultures (Osguthorpe, 2001)

The patients' history is vital in understanding and diagnosing the problem. In rhinitisand rhinosinusitis an accurate history is usually more important than any otherinvestigation. The aimof any history taken is to evaluate thepresence, severity andduration of symptoms, aiming at an accurate diagnosis and enabling adequate treatment. All cases of rhinosinusitis involve inflammation of the mucosal linings, in practice however; the focus is on those patients in whom this inflammation leads to symptoms. Due to this important relationship to symptoms, the Rhinosinusitis Task Force's definitions include a group of symptoms to be applied to these conditions to allow for clinical diagnosis (Lubbe, 2009).

Other parameter up on which clinical examination depends is a Physical examination aims to find any abnormality or disease that can explain the symptoms such as inspection, palpation and anterior rhinoscopy (Figure 2.13) are easy and rapid ways to examine any nasal problems (Lubbe, 2009).

Figure (2.11) shows an anteriorrhinoscopy performed with a nasal speculum and headlight (Lubbe, 2009).

2.3.1 PNS x-ray (Water's view)

Imaging of the sinuses is usually reserved to confirm the diagnosis, if history and physical examination are equivocal, or if conventional treatment has failed. Conventional plain radiographs will continue to play a major role in the initial investigation of diseases of the paranasal sinuses, despite the limitations of this technique. Good radiographic method and positioning of the patient are important to detect early signs of disease such as erosion of the sinus walls (Bendouah et al., 2006).

The standard plain film sinus series usually consists of four views: lateral, Caldwell, Waters and Submentovertex. Plain films serve as a survey evaluation of the transparency, size, and wall integrity of the sinuses. The overlapping structures and the limited resolution of the fine body outlines provided by plain films hamper this modality in the evaluation of the sphenoid and particularly in the evaluation of the ethmoid sinuses The radiographic signs of PNS disease include variable degrees of opacification, mucosal thickening, air- fluid levels, bony erosion, mass lesion (solid or cystic), foreign body, calcification, and fracture.

Meaningful interpretation of these roentgen findings rests on correlation with the clinical signs and symptoms. Although the standard radiographs may be accurate in showing air fluid levels; the degree of chronic inflammatory disease is consistently and significantly underestimated. Furthermore, the superimposition of structures precludes the accurate evaluation of the anatomy of the osteomeatal channels with which the modern surgeon needs to be familiar (Bendouah et al., 2006).

The standard film of sinus series usually consists of four views: Lateral, Caldwell, Waters and Submentovertex.Plain films serve as a survey evaluation of the transparency, size, and wall integrity of the sinuses. The overlapping structures and the limited resolution of the fine body outlines provided by plain films hamper this modality in the evaluation of the sphenoid and particularly in the evaluation of the ethmoid sinuses The radiographic signs of PNS disease include variable degrees of opacification, mucosal thickening, air-fluid levels, bony erosion, mass lesion (solid or cystic), foreign body, calcification, and fracture. Meaningful interpretation of these roentgen findings rests on correlation with the clinical signs and symptoms (Bendouah et al., 2006.. Although the standard radiographs may be accurate in showing air fluid levels, the degree of chronic inflammatory disease is consistently and significantly underestimated. Furthermore, the superimposition of structures precludes the accurate evaluation of the anatomy of the osteomeatal channels with which the modern surgeon needs to be familiar (Delbert et al., 1981)

Among these views; Waters' view was developed by Waters and Waldron in 1915 as a modification of the occipito-frontal projection. It was essentially designed to provide a view of the maxillary sinus unobstructed by the petrous bone, and it has been regarded as the best single view for the maxillary sinuses (Merrell and Yanagisawa, 1968). Occipitomental or Water's view is the commonest projection requested by the clinician to diagnose sinusitis. This view shows the maxillary sinuses clearly. The frontal sinus is projected obliquely (Axelsson and Runze, 1982).

The ethmoid air cells are seen along the medial walls of the orbit and within the nose. Most studies have demonstrated that about 90% of cases of sinusitis involve the maxillary sinuses and, therefore, most cases of sinusitis would be diagnosed using only the Waters view (Williams et al., 1992). Asingle Waters' view (occipitomental) appears to provide as much information as the standard four-view series (Axelsson and Runze, 1982).

Physicians usually order a single occipitomental radiograph, rather than a complete sinus series (four views), to lower diagnostic costs and limit radiation exposure. A recent study comparing the Waters view with three views (Waters, occipito-frontal, and lateral) found 99% similarity and concluded that a single Water's view is sufficient for diagnostic purposes (Kenneth and John, 2009).

The purpose ofWaters view is to project the petrous bone below the maxillaryantrum. It is obtained by extending the patient's head so that the chin touches the table top. The waters view obtained with mouth open allows visualization of all the paranasal sinuses including the sphenoid sinuses. The medial bony wall of the orbit is formed by the anterior aspect of the lamina papyracea, so that the ethmoidal cells projected between the two orbitsrepresent the anterior cells. The posterior cells are projected into the maxillary antra, together with the superior orbital fissure and the sphenoid sinuses (Figure 2.14) (Axelsson and Runze, 1982).

Plain films are inadequate in the evaluation of the OMC and pneumatisation variants, and therefore insufficient in the preoperative evaluation for planning FESS. While conventional plain radiography readily demonstrates maxillary and frontal sinus disease they provide limited views of the anterior ethmoid cells, the upper two thirds of the nasal cavity and the frontal recess.

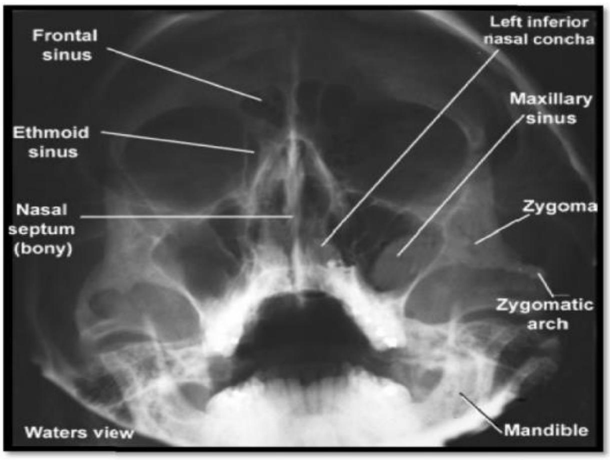


Figure (2.12): radiographic appearance of Water's view x-ray

2.3.2 Computed tomography:

CT utilizes a conventional X-Ray tube a bank of detectors, which rotate around the patient to produce a finely focused series of projections, which are reconstructed by computers to produce across-sectional image, usually transaxial image (Jorie, 1991).

High resolution computerized tomography gives an excellent demonstration of both fine bone detail and soft tissue anatomy on the same sectional picture and is now the investigation of choice. CT scan can detect early swellings and tumors in course of the disease and can be used to recognize the exact extent of the lesion for optimal staging prior to therapy. CT plays an important role in the follow-up and can be used to show residual or recurrent disease (Jorie, 1991).

Magnetic resonance gives better soft tissue imaging in three dimensions and appears to be better than CT for demonstration of extension of the disease inside the cranial cavity. However, MR does not image the bony structures and therefore does not appear likely to replace CT for the investigation of diseases of the paranasal sinuses in future (Jorie, 1991).

CT image has low spatial resolution but it has high contrast resolution in comparison with the conventional radiograph. CT scan can now be obtained in about 1 second and new spiral scanners which combine continuous table movement and continuous X-Ray tube emission allow volumes of tissue up to 60 cm in length to be scanned, with slice obtain anywhere with this volume. This allows better multiplaner reconstruction (Jorie, 1991).

Finally, the image can be stored on magnetic tapes or optical disk and recorded permanently on C-Ray film.

The advantages of CT are as follow:

- Excellent contrast resolution.
- Transaxial image with no tissue superimposition.
- Excellent anatomical display can be used to guide biopsies.

2.3.2.1Contrast medium:

Some patients require an injection of a contrast material to enhance the visibility of certain tissues or blood vessels. A nurse or technologist will insert an intravenous (IV) line into a small vein in the patient's hand or arm. The contrast material will be injected through this line (Jorie, 1991).

Next, the table will move quickly through the scanner to determine the correct starting position for the scans. Then, the table will move slowly through the machine as the actual CT scanning is performed (Jorie, 1991).

Technologist may be asked to hold your breath during the scanning. Any motion, whether breathing or body movements, can lead to artifacts on the images. This is similar to the blurring seen on a photograph taken of a moving object.When the examination is completed, the patient will be asked to wait until the technologist verifies that the images are of high enough quality for accurate interpretation (Alho, 2004). The actual CT scan takes less than a minute and the entire process is usually completed within 10 minutes (Jorie, 1991).

2.3.2.2 Experience during and after the procedure:

CT exams are generally painless, fast and easy. If the patient has claustrophobic or chronic pain, the technologist or nurse, give him sedative to help them tolerate the CT scanning procedure. When the patient enters the CT scanner, special lights may be used to ensure that the patient is properly positioned (Jorie, 1991). With modern CT scanners, patient will hear only slight buzzing, clicking and whirring sounds as the CT scanner revolves around him during the imaging process (Jorie, 1991).

Patient will be alone in the exam room during the CT scan. However, the technologist will be able to see, hear and speak with you at all times.With pediatric patients, a parent may be allowed in the room but will be required to wear a lead apron to minimize radiation exposure (Jorie, 1991).

2.3.2.3 Limitations of CT of the Sinuses:

While CT is occasionally used to detect the presence of tumors, magnetic resonance imaging (MRI) is the primary choice for this purpose, A person who is very large may not fit into the opening of a conventional CT scanner or may be over the weight limit for the moving table which is usually about 450 pounds (Jorie, 1991).

Limitations of CT imaging include increased cost and radiation dosage. Radiation dose is related to technique and may deliver over 10 times the dosage compared with plain film radiography (Ballinger and Frank, 1999)

The radiation dose to the lens from coronal CT scanning of the sinus show mean lens dose ranging as high as 70,3mGy, this is well in excess of the average annual recommended dose limit for the general public of 5mGy Radiation dose to the lens is particularly high when axial cuts are taken – nearly 185 times more than that recorded for plain X – rays (Ballinger and Frank, 1999)

2.4 Clinical assessment an appearance:

2.4.1Inflammatory disease :(acute and chronic sinusitis)

Diagnosis of acute and chronic sinusitis based on symptoms (requires the presence of at least two major or one major plus 2 minor factors) as shown in (Table2.1), duration of symptoms highlighted in (Table2.2), and physical examination (signs) (Table 2.3) (Sobiesk and Munakomi, 2020).

Table (2.1) shows the factors associated with diagnosisof Rhinosinusitis

Major Factors	**Minor Factors**
Facial pain / pressure Facial congestion / fullness	Headache Fever (in non-acute cases)
Nasal obstruction / blockage	Halitosis
Nasal discharge	Fatigue
Purulence	Dental pain
Discolored postnasal discharge	Cough
Hyposomia / anosmia	Ear pain / pressure / fullness
Purulence in nasal cavity	
Fever (acute rhinosinusitis only)	

Table (2.2) shows the Clinical Categories of Rhinosinusitis

Clinical categories	**Duration**
Acute (ARS)	7 days to ≤ weeks
Subacute (SARS)	4-12 weeks
Chronic (CRS)	≥ 12 weeks
Recurrent acute	≥ 4 episode of ARS per year
Acute exacerbation of chronic (AECRS)	Sudden worsening of CRSwithreturn to baseline after treatment

Table (2.3) shows the Physical Sings in Rhinosinusitis (Sobiesk and Munakomi, 2020).

External Findings
Swelling and erythema of maxillary, ocular, orbital and frontal areas may be seen
Anterior Rhinoscopy
Hyperemia Oedema Crusts Purulence Polyps Changes in symptoms after topical congestion

2.4.2Nasal Polyps:

Symptoms of nasal polyp include; nasal obstruction, retention of nasal and sinus secretion, loss of smell, headache, and reduced general well-being **(**Bachert et al., 1998)**.**

While the signs on anterior rhinoscopy include the following; Polyp appears as smooth glistening grape like masses often pale in color.They may be sessile or pedunculated, Insensitive to probing, Bleeding less when touch (Don’t touch on bleeding and nasal cavity may show purulent discharge due to associated sinusitis (Desrosiers et al., 2011).

Chronic rhinosinusitis (CRS) can be further categorized based on the absence or presence of nasal polyps (chronic rhinosinusitis without nasalpolyps (CRSsNP) or chronic rhinosinusitis with nasal polyps, (CRSwNP). Both are characterized by mucopurulent drainage and nasal obstruction (CRSsNP) is frequently associated with facial pain, pressure, and fullness whereas (CRSwNP) is frequently characterized by hyposmia (Desrosiers et al., 2011).

2.4.3 Mucocele:

The symptoms can be facial deformity, (swelling) abnormal protrusion of the eyeball (proptosis) or abnormal retraction of the eyeball into the socket (enophthalmos), loss of vision or double vision (diplopia). They may also be non-specific, such as facial pain, headache or nasal obstruction (Timmanagouda, 2008).

2.4.4 Fungal Sinusitis:

Headache, facial pain, nasal obstruction and nasal discharge are the usual features of any type of sinusitis. Fungal sinusitis is suspected when the facial pain is severe and the discharge dark colored. It is also considered when the symptoms fail to respond to repeated doses of the usual antibiotic treatment aimed at bacteria (Jaluskar and Patil, 1992).

2.4.5 Tumors:

Although most of the tumors of the sinonasal tract are symptomatic but most of these symptoms are non-specific such as swelling and pressure effects of the concerned area and other associated features like nasal obstruction, headache, visual disturbance or proptosis, epistaxis and nasal discharge. The clinical features of sinonasal malignancy of maxillary tumor are: nasal obstruction, epistaxis, infraorbital anaesthesia, tooth ache, facial swelling, facial pain and neck swelling. The clinical features of sinonasal malignancy of ethmoid tumor are: nasal obstruction, epistaxis, proptosis or diplopia and neck swelling (Swaroop, 2010).

2.5 X-ray (Water's view) assessment and appearance:

2.5.1Inflammatory disease :(acute and chronic sinusitis)

The used criteria for diagnosis sinusitis from x-ray (water's view) which in turn improved its accuracy to more than 80%are:

- Presence of air fluid level
- Sinus opacity
- Mucosal thickening greater than 6 mm (Ros et al., 1995)

2.5.2Nasal Polyps:

The commonest finding in x-ray is generalized bilateral loss of translucence in all sinuses [Gleeson M J. (2008)]. It is not radiologically possible to establish the true nature of an opaque sinusi.e. if it is a fluid, (polypoid) mucous membrane thickening, cyst or tumor (Axelsson et al., 1970).

2.5.3Mucocele:

Radiographically the definition being an airless mucoid filled expanded paranasal sinuses (Webber, 1988)

2.5.4 Fungal Sinusitis:

Dense soft tissue opacity of the affected sinuses with or without bone destruction (Webber, 1988)

The X-ray finding could include dense soft tissue opacity of the affected sinuses with or without bone destruction (John, 2005).

2.6 CT assessment and appearance:

2.6.1 Inflammatory disease :(acute and chronic sinusitis)

CT findings of acute sinusitis include: opacification, air-fluid level and thickened localized mucosa, and findings of chronic sinusitis include: mucosal thickening, air cells, bony remodeling, narrowing or blockage of the osteomeatal unit and bony thickening due to inflammatory osteitis of the sinus cavity (Hansberger et al., 1986).

2.6.1.1Nasal Polyps:

Sinonasal polyps appear on CT scan as nodular or rounded masses in the nasal cavity, with widening of the infundibulum, opacification of the sinuses, and thinning of sinus walls and the nasal and ethmoid septa. Bony remodeling can occur (Fatma et al., 2006)

2.6.1.2Mucocele:

On CT scan, a mucocele appears as an expanded sinus filled with homogenous matrial of fairly low (15 HU) attenuation contents with a few having higher attenuation due to concentrated secretions within. Along with this, other features pertinent to the sinus involved may also be seen. The surrounding sinus bone is remodeled around the sinus content and this bone may be focally thinned or eroded. The overall CT appearance is that of bone preservation and remodeling (John, 2005).

The critical points to be noted in describing the paranasal sinus mucoceles are the presence of intracranial extension (extra axial) mass and intra orbital extension. The preservation of fat planes outside the areas of bone destruction was seen whereas in carcinoma this is lost (John, 2005).

2.7Fungal Sinusitis:

2.7.1Findings on CT appear as follow:

2.7.1.1 Invasive Fungal Sinusitis:

On CT appears as a high-density central mass separated by mucoid secretion. Area of calcification may be present and may be diffuse, nodular or linear and may be accompanied by bone expansion and bone destruction (Webber, 1988)

2.7.1.2 Noninvasive fungal sinusitis (Mycetoma):

CT finding may include localized sinus, opacification, homogenous mass that does not change shape with head position and a mass with presence of calcification (found in 25% of cases) (Webber, 1988).

2.7.1.3Allergic fungal sinusitis (AFS):

On CT scan heterogeneous opacification can be seen with a typical pattern of central hyper dense area of opacification surrounded by less dense areas of opacification and calcified areas can see sometimes. Bony destruction can be seen in advanced cases (Webber, 1988)

2.7.1.4 Benign tumors:

The CT findings appear as very dense lesion if the osteoma comprises compact mature bone and may be confused with retention cysts or polyps. CT findings appear as following subdivide:

2.7.1.5Papillomas:

On imaging, the appearances of all Papillomas can vary from a small nasal polypoid massto an expansile nasal mass with remodeling of the nasal cavity and extension into the sinuses with secondary obstructive sinusitis,CT is required to stage these tumors in order to visualize the extent of tumors beyond the sinuses. CT is sensitive to bone destruction (John, 2005).

2.7.1.6 Malignant tumors:

CT is required to stage these tumors in order to visualize the extent of tumors beyond the sinuses. CT is sensitive to bone destruction (John, 2005).

2.7.1.7 Carcinoma of the sinuses:

CT plays important roles in the staging of these tumors, the location and extent of disease. Carcinoma appears as aggressive soft-tissue that occludes sinus Ostia, exhibit local soft-tissue invasion, and cause bone destruction (John, 2005).

2.6 Previous study:

Perez et al (2000) studied Anatomical variations in the human paranasal sinus region studied by CT. and resulted to the highest degree of variability in 110 cases studied was for the nasal septum (55%), followed by the middle nasal concha (25%), the ethmoidal air cells (10%), the ethmoidal uncinate process (4%), and other sites (6%).

(Fadda et al., 2012) had studied Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis and concluded that 140 of 200 (70%) patients had anatomic variations. In particular, 122 patients (87%) were affected by common anatomic variations, and 18 patients (13%) with uncommon variations. There were 85 (60.7%) male and 55 (39.3%) females with ages ranging from 13 to 77 years (mean 45.5 years). The maxillary sinus was most commonly involved, followed by the anterior ethmoid, frontal sinus, posterior ethmoid and sphenoid sinus. The most common anatomic variation observed on CT scans was nasal septal deviation, which was presented by 82 patients (58.5%). Concha bullosa of the middle turbinate was the second most common variant, observed in 69 patients (49.3%), and was mostly seen on one side of the nasal wall (30.7%). A total of 46 patients (32.8%) had hypertrophic ethmoid bulla, whereas agger nasi cell was observed in 34 patients (24.3%). Considering the UP, its lateral deviation was found in 30 patients (21.4%), whereas its medial deviation was presented by 32 patients (22.8%); a hypertrophic UP was observed in 14 patients (10%) and atelectatic in 9 patients (6.3%). Haller cell was observed in 32 patients (22.8%); frontal cells were seen in 17 patients (12.1%), and Onodi cell in 12 patients (8.5%); paradoxical middle turbinate was observed in only 9 patients (6.4%); hypoplastic maxillary sinus was present in 8 patients (5.7%) and septated maxillary sinus in 7 patients (5%). With respect to the level difference between the ethmoid and cribriform plate, Keros type I was the most common and seen in 22 patients (15.7%), followed by type II in 11 (7.8%)

and type III in 2 patients (1.4%). Pneumatization of crista galli was observed in 19 patients (13.6%) and pneumatization of the nasal septum in 13 patients (9.3%)

Badia et al (2005) studied Ethnic variation in sinonasal anatomy on CT-scanning. And resulted to Pneumatisation of the agger nasi, ie anterior to the anterior attachment of the middle turbinate is the commonest variant in both groups, 44-57% (maximum range, either unliteral or biliteral) in the Caucasian group and 47-53% in the Chinese group, and there is no statistical difference in the incidence between the two groups. Pneumatisation of the middle turbinate (concha bullosa) and paradoxical bending of the middle turbinate, is the second and third commonest variants in the Caucasian population and their incidence significantly higher than in the Chinese population. Concha bullosa occurs in 12-31% and paradoxical bending of the middle turbinate in 10-22% in the Caucasian group and in 4-13% and 5-8% respectively in the Chinese group. Spheno-ethmoidal cells (Onodi cell), ie pneumatisation of the posterior ethmoid lateral or superior to the sphenoid, are the second commonest variant in the Chinese population and the incidence is significantly higher than in the Caucasian population; 20-30% in the Chinese group compared to 5-17% in the Caucasian group. Infra-orbital cells (Haller cell), ie pneumatisation of the orbital floor inferior to the infundibulum, occur more frequently in the Caucasian than in the Chinese group; 10-15% and 1-9% respectively. The incidence of a bent uncinate process is higher in the Chinese group than in the Caucasian group; 12-24% and 3-6% respectively. The presence of suprabullar cells obstructing the frontal recess was higher in the Caucasian group (5-17%) than in the Chinese group (1-2%) whereas complete absence of a sinus was higher in the Chinese group (11-17%) then in the Caucasian group (2-6%). There was no significant difference in the incidence of pneumatisation of uncinate process (2% Caucasian, 1% Chinese), in the exposure of > 50% of circumference of the carotid artery within the sphenoid or posterior ethmoid (3% Caucasian, 0% Chinese), in the presence of septation joining carotid artery in sphenoid (4-22% Caucasian, 2-20% Chinese), in the exposure of >50% of circumference of optic nerve within sphenoid or posterior ethmoid (2% Caucasian, 0% Chinese), in the pneumatisation of anterior clinoid process (4-6% Caucasian, 5-9% Chinese), in presence of accessory ostium in posterior fontanelle (2-3% in both groups) or in the presence of nasal septal deviation of > 4 mm either side of perpendicular plate (13-20% Caucasian, 7-8% Chinese). When asymmetry of the ethmoidal roof was considered, the left was consistently the highest in both groups; though there was no difference in the depth of the cribriform niche between right and left or between Caucasian and Chinese. The depth of the cribriform niche was type I (1-3mm) or type II (4-7mm)/ III (8-16mm). Types II/III was collapsed, as it is difficult to accurately distinguish between them. Table 1 shows the percentage of type I, and type II/III corresponds to the rest.

Adeel etal (2013) studied Anatomical variations of nose and para-nasal sinuses; the mean age of the patients was 31±13.15 years. One-third 26 (33%) of the scans were of females, and two-third 51 (66%) of males. There was no anatomical variation identified in 37 (48.1%) images. Single variation was seen in 16 (20.7%), two variations in 18 (23.3%), and in 6 (7.7%) scans more than three variations were present. DNS was the most common variation, 20 (26%); Concha bullosa (CB), 14 (18.2%); paradoxical middle turbinate (PMT), 11 (14.3%); Haller's cell, 7 (9.1%); Onodi cells, 6

(7.8%); and pneumatisation of Uncinate process (UP), 4 (5.2%) Septal pneumatisation was not identified in any case.

Ibrahim et al (2018) studied Anatomical Variations of Paranasal Sinuses Gender and Age Impact for 293 patients. The deviated nasal septum found in 30.7%, Concha bullosa was present in 24.2%, superior turbinate pneumatization in 1.7%. Paradoxical middle turbinate in 9.5%, crista gali pneumatization in 8.7%, uncinate process attachment to lamina papyrecia in 73.7%, frontal sinus was hyperpneumatized in 26.3%, frontal air-cell in 25.9%, supraorbital air-cell in 37.5%, Onodi cell in 31.4%, Haller cell in 25.9%, sphenoid sinus hyperpneumatization in 24.2%, anterior ethmoid artery running within the sinus cavity in 29.4%, posterior ethmoid artery running within the sinus cavity in 5.5%, type II depth of cribriform plate in 45.4%, carotid artery dehiscence in 20.8%, optic nerve was dehiscence in 15%, sphenoid intersinus septum was attached to the carotid canal in 16.4%, and to optic canal in 29.7%.

Lerdlum et al (2005) studied Prevalence of anatomic variationdemonstrated on screening sinus computed tomography and clinical correlation, Screening sinus computed tomography (SCCT) of 133 patients performed from March 2003 to February 2004, were retrospectively reviewed, concerning anatomic variation at ostiomeatal unit (OMU) and nasal septal deviation. Six patterns of inflammatory sinus disease were designated: maxillary infundibulum, nasofrontal duct, OMU, sphenoethmoidal recess, polyposis and sporadic. The most common anatomic variation was concha bullosa (14.3%), followed by Haller cell (9.4%), large Agger nasi cell (7.9%) and paradoxical middle turbinate (5.3%). Nasal septal deviation was presented in 75 patients (56.4%). Inflammatory sinus disease was (68%) and maxillary infundibular pattern was the most common (33.1%). There was significant correlation between large Agger nasi cell and nasofrontal duct pattern ($p < 0.05$). The remaining anatomic variations and nasal septal deviation had no significant correlation to the inflammatory sinus disease. Overall, the anatomic variation which can compromise the mucociliary drainage was frequently observed, however, only the large Agger nasi cell had significant correlation to the inflammatory sinus disease.

Dua et al (2005) studied CT scan variations in chronic sinusitis and resulted to the men out numbered the women in the ratio of 2: 1 (33 men, 17 women). Anatomic variations as mentioned Deviated nasal septum was the most common variation in 22 (44%) followed by agger nasi in 20 (40%) patients. Other variations found were concha bullosa, paradoxical middle turbinate, overpneumatised ethmoidal bulla or giant bulla, haller cells, onodi cells, lamina papyracea pushed laterally, maxillary sinus septae and pneumatization of vomerine bone in 1 (2%) patient

Jagram etal (2016) studied Computed tomography of paranasal sinuses for early and proper diagnosis of nasal and sinus pathology Out of 100 cases 51 (51%) cases were males and rest 49 (49%) patients were females. The majority of the cases were of age group 16-30 which were 37case (37%) The most common symptoms were nasal obstruction (50%), followed by nasal discharge (49%), headache in 20% cases. Most common anatomical variations seen was deviated nasal septum (49%) more commonly on right side next common was agger nasi in 48% of cases. Maxillary sinuses are most commonly involved in the study (82 cases), followed by the ethmoid sinuses and frontal sinus 55 cases. The most common pathology seen was masses in 30% cases followed by DNS in 21% cases. The most common form of mucosal thickening noted is circumferential type seen in 7% cases. The most common pathology involving the sinuses was sinusitis (30%) followed by polyp (25%)

Kushwah et al (2015) studied CT evaluation of diseases of Paranasal sinuses & histopathological studies for 50 patients the results were derived. Majority of case were found in age group 21-30 and 41-50 years age i.e Incidence of paranasal sinus disease was more in male (80%) as compared to female (20%).The Female: Male ratio is 1:4. Predominant symptoms in study group were headache in 29 patients (58%) followed in decreasing order by facial pain & swelling in 19 patients(38%) and nasal obstruction in 8 patients(16%).In this study most common diseased sinus was maxillary sinus (88%). DNS was seen in 18 patients (36%) with more common towards right side. DNS towards right side seen in 10 patients (20%), DNS towards left side seen in 8 patients (16%). OMU obstruction was observed in 27 patients (54%) with Bilateral Involvement seen in 4 patients (8%)

Rashi et al (2014) Studied Anatomical Variations on CT in Chronic Sinusitis A total of 85 patients of chronic rhinosinusitis were examined. Presence of various anatomical variants in relation to chronic rhinosinusitis was observed. Out of 85 patients 58 were males and 27 were females with male female ratio being 2.1:1. The various cases of chronic rhinosinusitis are divided into five age groups and the maximum number of patients were seen in age group 21–30 followed by age group 10–20 years, and least in age group >50 years Of the 85 patients of the study group; 75 had DNS either to left/right/bilateral side, 65 had concha bulosa, prominent ethmoidal bulla was seen in 54 cases. The abnormal uncinate process found in 9 cases. Pneumatization of the bony nasal septum was seen in 7 cases, there were six cases who had agger nasi cells and three had Haller cells and 1patient had onodi cell. Concha bullosa and deviated nasal septum are the two most common anatomical variants seen in patients with chronic rhniosinusitis.

Chapter three

Materials and Method

3.1 Material:

3.1.1 Machine;

CT machine general electric (GE) Hi Speed CT/E Dual CT Scanner was used, made by GE Healthcare Manufacturer, in years of 2000.with the following specifications, tube 2.0MHU MX 135, 3.9 million mAs, Software level 6.03, Fast Scan 1.0sec, Helical plus, 3D max, Power 200mA, Max 1mm thickness, Acquisition, Helical 60Max, Smartpre, DICOM MOD, and the following specification have been used, the voltage 120Kvp. Four options of mA, High (110), medium (77), low (55), and extra low (22). Three options of slice thickness: 2mm, 5mm and 10mm.Similar scan interspaces, the scan time of 4.8 sec, and construction algorithm of two option, normal (soft tissue), and high frequency (bony), film print with laser printer .

3.1.2 Subjects:

This study was done in Riyadh Hospitals, Saudi Arabia, mostly from Consultant Radiologists Diagnostic Center. The study sample consists of 392 patients (272 males, and 120 females) with the age ranged (18-68 years).Candidates those have rhinosinusitis were selected and those who have, trauma, surgery or tumor that disturbed their normal anatomy were excluded.

3.2 Method:

3.2.1 Study design:

A cross-sectional hospital-based study was conducted in Riyadh during the period from August 2017 to August 2020.

3.2.2Technique used:

Patient should wear comfortable, loose-fitting clothing to the exam. Given a gown to wear during the procedure. Metal objects including jewelry, eyeglasses, dentures and hairpins will affect the CT images and should be removed prior to exam, may also be asked to remove hearing aids and removable dental work.

Straps and pillows may be used to help the patient maintain the correct position and to hold still during the exam. (if needed).

CT scans typically obtained for visualizing the paranasal sinuses should include axial sagittal and coronal cuts. Proper positioning of the patients head is important to obtain symmetrical image for both sides

Axial Projections:

Patient should be positioned lying supine with the head in axial head holder. Scan should be taken parallel to the orbitomeatal line (0-10) degree gantry tilt; 5mm slice thickness should be taken forward through the entire face till we examined all sinus or area of interest.

Coronal Projection (direct):

Coronal images are obtained directly, with the patient prone or supine with the neck in hyperextension (hanging head) position.

The gantry should be angled perpendicular to the hard palate. Scan should be taken forward 5mm slice thickness until we cover all sinuses. Be reconstructing coronal from axial cuts, we can obtain images in coronal plane.

Exposure Factor

Kvp (120)

mA(77)

Second(S) (4.8)

Film evaluation: -

All films (axial and coronal) were evaluated by one radiologist and two technologists, and all rihanosinusitis patients were evaluated to detect the presence of any anatomical variations of the PNS.

3.3 Ethical consideration:

The research was conducted after receiving the ethical approval from the hospital (consultant radiological diagnostic center) then the procedure was explaining in concept form and given to the patients to take their signature.

3.4 Data analysis:

Data were collected using data collection sheet and analyzed using SPSS (20 IBM). For all comparisons conducted in this study, ($p < 0.05$) was considered to be statistically significant.

Chapter Four

Results

4.1 Results:

Table (4.1): Distribution of samples according to age

Age/Year	Frequency	Percentage
18 - 28	82	20.9
28 - 38	154	39.3
38 - 48	101	25.8
48 – 58	39	9.9
58 - 68	16	4.1
Total	**392**	**100.0**

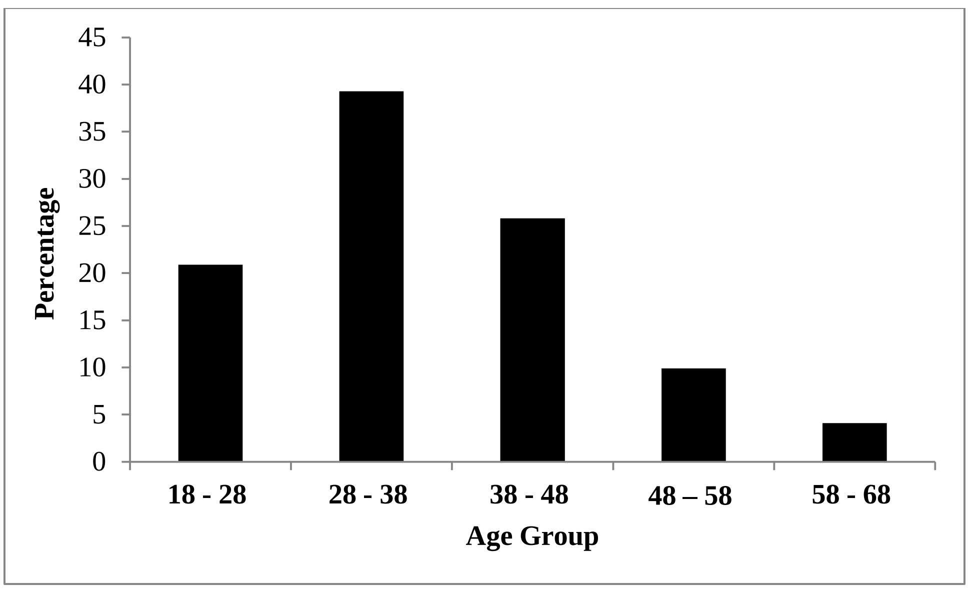


Figure (4.1): Distribution of samples according to age group

Table (4.2): Distribution of samples according to gender

Gender	Frequency	Percentage
Male	272	69.4
Female	120	30.6
Total	**392**	**100.0**

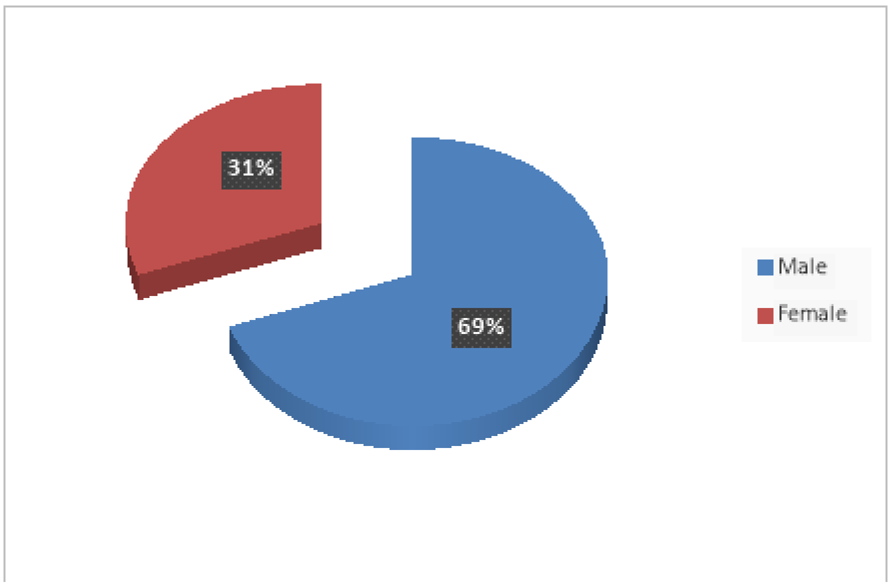


Figure (4.2): Distribution of samples according to gender

Table (4.3): Distribution of samples according to the habit of smoking

Smoking	Frequency	Percentage
Smoker	169	43.1
Non-smoker	223	56.9
Total	**392**	**100.0**

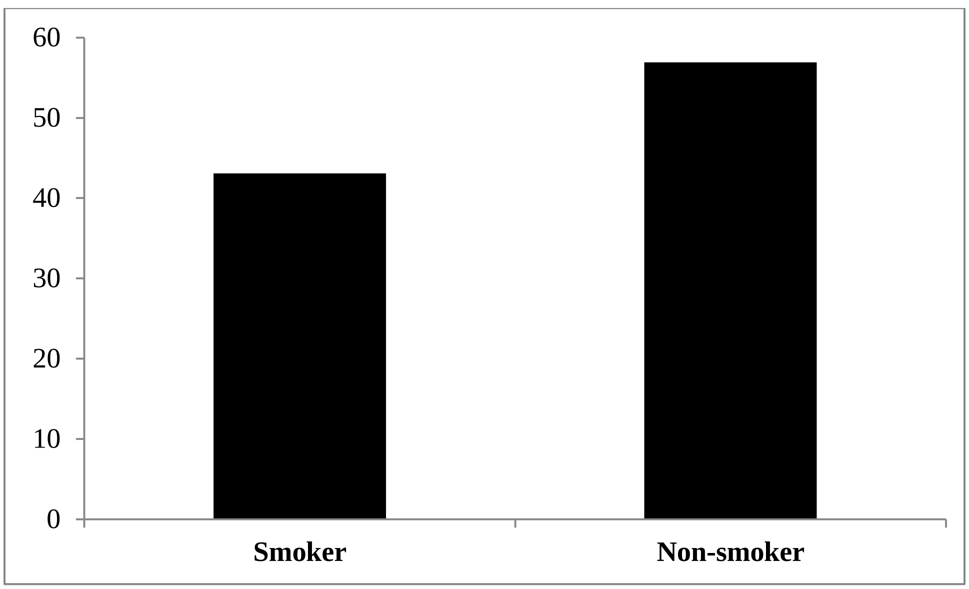


Figure (4.3): Distribution of samples according to the habit of smoking

Table (4.4): Distribution of samples according to occupation

Occupation	Frequency	Percentage
Accountant	79	20.2
Labourer	94	24.0
Medical profession	29	7.4
No job	42	10.7
Commercial career	49	12.5
Educational career	61	15.6
Legal career	5	1.3
Engineer	16	4.1
Administrator	17	4.3
Total	**392**	**100.0**

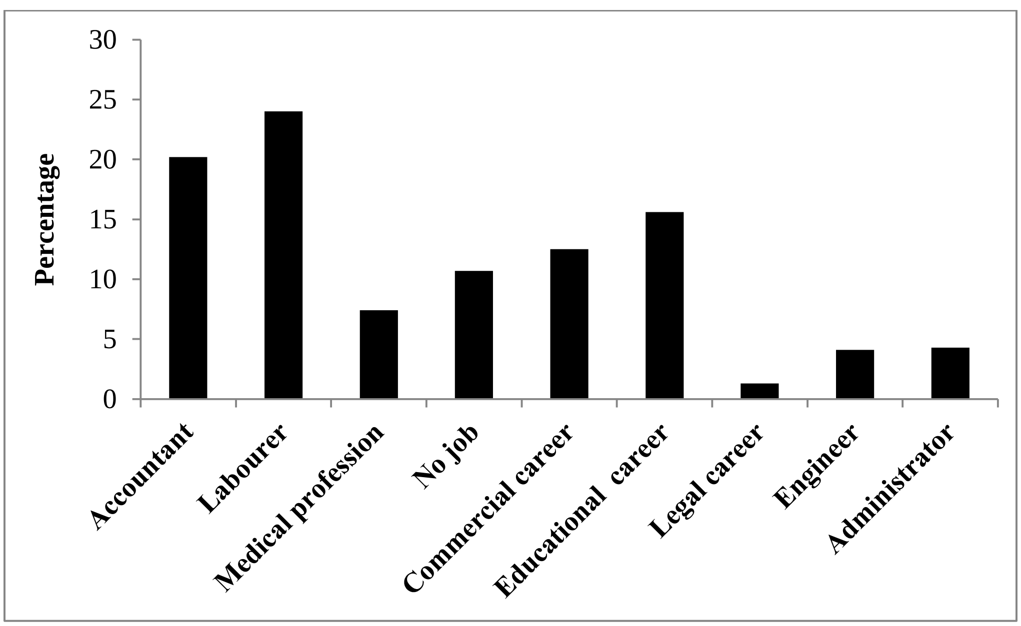


Figure (4.4): Distribution of samples according to occupation

Table (4.5): Distribution of samples according to signs and symptoms

Signs and symptoms	Frequency	Percentage
Dizziness	2	0.5
Nasal obstruction	13	3.3
Headache	276	70.4
Nasal discharge	90	23.0
Snoring	7	1.8
Reduced sense of smell	4	1.0
Total	**392**	**100.0**

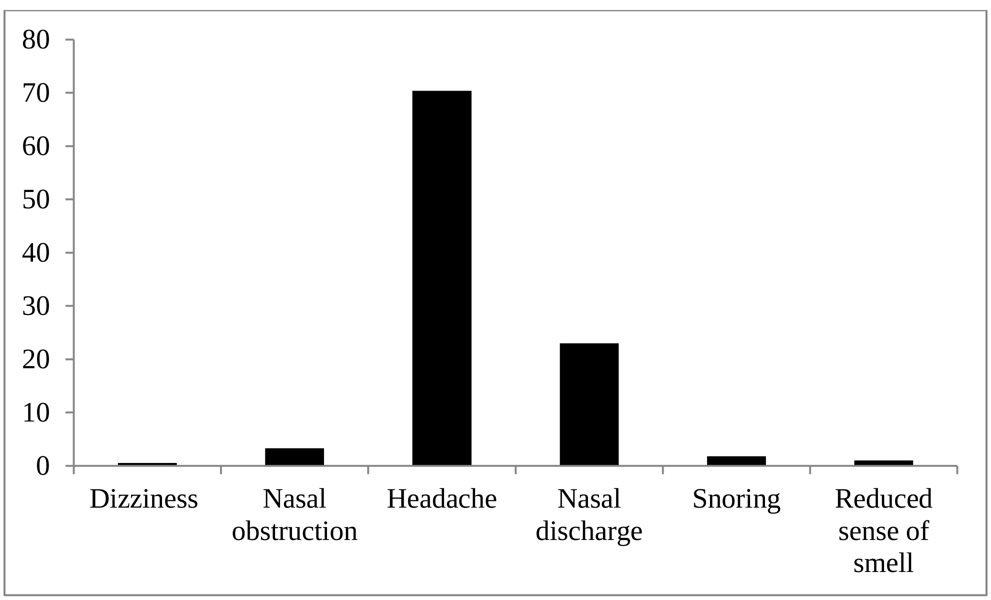


Figure (4.5): Distribution of samples according signs and symptoms

Table (4.6): Distribution of family history of rhinosinusitis

History	Frequency	Percentage
Yes	177	45.2
No	215	54.8
Total	**392**	**100.0**

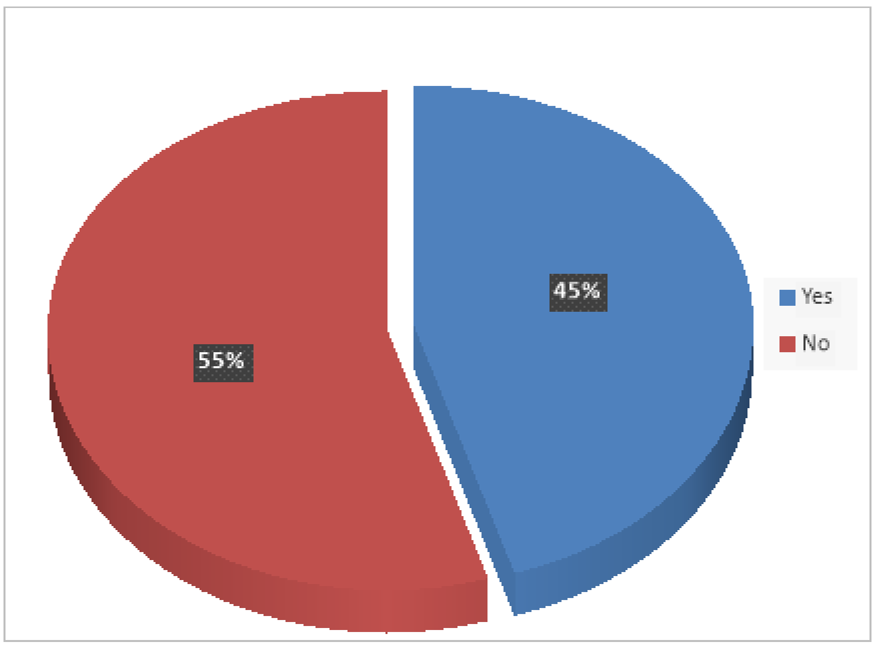


Figure (4.6): Distribution of family history of rhinosinusitis

Table (4.7): Distribution of samples according to living areas

Area	Frequency	Percentage
Apartment	290	74.0
Villa	96	24.5
Palace	6	1.5
Total	**392**	**100.0**

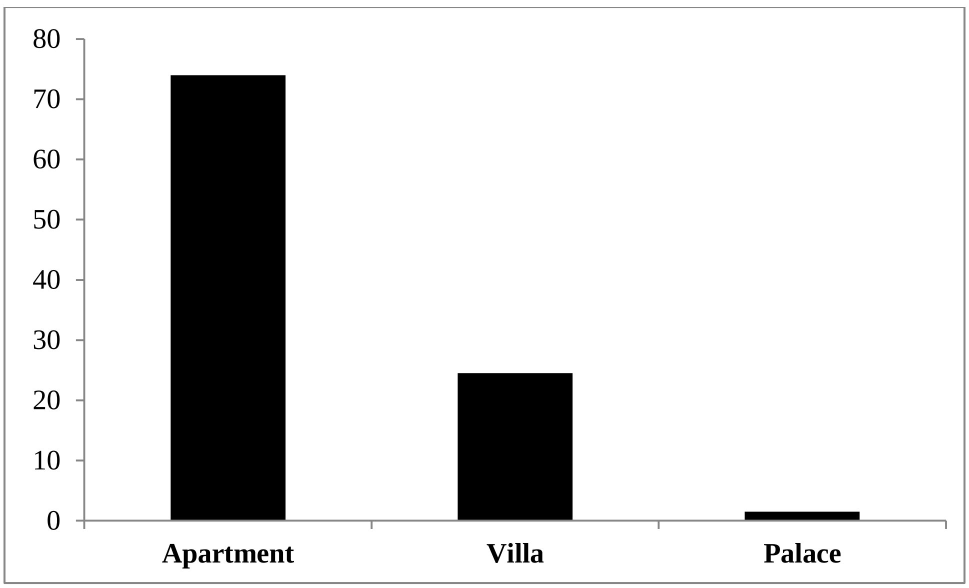


Figure (4.7): Distribution of samples according to living areas

Table (4.8): Distribution of samples according to residency in KSA

Residency	Frequency	Percentage
Citizen	153	39.0
< 5 years	55	14.0
5 - 10 y	81	20.7
> 10 y	103	26.3
Total	**392**	**100.0**

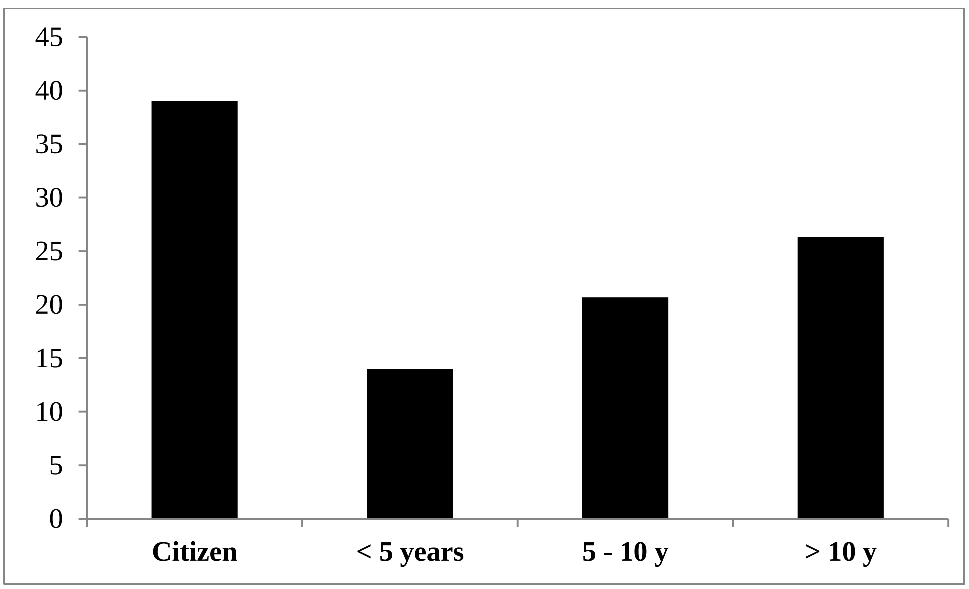


Figure (4.8): Distribution of samples according to residency in KSA

Table (4.9): Distribution of samples according to disease duration

Duration	Frequency	Percentage
< 1 Y	69	17.6
1 - 3 y	257	65.6
3 - 6 y	57	14.5
6 - 9 y	2	.5
9 - 12 y	7	1.8
Total	**392**	**100.0**

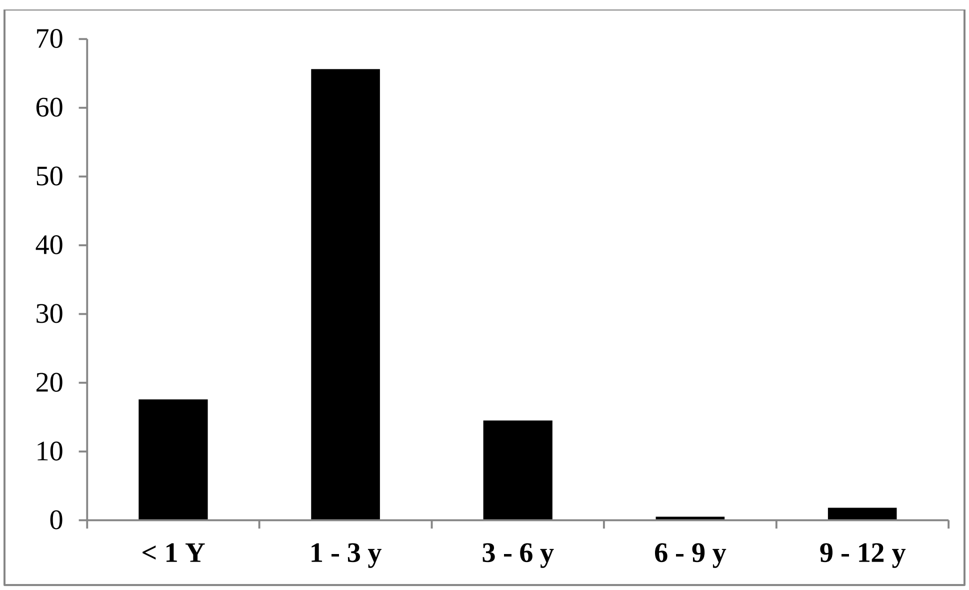
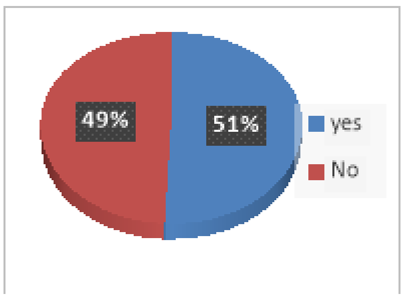


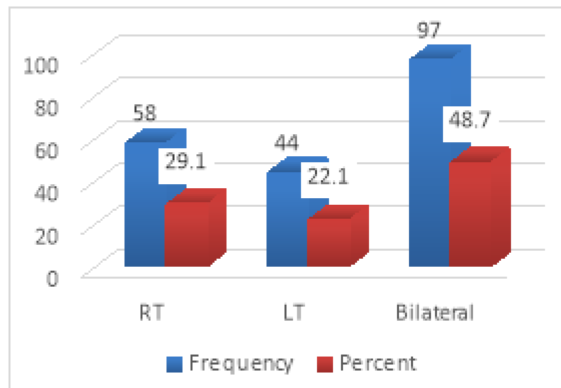
Figure (4.9): Distribution of samples according to disease duration

Table (4.10): Distribution of samples according to concha bullosa

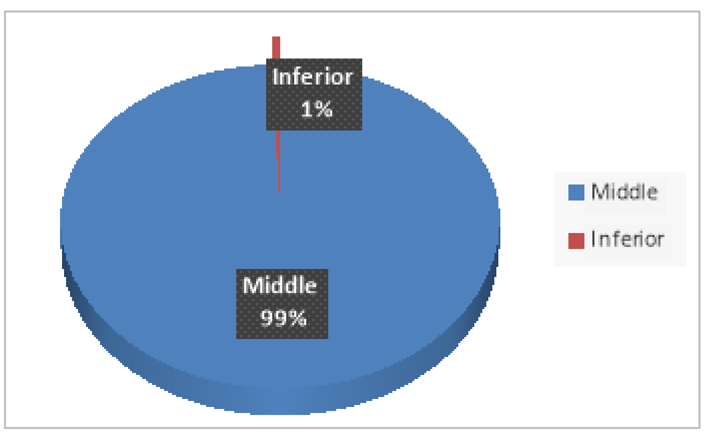
	Presence		**Sites**			**Side**	
	Yes	No	RT	LT	Bilateral	Middle	Inferior
Frequency	199	193	58	44	97	198	1
Percentage	50.8	49.2	29.2	22.1	48.7	99.5	0.5
Total	**392**		**199**			**199**	



Presence



Side

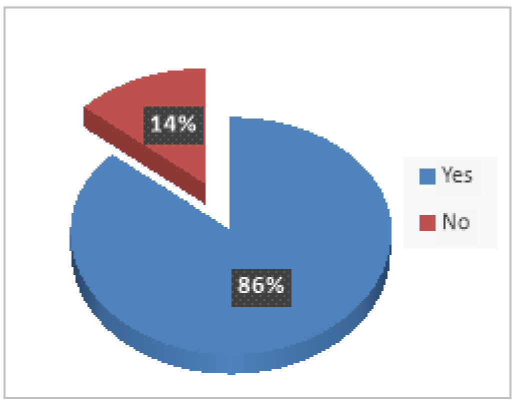


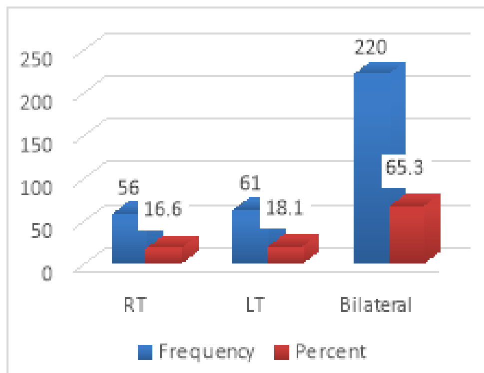
Site

Figure (4.10): Distribution of samples according to concha bullosa presence, side and site.

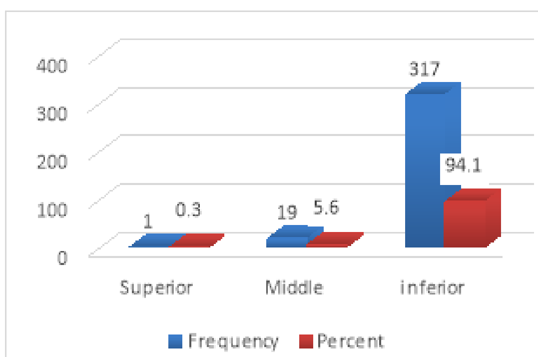
Table (4.11): Distribution of samples according to hypertrophiednasal turbinate

	Presence		**Sides**			**Site**		
	Yes	No	RT	LT	Bilateral	Superior	Middle	Inferior
Frequency	337	55	56	61	220	1	19	317
Percentage	86.0	14.0	16.6	18.1	65.3	0.3	5.6	94.1
Total	**392**		**337**			**337**		





PresenceSide



Site

Figure (4.11): Distribution of samples according to hypertrophiednasal turbinate presence, side and site

Table (4.12): Distribution of samples according to nasal septum deviation

Deviation	**Frequency**	**Percentage**
Yes	358	91.3
No	34	8.7
Total	**392**	**100.0**

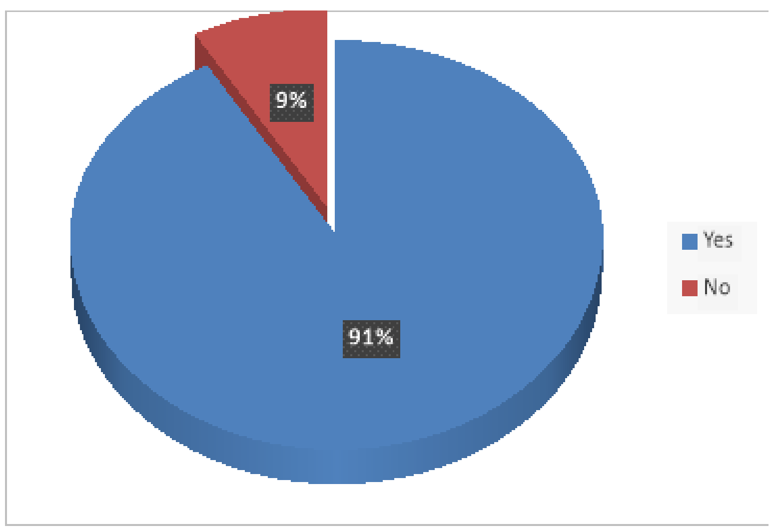


Figure (4.12): Distribution of samples according to nasal septum deviation

Table (4.13): Distribution of samples according to type of sinusitis

Sinusitis	Frequency	Percentage
Acute	174	44.4
Chronic	218	55.6
Total	**392**	**100.0**

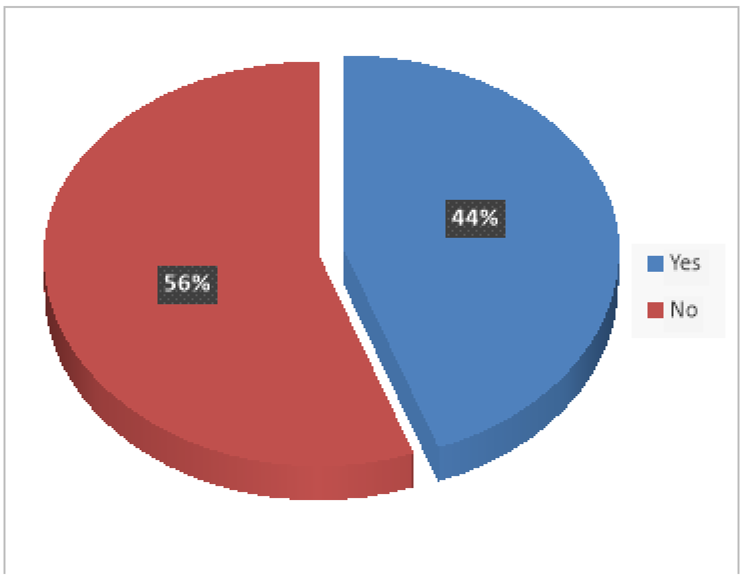
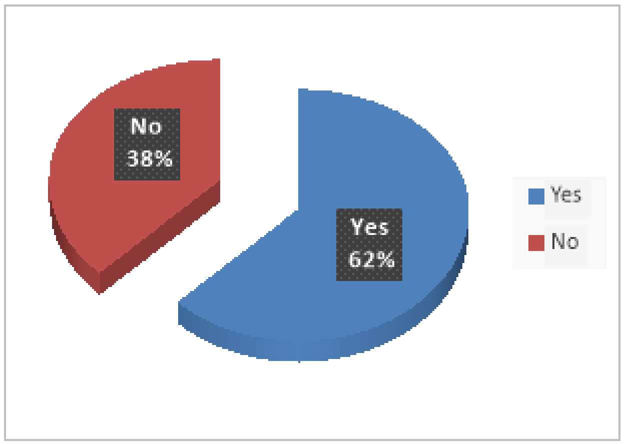


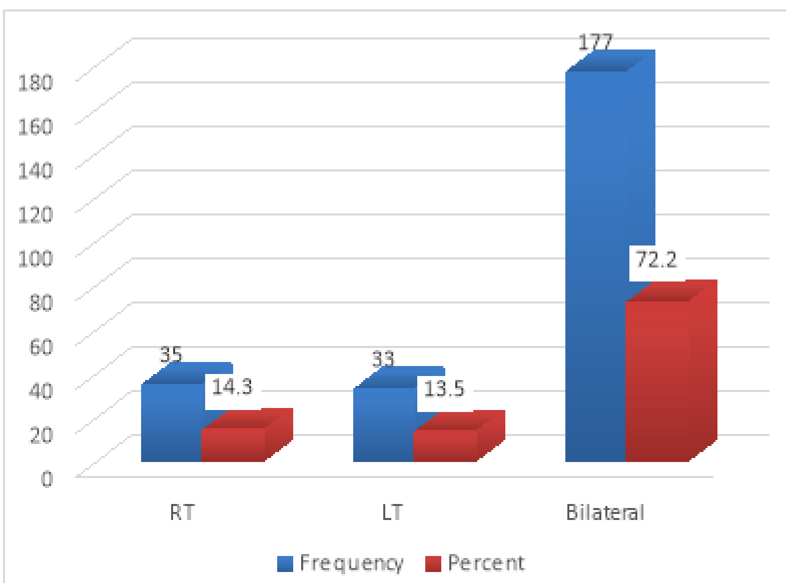
Figure (4.13): Distribution of samples according to type of sinusitis

Table (4.14): Distribution of samples according to mucosal thickening

	Presence		Sides		
	Yes	No	RT	LT	Bilateral
Frequency	245	147	35	33	177
Percentage	62.5	37.5	14.3	13.5	72.2
Total	**392**		**245**		



Presence



Side

Figure (4.14): Distribution of samples according to mucosal thickening presence and side

Table (4.15): Distribution of samples according to presence of fluid

Fluid	Frequency	Percentage
Yes	27	6.9
No	365	93.1
Total	**392**	**100.0**

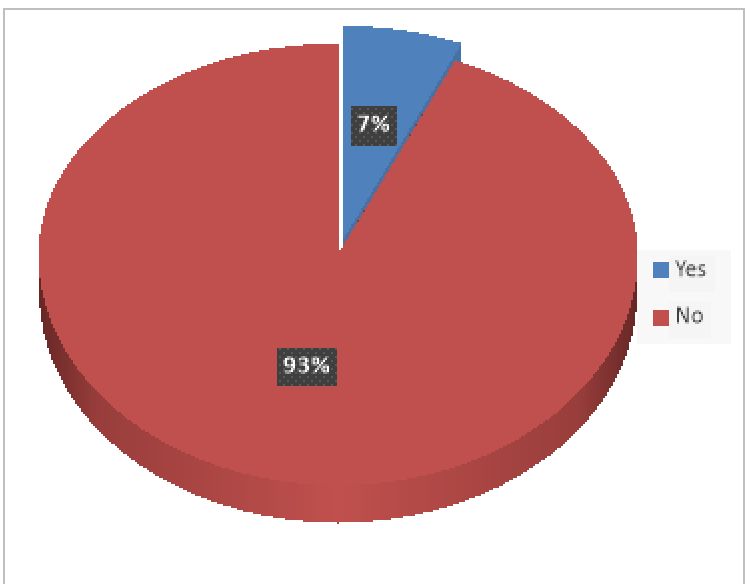
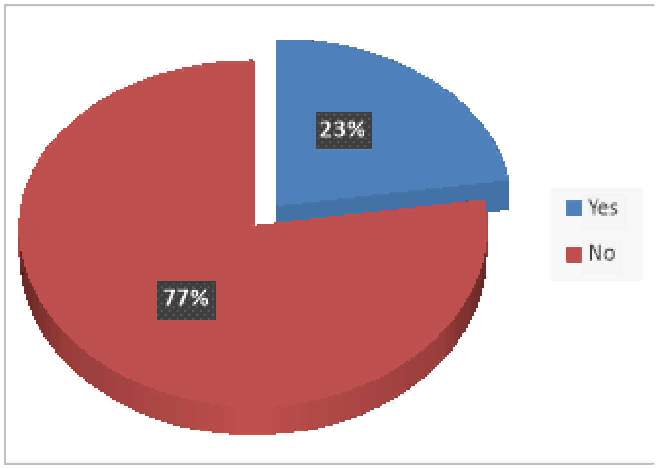


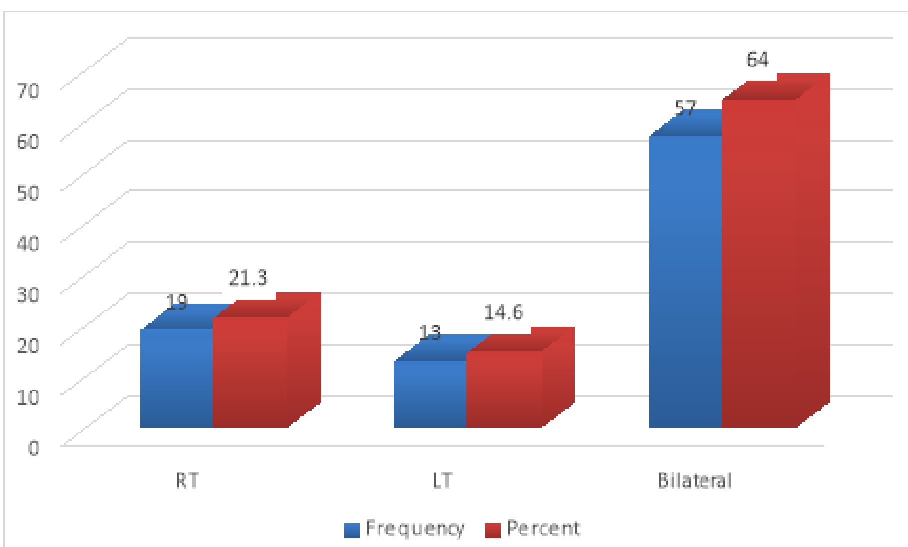
Figure (4.15): Distribution of samples according to presence of fluid

Table (4.16): Distribution of samples according to OMUobstruction

	Presence		Sites		
	Yes	No	RT	LT	Bilateral
Frequency	89	303	19	13	57
Percentage	22.7	77.3	21.3	14.6	64.1
Total	**392**		**89**		



Presence



Side

Figure (4.16): Distribution of samples according to OMUobstruction

Table (4.17): Distribution of samples according to presence of other abnormalities

Other	Frequency	Percentage
Retention cyst	37	9.4
Sinonasalpolyposis	34	8.7
Hypertrophied nasopharyngeal adenoid	11	2.8
Hypertrophied nasalmucosa	38	9.7
Hypo-pneumatized frontal sinuses	17	4.3
None	255	65.1
Total	**392**	**100.0**

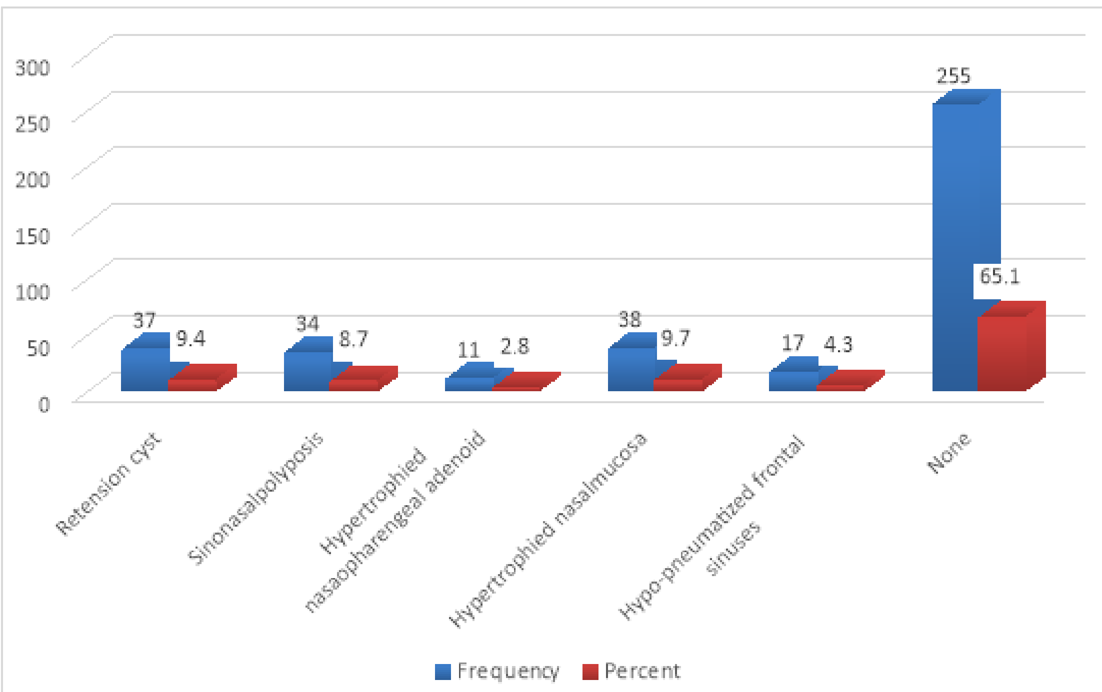


Figure (4.17): Distribution of samples according to presence of other abnormalities

Table (4.18): Analysis of sinusitis according to the age group

(Using chi-square test, P-value = 0.002)

			Type of sinusitis		Total
			Acute	Chronic	
Age Group	18 - 28 y	Count	24	58	82
		% within Age Group	29.3%	70.7%	100.0%
	28 - 38 y	Count	64	90	154
		% within Age Group	41.6%	58.4%	100.0%
	38 - 48 y	Count	59	42	101
		% within Age Group	58.4%	41.6%	100.0%
	48 - 58	Count	18	21	39
		% within Age Group	46.2%	53.8%	100.0%
	58 - 68 y	Count	9	7	16
		% within Age Group	56.2%	43.8%	100.0%
Total		Count	174	218	392
		% within Age Group	44.4%	55.6%	100.0%

Table (4.19): Analysis of sinusitis according to the gender

(Using chi-square test, P-value = 0.001)

			Type of sinusitis		Total
			Acute	Chronic	
Gender	Male	Count	137	135	272
		% within Gender	50.4%	49.6%	100.0%
	Female	Count	37	83	120
		% within Gender	30.8%	69.2%	100.0%
Total		Count	174	218	392
		% within Gender	44.4%	55.6%	100.0%

Table (4.20): Analysis of sinusitis according to the habit of smoking

(Using chi-square test, P-value = 0.006)

			Type of sinusitis		Total
			Acute	Chronic	
Smoking Habits	Smoker	Count	93	76	169
		% within Smoking Habits	55.0%	45.0%	100.0%
	Non-smoker	Count	81	142	223
		% within Smoking Habits	36.3%	63.7%	100.0%
Total		Count	174	218	392
		% within Smoking Habits	44.4%	55.6%	100.0%

Table (4.21): analysis of sinusitis according to the occupation

(Using chi-square test, P-value = 0.000)

			Type of sinusitis		Total
			Acute	Chronic	
Occupation	Accountant	Count	34	45	79
		% within Occupation	43.0%	57.0%	100.0%
	Laborer	Count	44	50	94
		% within Occupation	46.8%	53.2%	100.0%
	Medical profession	Count	10	19	29
		% within Occupation	34.5%	65.5%	100.0%
	No job	Count	19	23	42
		% within Occupation	45.2%	54.8%	100.0%
	Commercial career	Count	25	24	49
		% within Occupation	51.0%	49.0%	100.0%
	Educational career	Count	23	38	61
		% within Occupation	37.7%	62.3%	100.0%
	Legal career	Count	2	3	5
		% within Occupation	40.0%	60.0%	100.0%
	Engineer	Count	5	11	16
		% within Occupation	31.2%	68.8%	100.0%
	Administrator	Count	12	5	17
		% within Occupation	70.6%	29.4%	100.0%
Total		Count	174	218	392
		% within Occupation	44.4%	55.6%	100.0%

Table (4.22): analysis of sinusitis according to the signs and symptoms

(Using chi-square test, P-value = 0.037)

			Type of sinusitis		Total
			Acute	Chronic	
Signs and Symptoms	Headache	Count	1	1	2
		% within Signs and Symptoms	50.0%	50.0%	100.0%
	Nasal obstruction	Count	5	8	13
		% within Signs and Symptoms	38.5%	61.5%	100.0%
	Dizziness	Count	109	167	276
		% within Signs and Symptoms	39.5%	60.5%	100.0%
	Nasal discharge	Count	54	36	90
		% within Signs and Symptoms	60.0%	40.0%	100.0%
	Snoring	Count	3	4	7
		% within Signs and Symptoms	42.9%	57.1%	100.0%
	Reduced sense of smell	Count	2	2	4
		% within Signs and Symptoms	50.0%	50.0%	100.0%
Total		Count	174	218	392
		% within Signs and Symptoms	44.4%	55.6%	100.0%

Table (4.23): analysis of sinusitis according to the family history

(Using chi-square test, P-value = 0.611)

			Type of sinusitis		Total
			Acute	Chronic	
Family History	Yes	Count	76	101	177
		% within Family History	42.9%	57.1%	100.0%
	No	Count	98	117	215
		% within Family History	45.6%	54.4%	100.0%
Total		Count	174	218	392
		% within Family History	44.4%	55.6%	100.0%

Table (4.24): analysis of sinusitis according to the living area

(Using chi-square test, P-value = 0.81)

			Type of sinusitis		Total
			Acute	Chronic	
Living Area	Apartment	Count	126	164	290
		% within Living Area	43.4%	56.6%	100.0%
	Villa	Count	45	51	96
		% within Living Area	46.9%	53.1%	100.0%
	Palace	Count	3	3	6
		% within Living Area	50.0%	50.0%	100.0%
Total		Count	174	218	392
		% within Living Area	44.4%	55.6%	100.0%

Table (4.25): analysis of sinusitis according to residency in KSA

(Using chi-square test, P-value = 0.015)

			Type of sinusitis		Total
			Acute	Chronic	
Residency in KSA	Citizen	Count	63	90	153
		% within Residency in KSA	41.2%	58.8%	100.0%
	< 5 years	Count	16	39	55
		% within Residency in KSA	29.1%	70.9%	100.0%
	5 - 10 y	Count	39	42	81
		% within Residency in KSA	48.1%	51.9%	100.0%
	> 10 y	Count	56	47	103
		% within Residency in KSA	54.4%	45.6%	100.0%
Total		Count	174	218	392
		% within Residency in KSA	44.4%	55.6%	100.0%

Table (4.26): Distribution of the anatomical variations

Anatomical variation	Frequency	Percentage%
DNS	358	91.3
Agger cell	200	51.02
Concha bullosa	199	50.77
Sphenoid sinus extension into posterior nasal septum	142	36.22
Pnemotization posterior floor of cellaturcica	121	30.87
Hallar cell	118	30.10
Prominent ethimoidal bulla	117	29.85
Nasal septum spur	115	29.34
Superior turbinates’pneumatization	79	20.15
Crista galipneumatization	76	19.39
Supraorbital air-cell	63	16.07
Uncinate process pneumatization	50	12.76
Onodi cell	48	12.24
Pnemotization anterior clinoid process	43	10.97
Paradoxical middle turbinate	42	10.71
Infraorbital air cell	40	10.20
Hard palate pneumatization	36	9.18
Frontal sinus hyper pneumatization	34	8.67
Sphenoid septum direction	32	8.16
Pnemotizationptrigoid process	31	7.91
Sphenoid lateral pneumatization	30	7.65
Basal lamella pneumatization	21	5.36
Non pneumatized frontal sinus	19	4.85
Lamina papyracea dehiscence	7	1.79
Inferior turbinate pneumatization	5	1.28
Keros classification	2	0.51
Frontal air cell	0	0.00

Chapter five

Discussion, Conclusion and Recommendation

5.1Discussion:

This is a cross-sectional hospital-based study of 392 patients (272 males, and 120 females) referred for CT scan of PNS was conducted from 2017 to 2020 in Riyadh Hospitals, Saudi Arabia, mostly from Consultant Radiologists Diagnostic Center. All subjects complaining from rhinosinusitis and scanned with Toshiba Alexion 16 slice. The images were evaluated for the presence of any anatomical variants in paranasal sinuses.

The result of the study revealed that PNS stop developing at age of 18 years so we start our data from this age and we stop at year of 68 years because the rhinosinusitis reduce after this age in the place of our study also this could be due to the low life expectancy in our environment and the unwillingness of more elderly patients in our environment to seek orthodox medical attention. The most affected age group was (28-38) years found in 154 subjects with 39.3% followed by (38-48) years in 101subjects (25.8%) this could be attributed to more expose to the environment, the same result has been obtained by (Kushwah et al., 2015). In contrast (58-68) years in 16 subjects(4.1%) is considered to be the less affected age group, the result was in line with (Rashi and Rashmi, 2014) study.

rhinosinusitis affected male (69.4%) more than female (30.6%) because of many factors affecting their PNS such as male habits (smoking), nature of their work, the same results have been noticed by (Kushwah et al., 2015) in which they found that the incidence percent among male was 80% relative to female 20% and (Rashi and Rashmi, 2014) intheirstudy 68.2% for male and 31.8% for female.

Figure 4.3 shows Distribution of samples according to the habit of smoking; it has been shown that (56.9%) of subjects are non-smokers while (43.1%) are smokers so habits of smoking could not be considered as affecting factor but also considered to be a reason for PNS lesions because of 43.1% is not low percentage. linked this result to the type of sinusitis in table (4.20), it is clear that smoking has impact of chronic sinusitis. this result was in line with (Reh et al., 2012) study which stated that there is clear evidence in the literature that cigarette smoke, either through active smoking or passive exposure to second hand smoking (SHS), contributes to chronic rhinosinusitis.

Regarding the signs and symptoms, the predominant symptom was headache (70.4%) followed by nasal discharge (23%), an excess amount of secretion leads to nasal discharge anteriorly or posteriorly. Also an excess amount of secretion which cannot be released cause pressures which cause a headache. Same results have been noticed by (Kushwah et al., 2015) in which he found that the Predominant symptom was headache in (58%) of his sample.

Figure 4.6 shows distribution of family history of rhinosinusitis, it showed that (54.8%) have family history of rhinosinusitis while1 (45.2%) have no family history of rhinosinusitis; this might show good relation between family history and rhinosinusitis.

Figure 4.7shows distribution of samples according to living areas, (74%) live in apartment and have rhinosinusitis, (24.5%) live in villa, and (1.5%) live in palace the above findings lead us to say people who lives in natural environment have less possibility to get PNS lesions, While those who live in closed area depending in air-condition ventilation have higher risk to rhinosinusitis

Figure 4.8 shows distribution of samples according to residency in KSA It reveals that citizen was most affected group (39%) followed by those who live >10years(26%),(20.7%)for those who live 5-10 years and the less affected group those who live <5 years these findings showed that rhinosinusitis was directly proportional to the duration of the residency in KSA.

Figure 4.11 shows distribution of samples according to hypertrophied nasal turbinate It reveals that(86%) have hypertrophied nasal turbinate; most common was bilateral (65.3%), while (18.1%) their hypertrophied nasal turbinate was in Left side, and (16.6%) was in Right side; regarding the site most of hypertrophied nasal turbinate located inferiorly (94.1%), (5.6%) located in the middle and (0.3%) located superiorly.

Figure 4.13 shows distribution of samples according to type of sinusitiseither acute or chronic. It reveals that (55.6%) complain from chronic sinusitis while (44.4%) have acute sinusitis .

Figure 4.14 shows distribution of samples according to mucosal thickening It reveals that (62.5%) have mucosal thickening; most common was bilateral (72.2%), while (14.3%) their mucosal thickening was in Right side and (13.5%) was in Left side.

Figure 4.15 shows distribution of samples according to presence of fluid, it reveals that most of sample (93.1%) has fluid in their PNS.Figure 4.16 shows distribution of samples according to OMU obstruction, it reveals that

(22.7%) their OMU obstructed; most common was bilateral (64%), while (21.3%) their OMU was obstructed in Right side and (14.6%) was in the left.

Figure 4.17 shows distribution of samples according to presence of other PNS abnormalities such as retention cyst (9.4%), sino nasal polyposis was (8.7%), hypertrophied nasal mucosa was found in (9.7%) and hypertrophied nasopharyngeal adenoid is noted in (2.8%)

Table 4.18 shows analysis of sinusitis according to the age (cross tabulation) (when we use chi-square test ,p-value was0.026) the table shows the following according to age groups: (18-28)year 58pt have chronic sinusitis while 24pt have acute sinusitis ,in (28-38)year 90pt have chronic sinusitis and 64pt have acute ,in (38-48)year 42pt chronic and 59pt acute, in (48-58)year 21pt have chronic while 18 have acute, in (58-68)year 7 chronic and 9 acute at the end we conclude the majority of pt have chronic sinusitis(218)pt of them while (174)pt have acute sinusitis.

Table 4.29 shows analysis of sinusitis according to the gender (cross tabulation) (when we use chi-square test, p-value was0.026) It reveals that: most of pt have chronic sinusitis 218pt, (135 of them male, 83 of them female) while 174 have acute sinusitis 137 of them male and 37 females.

Table 4.20 shows analysis of sinusitis according to the habit of smoking (cross tabulation)when using chi-square test, P-value was 0.006 we found that 218 of our pt have chronic sinusitis (142 nonsmokers and 76 were smoker) while 174 have acute sinusitis (93 were smoker, 81 were non-smoker)

Table 4.21 shows analysis of sinusitis according to the occupation (cross tabulation) when using chi-square test, P-value was 0.000 we found that

218pt have chronic sinusitis (45, 50, 19, 23, 24, 38, 3, 11, 5,) while 174 have acute sinusitis (34, 44, 10, 19, 25, 23, 2, 5, 12 (occasionally)accountant, laborer, medical profession, no job, commercial career, educational career, legal career, engineer, administrator)

Table 4.22 shows analysis of sinusitis according to the signs and symptoms (cross tabulation) when using chi-square test, P-value was 0.000 we found that 218pt have chronic sinusitis (1, 8, 167, 36, 4, 2), 174 have acute sinusitis (1, 5, 109, 54, 3, 2 (occasionally)dizziness, nasal obstruction, headache, nasal discharge, snoring, reduced sense of smell)

Table 4.23 shows analysis of sinusitis according to the family history (cross tabulation) when using chi-square test, P-value was 0.055 we found that 218pt have chronic sinusitis (101 pt have family history, 117 have no family history) while 174pt have acute sinusitis (76 have family history, 98 have no family history.(

Table 4.24shows analysis of sinusitis according to the living area (cross tabulation) when using chi-square test, P-value was 0.000 we found that 218pt have chronic sinusitis (164, 51, 3) while174 have acute sinusitis (126,45, 3((occasionally)apartment, villa, palace(

Table 4.25 shows analysis of sinusitis according to residency in KSA (cross tabulation) when using chi-square test, P-value was 0.000 we found that 218pt have chronic sinusitis (90, 39, 42, 47) while174 have acute sinusitis (63, 16, 39, 56) (citizen, <5years, 5-10 years>10 years.

Table 4.26 shows analysis of sinusitis according to disease duration (cross tabulation) when using chi-square test, P-value was 0.000 we found that 218pt have chronic sinusitis (43, 144, 26, 1, 4) while174 have acute sinusitis

(26, 113, 31, 1, 3) (<1y ,1-3y, 3-6y, 6-9y, 9-12y).(Occasionally) .

In the regional and domestic literature, two studies published tackling these anatomical variations one of them in the eastern province of Saudi Arabia evaluated 121 candidates (all of them are Saudis population) and concluded that there is the difference of the prevalence of some variant among Saudi population compared with other study group (Alrumaih et al., 2016). The second one was done in southern Saudi Arabia evaluated 293 candidates (also they are all Saudi population) and concluded many differences (Sumaily et al., 2018).

Another domestic study conducted in Oman and concluded that deviation nasal septum (DNS) and concha bullosa (CB) are the most common in the Omani population (Al-Abri et al., 2014).

The current study which was carried in center of KSA evaluated 392 candidates including all resident (Saudis and non-Saudis) and concluded to many findings regarding anatomical variation, it reveals that The most common anatomical variant in this study is deviated nasal septum (DNS) which was found in (91.3%), similar to this study those who find that DNS is the most common are percentage ranging between 26 - 82% (Adeel et al., 2013, Ibrahim et al., 2018, Al-Abri et al., 2014, Fadda et al., 2012, Mamatha et al., 2010) see figure 4.12.

Regarding concha bullosa (CB), the study reveals that (50.8%) have CB; most common was bilateral (48.7%), while (29.1%) their CB was in the Right side and (22.1%) was in the Left ; regarding the site most of CB located in the middle (99.5%) while (0.5%) located inferiorly, In the other studies reported prevalence of CB varies widely from 2.8-55.4% (Fadda et al., 2012, Mamatha et al., 2010, Roman et al., 2015, Adeel et al., 2013, Al-Abri et al., 2014, Sumaily et al., 2018, Al-Qudah et al., 2010, Alrumaih et al., 2016).

Agger nasi is the second most common anatomical variation among Saudi resident it present in (51.02%) it consider not too high percentage if as we compare with the reviewed literature (Ibrahim et al., 2018, Al-Qudah, 2010, Mamatha et al., 2010, Fadda et al., 2012) with the following percentage (97.5%, 84%, 50% and 34%).

In this study frontal air cell was not identified in any case unlike other studies mentioned in three studies(Fadda et al., 2012, Sumaily et al., 2018, Alrumaih et al., 2016). In this study many anatomic variants (Sphenoid sinus extension into posterior nasal septum, Pnemotization posterior floor of cellaturcica, Prominent ethmoidal bulla, Nasal septum spur, hard palate pneumatization, Pnemtization pterygoid process, Non pneumatized frontal sinus, Inferior turbinate pneumatization) with these frequencies (36.22%, 30.87%, 29.85%, 29.34%, 9.18%, 7.91%, 4.85% and 1.28%) respectively.

Lamina papyracea dehiscence (Dua et al., 2005), anterior clinoid process pneumatization (Nouraei et al., 2009), infraorbital air cell (Nouraei et al., 2009), all these variants mentioned in only one study of reviewed literature beside our current study by these frequencies (4, 18, 12) % in the reviewed studies and these frequencies (1.79%, 10.97%, 10.20%) (figure 4-18) in our current study, and we notice our study frequencies is less for all of the three mentioned anatomic variants. Among the reviewed literature Basal lamella pneumatization is mentioned in two studies only (Perez et al., 2000, Sumaily et al., 2018) by these frequencies (15.7% and 3.1%) while in our current study presented by 5.36%. Keros classification in our current study was considered too presented by too low percentage 0.51% if we compared by other reviewed literature (Badia et al., 2005, Al-Abri et al., 2014, Sumaily et al., 2018, Nouraei et al., 2009) by these percentage (27.29%, 36%,45.4% and 92%).

5.2 Conclusion:

The anatomical variation of the paranasal sinuses is very important to be identified preoperatively. These variations found to be different among regions and countries. In our study, we found all patients with rhinosinusitis have one or more than one anatomic variant mentioned. Anatomical variations of paranasal sinuses are best depicted on MDCT scan of PNS. The deviated nasal septum is the commonest anatomical variation (93.11%) followed by agger nasi cell (51.02%) and Concha bullosa (50.77%).

5.3. Recommendations:

By the end of the following thesis we would like to recommend the following points:-

- First important recommendation of our study is that natural ventilation will save our PNS healthy.
- Same study in the future should be done in other regional areas in KSA and compare the fidings with our findings which was in the center of KSA.
- Same study in the future should be done by using other imaging modalities and comparing with the our study findings .

References:

Adeel M, Rajput MS, Akhter S, Ikram M, Arain A. (2013) Anatomical variations of nose and paranasal sinuses; CT scan review. Journal of the Pakistan Medical Association 63(3): 317.

Ahmet Kaygusuz, Mehmet Haksever, DavutAkduman, Sundus, Aslan, ZeynepSayar (2014).Sinonasal Anatomical variations: Their Relationship with Chronic Rhinosinusitis and Effect on the Severity of Disease-A Computerized Tomography Assisted Anatomical and Clinical Study. Indian J Otolaryngol Head Neck Surg.; 66(3):260–266 .

Al Abri R, Bhargava D, Al-Bassam W, Al Badaai Y, Sawhney S (2014) Clinically significant anatomical variants of the paranasal sinuses. Oman Med J 29(2): 110-113.

Alho O. (2004). Nasal Airflow, Mucociliary Clearance, and Sinus Functioning During Viral Colds: Effects of Allergic Rhinitis and Susceptibility to Recurrent Sinusitis. Am J Rhinol. Vol. 18 (6), P: 349-55.

Alkire BC and Bhattacharyya N (2010): An assessment of sinonasal anatomic variants potentially associated with recurrent acute rhinosinusitis. Laryngoscope,; 120: 631–34

Al-Qudah MA (2010) Anatomical variations in sinonasal region: A computer tomography (CT) study. J Med J 44(3): 290-297.

Alrumaih RA, Mona M Ashoor, Ahmed A Ob (2016). Radiological sinonasal anatomy. Exploring the Saudi population. Saudi Med J 37: 521-526.

Axelsson A, Grebelius N, Chidekel N, Jensen C. (1970). The Correlation between the Radiological Examination and the Irrigation Findings in Maxillary Sinusitis. Acta Otolaryngol (Stockh), vol, 69 P: 302-6.

Axelsson A. Runze U. (1982). Comparison of Subjective and Radiological Findings during the Course of Acute Maxillary Sinusitis. The Annals of otology, rhinology, and laryngology, Vol, 92 P: 75-77.

Bachert C, Wagenmann M, Rudack C, Höpken K, Hiltebrandt M, Wang D, Cauwenberge P.(1998) The Role of Cytokines in Infectious Sinusitis and Nasal Polyposis. Allergy, vol.53, P: 2- 13.

Badia L, Lund VJ, Wei W, Ho WK (2005): Ethnic variation in sinonasal anatomy on CT-scanning. Rhinology; 43:210-4 .

Ballinger Ph, Frank EN. (1999).Merrill's Atlas of Radiographic Positions And Radiographic Procedure.9thed, P: 286-294.

Becker DG.(2003). Septoplasty and Turbinate Surgery. Aesthetic Surg J, vol. 23, P: 393-403.

Bendouah Z, Barbeau J, Hamad WA, Desrosiers M. Biofilm formation by Staphylococcus aureus and Pseudomonas aeruginosa is associated with an unfavorable evolution after surgery for chronic sinusitis and nasal polyposis. (2006). Otolaryngol Head Neck Surg. Vol, 134(6) P: 991-6.

Benninger MS, Ferguson B J, Hadley J A, Hamilos DL, Jacobs M, kennedy D W, Lanza D C, Marple BF, osguthorpe JD, Stankiewicz JA. (2003) Adult Chronic Rhinosinusitis: Definitions, Diagnosis, Epidemiology, and Pathophysiology. Otolaryngology-Head and Neck Surgery, vol.129, P: S1-S32.

Caughey RJ, Jameson MJ, Gross CW, Han JK (2005). Anatomic risk factors for sinus disease: fact or fiction? American journal of rhinology 19(4): 334-339 .

Delbert A B, Jocyline L M, Mutsuhisa F, Kook S O, Lionel W.(1981) Radiologic Imaging in Otorhinolaryngology. Pediatric Clinics of North America Vol, 28(4) P:998-7.

Desrosiers M, Evans G A, Keith P K, Wright E D, Kaplan A, Bouchard J, Ciavarella A, Doyle P W, Javer A R, Leith E S. (2011). Canadian Clinical Practice Guidelines for Acute and Chronic Rhinosinusitis. Allergy Asthma ClinImmunol, vol, 7.P: 95-7.

Devaiah AK. (2004) Adult Chronic Rhinosinusitis Diagnosis and Dilemmas. Otolaryngol Clin North Am, vol. 37, P: 243-52.

Drake AB. (1987) Nasal Polyps.In:Scott-Brown’s Otolaryngology.London: Butterworths, P: 147-53.

Dua K, Chopra H, Khurana AS, Munjal M (2005) CT scan variations in chronic sinusitis. Indian Journal of Radiology and Imaging 15(3): 315.

Fadda GL, Rosso S, Aversa S (2012): Multi parametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. ActaOtorhinolaryngology Ital; 32(4):244–51

Fatma CA , Haluk YA ,Alper CA, Levent NA.(2006).Endoscopic Sinus Surgery for Maxillary Sinus Mucoceles. Head and Face Medicine.

Gebrim ES. (2008). The relevance of sinonasal anatomical variations in the preoperative evaluation by computed tomography for endonasal surger. Radiol Bras.;41:5-6

Gleeson M J. (2008) Scott-Brown's Otorhinolaryngology: Head and Neck Surgery. 7th ed Oxford University Press.

H. Mamatha, N.M. Shamasundar, M.B. Bharathi, L.C (2010). ParanasalVariations of ostiomeatal complex and its applied anatomy: a CT scan study. Indian journal of science and technology; 3 (8):904-907.

HadleyJ A, Schaefer SD. (1997) Clinical Evaluation of Rhinosinusitis: History and Physical Examination. Otolaryngology head and neck surgery, vol. 117, P: S8-S11.

Hansberger HR, Osborn AG, Smoker WRK.(1986) CT in the Evaluation of the Normal and Diseases of Paranasal Sinuses. Seminars in ultrasound,CT,MR ,vol,7 P:68-90.

Jorie Boulevard, 1991 Preston (1-2-214). (Computed Tomography (CT) – Sinuses, American College of Radiology (ACR),.http://www.radiologyInfo.org

John Vartaian,MDCT scan of paranasal sinuses: date: 23.4.2005, pages (1-13). http:www.emedicine.com.

Ibrahim S, Saud A, Jibril H (2018). Anatomical Variations of Paranasal Sinuses Gender and Age Impact. Glob J Oto 2018; 14(1): 555-877.

Jaluskar SK, Patil NP.(1992). Value of CT in the Evaluation of the Chronic Sinus Diseases. Ind JLO Head and Neck surgery, vol, 4P:188-192.

Jones NS (2002). CT of the paranasal sinuses: a review of the correlation with clinical, surgical and histopathological findings. ClinOtolaryngol Allied Sci.;27:11-7 . .

Kapoor PKD. (2000). Maxillary Sinus Hypoplasia. J Laryngol Otol, vol. 116, P: 135-137

Kennedy,William E. Bolger,S. James Zinreich Snippet view (2001) disease of the sinuses

Kenneth LB, John LA.(2009) Textbook of Radiographic Positioning and Related Anatomy.7th ed. Mosby P: 438-442.

Kumar UI, Cotran RA, Robbins ST. (1997). Basis Pathology, by W.B Sanders Company.6th ed. P: 1316-1323.

Kushwah APS, Bhalse R, Pande S. (2015). CT evaluation of diseases of Paranasal sinuses & histopathological studies. Int J Med Res Rev;3(11):1306-1310.

Larsen PL, Tos M. (1991) Origin of Nasal Polyps. Laryngoscope, vol, 101 P: 305-12 .

Lerdlum S and Vachiranubhap B (2005) Prevalence of anatomic variation demonstrated on screening sinus computed tomography and clinical correlation. Journal of the Medical Association of Thailand Chotmaihet thangphaet 88: S110-S115.

Lubbe D. (2009). Rhinosinusitis: Management Guidelines. SA Journal of CPD: ENT, vol, 27 P: 349-350, 352.

Maclennan A. (1995) Radiation Dose to the Lens from Coronal CT scanning of the Sinuses. Clinical radiology, vol. 50, P: 265-267.

Maran AGD, Lund VJ. (1990). Infections and Non Neoplastic Disease. Clinical Rhinology. New York P: 94-8.

Maran AGD, Lund VJ.(1990) Infections and Non Neoplastic Disease.Clinical Rhinology. New York P: 94-8.

Marieb EN. (1998) Human anatomy & physiology 4th ed. Menlo Park, Calif: Addison Wesley Longman p: 633-634.

Mazza D, Bontempi E, Guerrisi A, Del Monte S, Cipolla G, Perrone A, (2007). Paranasal sinuses anatomic variants: 64-slice CT evaluation. Minerva Stomatol; 56: 311-318.

Merrell R A Yanagisawa E. (1968). Radiographic Anatomy of the Paranasal Sinuses: I. Waters' View. Archives of Otolaryngology, Vol, 87 P: 184-195.

MesserklingerW (1978): Endoscopy of the nose. Baltimore.MD:Urban& Schwarzenberg.

Nouraei SA, Elisay AR, Dimarco A, Abdi R, Majidi H. (2009). Variations in paranasal sinus anatomy: implications for the pathophysiology of chronic rhinosinusitis and safety of endoscopic sinus surgery. J Otolaryngol Head Neck Surg 38(1): 32-37.

Osguthorpe J D. (2001) Adult Rhinosinusitis: Diagnosis and Management. American family Physician, vol, 63, P: 13-47.

Pankey GA, et-al.(2000). Contemporary Diagnosis and Management of Sinusitis. Newtown PA: Handbooks in Health Care.

Perez Pinas I, Sabate J, Carmona A, Catalina-Herrera CJ, Jimenez Castellanos J (2000) Anatomical variations in the human paranasal sinus region studied by CT. The Journal of Anatomy 197(2): 221- 227.

Rashi Tiwari, Rashmi Goyal (2014) Indian J Otolaryngol Head Neck Surg Mar; 67(1): 18–20. Published online 3. doi: 10.1007/s12070-014-0734-2.

Reh, D. D., Higgins, T. S., & Smith, T. L. (2012). Impact of tobacco smoke on chronic rhinosinusitis: a review of the literature. International forum of allergy & rhinology, 2(5), 362–369.

Rice DH, Schaefer SD. (2003) Endoscopic Paranasal Sinus Surgery. 3rd ed. Philadelphia: Lippincott Williams and Wilkins.

Roman RA, Hedeşiu M, Gersak M, Fidan F, Băciuț G, Băciuț M (2016) Assessing the prevalence of paranasal sinuses anatomical variants in patients with sinusitis using Cone.

Ros SP, Herman BE, AzarKia B. Acute Sinusitis in Children: is the Water's View Sufficient?.(1995) Pediatr Radiol, vol, 25 P: 306-7.

Shpilberg KA, Daniel SC, Doshi AH (2015): CT of anatomic variants of the paranasal sinuses and nasal cavity: Poor correlation with radiologically significant rhinosinusitis but importance in surgical planning. Am J Roentgenol,; 204(6): 1255–60

Shuaib M. (2009). AComparative Study of Radiological Sinusitis with Clinical Sinusitis.M.Sc. Research; Rajiv Gandhi University of Health Sciences, Karnataka, Bangalore.

SOBIESK, J. L. & MUNAKOMI, S. 2020. Anatomy, Head and Neck, Nasal Cavity.StatPearls. Treasure Island (FL).

Stamm AC, Draf W. (2000). Micro-edoscopic Surgery of the Paranasal Sinuses and Skull Base. Berlin: Springer-Verlag.

Swaroop D M. (2010). Clinical Study of Tumors of Nose and Paranasal Sinuses.

Timmanagouda P. (2008).Computed Tomography in the Evaluation of Pathological Lesions of Paranasal Sinuses. D Space at RGUHS University 14.139.159.4,

Verma, Jagram, Tyagi, Sushant ,Srivastava, Mohit, Agarwal, Aman (2016). Computed tomography of paranasal sinuses for early and proper diagnosis of nasal and sinus pathology, VL - 2 DO - 10.18203/issn.2454-5929.ijohns20160957 JO- International Journal of Otorhinolaryngology and Head and Neck Surgery.

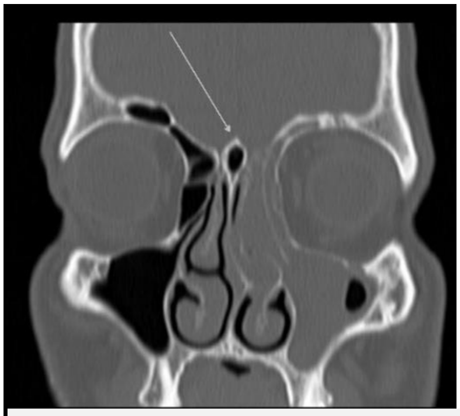
Warrick.(1969) Basic anatomy and physiology. 3rd ed. Edward Arnold, p: 107-110

Webber AL. (1988) Inflammatory Diseases of the Nasal Sinuses and Mucoceles. OCNA, vol, 21P:421-427.

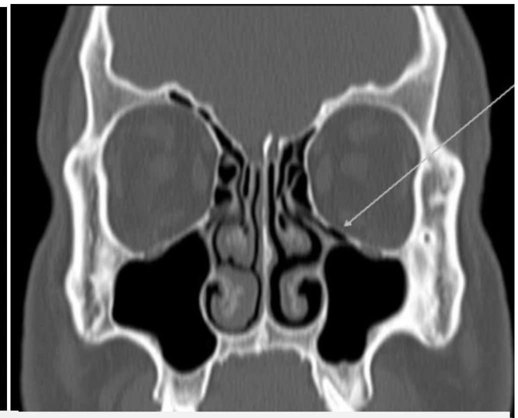
Williams JR, Roberts JR, Distell B, Simel D L. (1992). Diagnosing Sinusitis by X-ray. Journal of general internal medicine, Vol, 7 P: 481-485.

Yousem DM (1993). Imaging of Sino nasal inflammatory disease radiology.

Appendix (1)



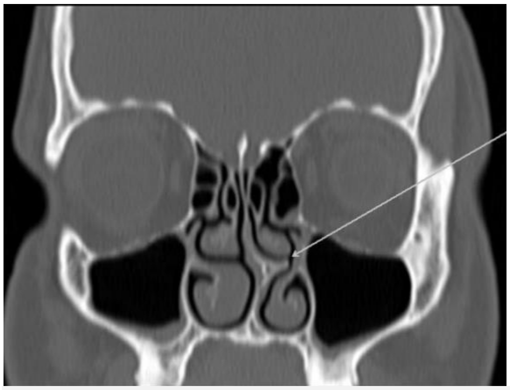
Coronal CT scan for 43 y male white arrow show Cristagali pneumatization



Coronal CT scan for 36 y male white arrow show Haller cell

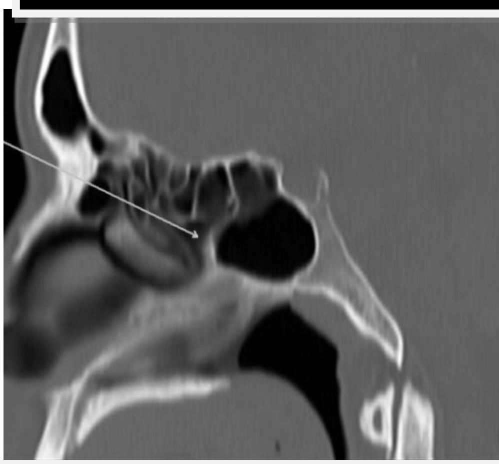
Coronal CT scan for 33 y male white arrow show Hypo-pneumatized Lt frontal sinuses

Coronal CT scan for 21 y male white arrow show Sphenoid pneumatization

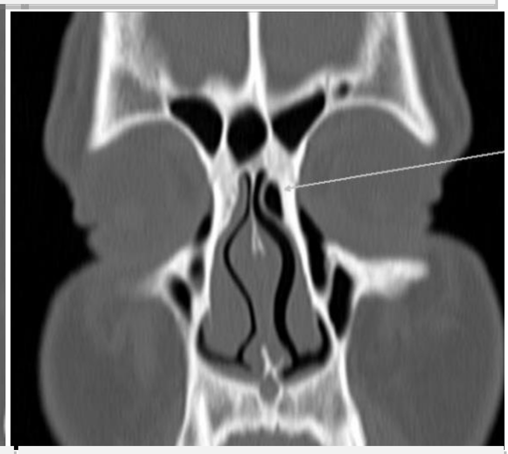


Coronal CT scan for 25 y male white arrow show Nasal septum spur

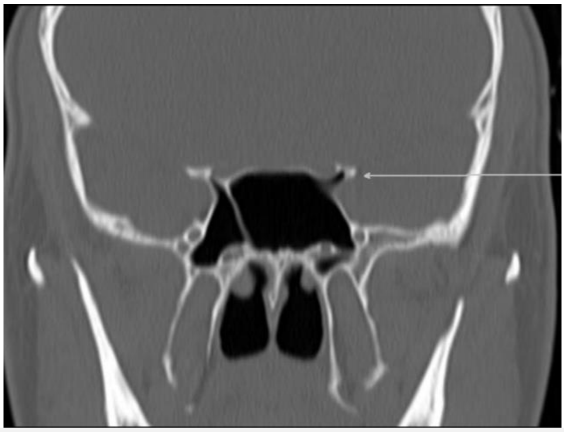
Axial CT scan for 65 y male white arrow show Deviated nasal septum

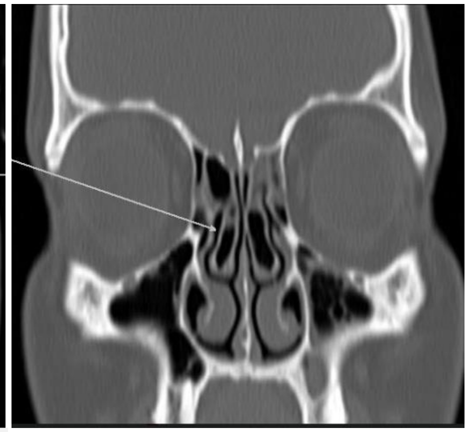


Saggital CT scan for 34 y male white arrow show Sphenoid sinus extended to posterior nasal septum.



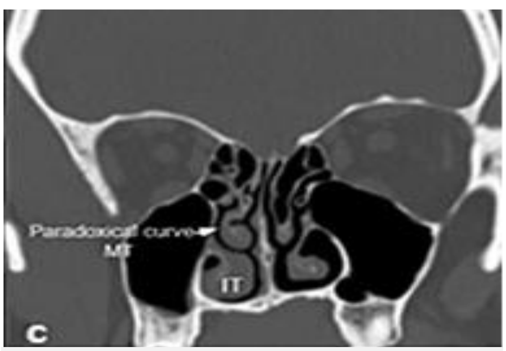
Coronal CT scan for 34 y female white arrow show Agger nasi cell.

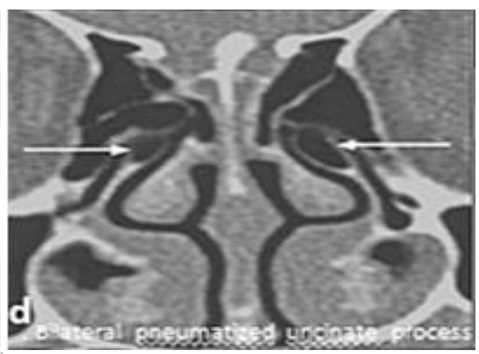




Coronal CT scan for 30 y male white arrow show Onodi cell

Coronal CT scan for 38y female white arrow show Bilateral middle concha bullosa





Coronal CT scan for 32y male white arrow show paradoxical curve middle turbinate

Coronal CT scan for 62y female white arrow show pneumatization of the uncinate process .

Appendix (2) Achievements

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Study of Anatomical Variations of Para nasal sinus (PNS) using Multislice Computed Tomography (CT) in Rhinosinusitis

Ohood A. Mohmmed[1], Mohamed Yousef[1,2], Lubna Bushara[3]

[1] College Of Medical Radiological Sciences, Sudan University Of Science And Technology, Khartoum, Sudan

[2] Radiologic Sciences Program, Batterjee Medical College, Jeddah, Saudi Arabia

[3]Hail University, College Of Medical Applied Sciences, Department Of Diagnostic Radiology Sciences, Hail – KSA.

PUBLISHED PAPER 1

MR Journals
- Bringing Research Knowledge to your doorstep...
MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Medicine and Medical Sciences (ISSN: 2354-323X) Vol. 7(12) pp. 489-497, December, 2019
Available online http://www.meritresearchjournals.org/mms/index.htm

Original Research Article

Computed Tomographic Evaluation of Anatomical Variations of Paranasal Sinuses Region in Rhinosinusitis

Ohood A. Mohammed[1], Mohamed Yousef[1,2], Ahmed Abukonna[1], Salem Saeed Alghamdi[3], Ikhlas Abdelaziz[1,3*] and Nasraldeen Alnaeem M. Alkhidir[4]

PUBLISHED PAPER 2

Appendix (3):- Consent Form

اقرار وقبول

أقر أنا :- ....

بموافقتي على إجراء فحص للجيوب الانفيه بالاشعه المقطعيه بعد أن تم لي شرح الفحص واهميته وأقر بموافقتي على إعطاء المعلومات الشخصية اللازمة لإلستبيان المرفق بغرض البحث المقدم من الباحثة: عهود الحسين محمد البشير

التوقيع.................................

التاريخ.................................

Appendix (4) our study comparing with the previous study

Study Anatomical Variation %	Perez-Pinas et al.	Badia et al.	Badia et al.	Lerdlum & Vachira-nubhap	Dua et al.	Caughey et al.	Mazza et al.	Nouraei et al.	Al-Qudah	Mamatha et al.	Fadda et al.	Adeel et al.	Al-Abri et al.	Roman et al.	Alrumaih et al	Sumaily et al	Ohood et al [current study]
Year	2000	2005	2005	2005	2005	2005	2007	2009	2010	2010	2012	2013	2014	2015	2016	2017	2019
Country	Spain	Hong Kong	United King-dom	Thailand	India	USA	Italy	United Kingdom	Jordon	India	Italy	Pakistan	Oman	Romania	Saudi Arabia	Saudi Arabia	Saudi Arabia
Number of candidates	110	100	100	133	50	250	100	278	110	40	200	77	360	130	121	293	392
DNS	58	15	33	56.4	44				43	65	82	26	80	-	-	30.7	91.3
concha bullosa	24.5	9.5	31	14.3	16	27.4	29	35.4	62	15	2.8	18.2	49	35.3	55.4	24.2	50.71
Basal lamella pneumatization	15.7	-	-	-		-	-	-	-	-	-	-	-	-	-	3.1	5.36
superior turbinates	-	-	-	-		-	-	-	25	-	-	-	1.4	-	-	1.7	20.15
crista gali pneumatization	-	-	-	-		-	-	-	28	-	13.6	-	0.3	-	89.2	8.7	19.39
Paradoxical middle turbinate	5	6.5	22	5.3	10	-	11	0.7	18	-	6.4	14.3	13	8	12.4	9.5	10.71
Uncinate process pneumatization	-	-	-	-		-	-	-	-	40	-	-	-	46	-	73.7	12.76
Frontal sinus hyperpneumatizati	-	-	-	-		-	-	-	-	-	2.1	-	-	-	-	26.3	8.67
Frontal air cell	-	-	-	-		-	-	-	-	-	7.8	-	-	-		24	0
supraorbital air-cell	-	2	17	-		-	-	6.1	-	-	-	-	13	-	-	37.5	16.07
Onodi cell	10.9	13	17	-	3	-	9	4.7	-	-	8.5	6	7.5	8	35	31.4	12.24
Hallar cell	45	5	15	9.4	16	27	5	12.2	20	17.5	22.8	9.1	24	25	39.7	25.9	30.1
Sphenoid lateral pneumatization	-	12	6	-		-	-	11	-	-	-	-	-	-	-	24.2	7.65
Keros classification	-	29	27	-		-	-	92	-	-	-	-	36	-	-	45.4	0.51
Sphenoid septum direction	-	35	36	-		-	-	-	-	-	-	-	0.8	-	-	29.7	8.16
Agger cell				7.9	40				84	50	34					97 .5	51.02
Lamina papyracea dehiscence	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1.79
anterior clinoid process pneumatization								18									10.97
infraorbital air cell								12									10.2

Appendix (5) Data Collection Sheet (Questionnaire)

DATA COLLECTION SHEET

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

SECTION A:-VOULNTEER DATA

A **AGE**:-

1. ☐ 18-28 2. ☐ 28-38 3. ☐ 38-48 4. ☐ 48-58 5. ☐ 58-68

B **GENDER**:-

1. ☐ MALE 2. ☐ FEMALE

C **HABITS**:-

1. ☐ SMOKER 2. ☐ NON SMOKER

D **OCCUPATION**:-

1. ☐ Accountant 2. ☐ Laborer 3. ☐ Medical professions 4. ☐ No job

5. ☐ commercial careers 6 ☐ educational careers

7. ☐ Legal careers 8 ☐ engineer

9 ☐ Administrative

E **SIGHNS AND SYMPTOMS**:-

1. ☐ Headache. 2. ☐ Nasal obstruction, congestion, itching or pain. 3 ☐ Dizziness.

4. ☐ Drainage of thick Yellow or greenish discharge from the nose or down the back of the throat (Postnasal drainage). 5. ☐ Snoring. 6. ☐ Reduced sense of smell and taste .

7. ☐ Reduced sense of smell and taste in adults. 8. ☐ Nasal bleeding .

F **FAMILY HISTORY**:-

1. ☐ YES 2. ☐ NO

G **LIVING AREA**:-

1. ☐ APARTMENT 2. ☐ VILLA 3. ☐ PALACE

H **RISEDENCE IN KSA**:-

1. ☐ SAUDI 2. ☐ Less than 5 years 3.5years to less than10 4 ☐ More than 10 years

I **RESIDENCE OF DISEASE**:-

1. ☐ Less than one year 2. ☐ 3.3-6 ☐ 6-9 5. ☐ -12 ☐

SECTION B :-CT SCAN FINDINGS

J. **Concha bullosa**

JA:SIDE

1 ☐ Rt 2 ☐ Lt 3 ☐ bilateral 4 ☐ NONE

JB:SITE

1 ☐ supirior 2 ☐ middle 3. ☐ Inferior 4 ☐ NONE

K. **Hypertrophiednasal turbinate**

KA:SIDE

1 ☐ Rt 2 ☐ Lt 3 ☐ Bilateral 4 ☐ NONE

KB:SITE

1. ☐ supirior 2. ☐ middle 3. ☐ inferior 4 ☐ NONE

L. **Nasal septum deviation**

1 ☐ yes 2 ☐ No

M. **Sinusitis**

1 ☐ yes 2 ☐ No

N. **Mucosal thickening**

1 ☐ Rt 2 ☐ Lt 3 ☐ Bilateral 4. ☐ NONE

O. Fluid

1 ☐ yes 2 ☐ No

P. OMU Obstruction

1 ☐ Rt 2 ☐ Lt 3 ☐ Bilateral 4 ☐ NONE

Q. Others

1 ☐ retension cyst

2 ☐ sinonasalpolyposis

3 ☐ hypertrophied nasaopharengeal adenoid

4 ☐ hypertrophied nasalmucosa

5 ☐ hypo-pneumatized frontal sinuses

R. Anatomical variations of PNS