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College of post Graduate Studies

Evaluation of Anthropometric Indices of Maxillary Sinusfor Gender Determination among Adult Sudanese Using Computed Tomography

تقويم المؤشرات القياسية للجيوب الفكية لتحديد الجنس بين البالغين السودانيين باستخدام التصوير بالأشعة المقطعية المحوسبة

A Thesis Submitted for Partial Fulfillment for the Requirements of

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By:

Safaa Mohamed Ahmed

Supervisor:

Dr. Ahmed Mustafa Abukonna

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الآيـة

قال تعالي:

(وقُلْ رَبِّ زِدْنِي عِلْماً)

[طـه : 114]

Dedication

This research is dedicated

To my inspiration mother

To my family

To my doctors

To my friends

To my colleagues

Acknowledgement

I am indebted to all those who directly or indirectly, have made it for me to write this research. I would like to express my deep gratitude to **Dr. Ahmed Mustafa Abukonna** for his kind contribution in stimulating the suggestions and encouragement; he helped me to coordinate my project especially in writing this thesis.

My thanks also for the staff and technologist in CT scan departments at Al Nileen hospital

Finally, special thanks to my family and friends for their great help during the whole study period.

Abstract

This is a descriptive study conducted during the period from March 2019 to December 2019 in Alnileen and Al ragi Hospitals. The objective of this study was to evaluate the anthropometric indices of maxillary sinus for gender determination among adult Sudanese.60 patients (30males and 30 females) were enrolled in the study, all of them referred for skull computed tomography examination for different reasons. The maximum height, maximum width, anterior-posterior (AP) diameter and distance between maxillary sinuses were measured in both sexes.

The results of the study showed that the mean and standard deviation of Right and Left height, width and maximum A-P diameter of maxillary sinuses for male were (Right : 3.843 ± 0.43 cm, 2.827 ± 0.55 cm, 3.563±0.62963 cm. Left: 3.808 ± 0.61 cm, 2.734 ± 0.53cm, 3.534 ± 0.67 cm)respectively. The Right and Left height, width and maximum A-P diameter of maxillary sinuses for female were (Right: 3.684 ± 0.39 cm, 2.657 ± 0.695 cm, 3.129 ± 0.561 cm. Left: 3.599 ± 0.586 cm, 2.699 ± 0.567 cm, 3.117 ± 0.642 cm) respectively .The distance between maxillary sinuses for male was 3.14 ± 0.43 cm and for female was 3.08 ± 0.34cm . There was a significant difference between men and women regarding the maximum A-P diameter of the right and left maxillary sinuses in all participants. The study also revealed that the highest accuracy for sex determination was related to the maximum A-P diameter of the right and left maxillary sinus.

The study concluded that regardless of age, the maximum A-P diameter of maxillary sinuses is partially valuable for sex determination among Sudanese.

المستخلص

هذه الدراسة الوصفية قد أجريت في الفترة من مارس 2019 إلي ديسمبر 2019 في مستشفي النيلين ومستشفي الراقي . أجريت هذه الدراسة علي عينة من 60 مريض(30 ذكر و30 أنثي) الذين خضعوا لفحص الأشعة المقطعية للرأس للأسباب مختلفة. وقد كان الهدف من هذه الدراسة تقيم المؤشرات القياسية للجيوب الفكية للتحديد الجنس بين البالغين السودانيين.

أظهرت نتائج الدراسة أن المتوسط والانحراف المعياري للارتفاع الأيمن والأيسر والعرض والحد الأقصى للقطر الأمامي الخلفي للجيوب الفكية للذكور كانت (الأيمن: 3.843 ± 0.43 سم ، 2.827 ± 55.0 سم ، 3.563 ± 0.62963سم. الأيسر: 3.808 ± 0.61 سم ، 2.734 ± 0.53 سم ، 3.534 ± 0.67 سم) على التوالي. و المتوسط والانحراف المعياري للارتفاع الأيمن والأيسر والعرض والحد الأقصى للقطر الأمامي الخلفي للجيوب الفكية للإناث (الأيمن: 3.684 ± 0.39 سم ، 2.657 ± 0.695 سم ، 3.129 ± 561.0 سم. الأيسر: 3.599 ± 0.586 سم ، 2.699 ± 0.567 سم ، 3.117 ± 0.642 سم) على التوالي. بينما كانت المسافة بين الجيوب الفكية للذكور 3.14 ± 0.43 سم وللإناث 3.08 ± 0.34 سم ، كان هناك فرق كبير بين الرجال والنساء فيما يتعلق بالقطر الأقصى الأمامي الخلفي للجيوب الفكية اليمنى واليسرى في جميع المشاركين. وكشفت الدراسة أيضا أن أعلى دقة لتحديد الجنس كانت مرتبطة بالقطر الأقصى الأمامي الخلفي للجيوب الفكية اليمنى واليسرى.

وخلصت الدراسة إلى أنه بغض النظر عن العمر ، فإن الحد الأقصى للقطر الأمامي الخلفي من الجيوب الفكية ذو قيمة جزئية لتحديد الجنس بين السودانيين.

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Abbreviation

CTA	Computed tomography axial
CT	Computed tomography
CBCT	Cone beam computed tomography
DAS	Data acquisition system
PNS	Para nasal sinus
AP	Anterior –posterior diameter

Chapter One

Introduction

1.1 Introduction:

Sex determination is one of the important parameters in forensic identification. Gender determination in damaged and mutilated dead bodies or from skeletal remains constitutes the foremost step for identifying in medico-legal examination. Matching specific features detected on the dead bodies with data recorded during the life of an individual is an important aspect in forensics, and can be performed by fingerprint analysis, deoxyribonucleic acid matching, anthropological methods, radiological methods and other techniques which can facilitate age and sex identification (Uthman et al., 2011).

Determination of gender is done through various body parts, the skull, the pelvis, the long bones with an epiphysis and a metaphysis in skeletons, the mastoid process, the foramen magnum and the paranasal sinuses. In explosions, warfare, and other mass disasters like aircraft crashes, the skull and other bones are badly disfigured, however it has been reported that maxillary sinuses remain intact (Teke et al., 2007).

Studying paranasal sinuses is very useful in identification of mutilated or burnt bodies from accidents such as plane crashes. Sinuses are highly resistant to trauma and since they are situated in a relatively hard part of the skull, they are reserved better and can resist trauma. Also, the sinuses are unique so that the sinus airway patterns of no two individuals are alike, even in identical twins(Saukko and Knight, 2015).Assessing the anthropometric characteristics of the maxillary sinus is one of the important and aiding factors in sex determination. Since ethnicity is an influential factor in the form and shape of the human skeleton ,sex determination from skeletons varies in different ethnic groups with respect to the sensitivity and specificity of anthropometric indices(Vij, 2011).

There are many studies in forensic literature on different ethnic groups regarding the paranasal sinuses(Rubira-Bullen et al., 2017, Raoof et al., 2013)especially the maxillary sinuses and also various anthropometric parameters that have been assessed for sex determination. Most of these studies have used radiography of the maxillary sinuses and there are limited studies using CT-scan images (Sholts et al., 2010).

Computed tomography (CT) scans are excellent imaging modality used to evaluate the signal-nasal cavities. They provide an accurate assessment of the paranasal sinuses, craniofacial bones, as well as the extent of pneumatization of the sinuses. It provides detailed information that is not available from standard radiographs. CT measurements of maxillary sinuses are useful to support gender determination(Ono et al., 1992).

1.2 The problem of study:

In some case it is difficult to determine Gender in damaged and mutilated dead bodies or from skeletal remains constitutes especially in forensic identification.

1.3 Objectives

1.3.1 General objective:

Evaluation of anthropometric indices of maxillary sinus for gender determination among adult Sudanese using computed tomography

1.3.2 Specific objectives:

- To compare between males and females dimensions.
- To compare between the right side and left side of maxillary sinus.
- To correlate measurements to age.

1.4 Overview of the study:

This study consisted of five chapters, chapter one an Introduction which includes General, specific objectives also contain problem of study. Chapter two includes: Theoretical Background and literature review. Chapter three describes material and method. Chapter four include result of presentation of finding of study, finally Chapter five includes discussion, conclusion and recommendation.

Chapter Two

Theoretical Background and Literature Review

2.1 Anatomy and physiology:

2.1.1 The maxillary sinus or (antra):

The maxilla (Antrum of Highmore): is the second largest facial bone, forming the majority of the roof of the mouth, the lateral wall and floor of the nasal cavity and the floor of the orbit. The body is usually described as a quadrilateral pyramid, and contains the maxillary sinus. The roof of the maxillary sinus forms most of the orbital floor. It is traversed by the infra orbital canal, which may be dehiscent. Inferiorly the floor of the sinus is generally thicker, but can be encroached upon by the roots of teeth - for instance the second premolar and three molar teeth. The medial wall contains a large defect, the maxillary hiatus, which is completed in life by a number of bones and mucous membrane leaving only the natural maxillary ostium Maxillary sinus. These paired sinuses lie under the cheek and occupy a central portion in the facial skeleton. It is the largest of the group of paranasal sinuses which are formed as a result of pneumatisation of the maxilla. They are more or less shaped like a pyramid. The capacity of the maxillary sinus is roughly 1 fluid ounze (30ml). 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(Rysz and Bakon, 2009).

Roof of the sinus is formed by its thin orbital wall which is traversed by the infra orbital foramen containing the infra orbital vessels and nerves. This wall is very fragile and any disease process involving the maxilla is likely to affect the orbit through this wall Floor is formed alveolar process of the maxilla and the hard palate. The roots of the first and second molar reach up to the floor of the maxillary sinus. Dental infections involving the 1st and 2nd molars may involve the maxillary sinus(Beale et al., 2009).

The anterior wall of the sinus corresponds to the anterior surface of the maxilla extending superiorly from the orbital rim above to the teeth below. The posterior wall is formed by the corresponding surface of the maxilla superiorly, and part of the palatine bone inferiorly (Sobiesk and Munakomi, 2020).

Laterally: Bounded by the canine eminence which is caused by the canine tooth.

The medial wall of the sinus is shared with the nasal cavity and forms part of the lateral nasal wall within which is present the nasolacrimal duct. Which is drains into the inferior meatus (that is bordered by the inferior turbinate bone). This is one reason why our nose drips when we cry(Sobiesk and Munakomi, 2020).

The sinus drains into the nasal cavity through its ostium that is present high up in its medial wall and empties in the posterior aspect of the hiatus semilunaris situated in the middle meatus, so the chance that infection maybe spread from frontal and anterior ethmoidal sinuses into the maxillary sinuses is great and 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. The maxillary sinus is innervated by branches of V2. Specifically, the greater palatine nerve and the branches of the infraorbital nerve (Lohiya et al., 2016).

2 -1-2 Developments of maxillary sinus:

The maxillary sinus grows most rapidly between ages 1 and 8 years, growing laterally past the infraorbital canal and inferiorly to the middle aspect of the inferior meatus . At age three years, the downward pull of the facial muscles continues to pull on the maxillary bones . The roof of the sinus presents a more inferolateral position in childhood, before assuming its more horizontal position in adulthood due to progressing pneumatization . The floor of the sinus lies somewhat lower than the insertion of the inferior nasal conchae at the end of the second year of life . The floor lies at about the height of the inferior nasal conchae at age seven years, and at the level of the floor of the nasal cavity at age 9 years. In some cases, the floor of the sinus can continue further into the hard palate in the medial direction, creating the palatine recess (Iwanaga J , Wilson ,Lachkar,2019).

The maxillary sinuses are the only sizeable sinuses present at birth they have the size of a small lima bean measuring about 8x4mm ;and are situated with their longer dimension directed antriorly and posteriorl. They develop at the third month of intrauterine life; in the place existing between the oral cavity and the floor of the orbit. They develop as evagination of mucous membrane of the lateral wall of the nasal cavity at the level of the middle nasal meatus forming aminute space that expands in an inferior direction in to the primordium of the maxilla (Rysz and Bakon, 2009).

Growth of the maxillary sinus is determined by aprocess of bone remodling referred to as pneumitization which is carried out by resorption of the internal wall (except the medial wall) at rate that ligthtly exceeds growth of the maxilla

In young age, sinus growth by pneumotization is proportional to the growth of the maxilla. However with the advance of age pneumatization exceeds maxillary growth .thus the anturm will expand at the expense of the maxillary process (Evteev and Grosheva, 2019).

At birth, the maxillary sinus measures <7.0 mm in anteroposterior depth, <4.0 mm in height, and <2.7 mm in width. The height of sinus development depends on several factors: pressure from the eyeball against the orbit wall, the traction on the inferior portion of the maxilla by the facial muscles, and the eruption of permanent detention.

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2- 1-3 Function of the maxillary sinus;

The function of maxillary sinus is lightening the weight of the skull, resonance of voice olfactory and respiratory modulation through regulation of the air pressure within the sinus during respiration and inspired air condition. In addition it gives Crainofacial protection against mechanical trauma. Also it produces of the bacterial enzyme (lysozyme) which may be significant in protection against bacterial infection of the nasal mucosa (Chamanza and Wright, 2015).

2- 1-4 Anatomical variation of maxillary:

The maxillary sinus can exhibit anatomic variations such as Maxillary sinus pneumatization, Maxillary sinus hypoplasia, Maxillary sinus septa and Accessory maxillary sinuses ostia(Rysz and Bakon, 2009)

The nasal 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 20 years old (Sobiesk and Munakomi, 2020).

In all, there are eight sinuses they are divided into two groups; the anterior and posterior groups (figure2-1) 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 (Ogle et al., 2012).

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. Although in a minority of patients some of the sinuses do not fully form. These hypoplastic (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 (Chamanza and Wright, 2015).

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) (Chamanza et al., 2016).

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 micro hairs, or blockage of the natural sinus openings may lead to symptoms of sinusitis. The micro hairs move at a frequency of 10 strokes per second in a coordinated fashion.

The action of these micro hairs 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% (Chamanza et al., 2016).

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 (Konstantinidis et al., 2010).

2.1.5 Blood supply of maxillary sinus:

Vascular supply to the maxillary sinus is derived primarily from branches of the maxillary artery: the posterior superior alveolar artery, the infraorbital artery, and the posterior lateral nasal artery. The posterior superior alveolar artery can course along the medial wall of the sinus. The infraorbital artery passes along the infraorbital groove and canal, under the orbit, and finally through the infraorbital foramen on the facial surface of the maxilla. The Posterior superior alveolar artery and the infraorbital artery anastomose along the anterolateral wall of the sinus, supplying the mucous membrane of the nasal chambers. An extraosseous anastomosis often exists between these two arteries. The posterior lateral nasal artery branches from the sphenopalatine artery and passes through the sphenopalatine foramen to enter the nasal cavity and can be found within the medial wall of the sinus. As it continues anteriorly, the posterior lateral nasal artery begins to branch, supplying blood to the posterior and medial wall of the sinus (Iwanaga J , Wilson ,Lachkar,2019).

2.1.6 Innervation of maxillary sinus:

The maxillary sinus receives general sensation innervation from the infraorbital and anterior, middle, and posterior superior alveolar branches of the maxillary nerve. Most sensory innervation is provided by the posterior superior alveolar branch, which usually has two to three branches. The anterior superior alveolar branch innervates the anterior portion of the maxillary sinus, whereas the middle superior alveolar branch contributes secondary mucosal innervation. The ostium of the maxilla is innervated by the greater palatine nerve while the infundibulum is innervated by the anterior ethmoidal branch of the ophthalmic nerve . Parasympathetic secretomotor fibers originate from the nervus intermedius of the facial nerve, synapsing in the pterygopalatine ganglion and proceeding to the sinus mucosa via the trigeminal sensory branches (Iwanaga J , Wilson ,Lachkar,2019).

2.1.7 Histology of the maxillary sinus:

Histology The most anterior portion of the nasal cavity, or nasal vestibule, is an inward extension of the skin of the external nose. It is lined by keratinized squamous epithelium with associated dermal adnexa, including hair follicles, sebaceous glands, and sweat glands. This inward cutaneous extension averages 1 to 2 cm in depth, at which point there is a gradual loss of adnexal structures and replacement of the keratinized squamous epithelium by schneiderian epithelium (19), denoted with this eponym primarily to emphasize its ectodermal origin, as distinct from the endodermal origin of the mucosa lining the pharynx and larynx. The schneiderian epithelium lines the nasal cavity and paranasal sinuses. With the exception of olfactory mucosa, schneiderian epithelium lacks any histologic distinction from the linings of the pharynx and larynx. It is primarily composed of a mixture of nonkeratinizing squamous cells, ciliated respiratory cells, scattered mucus-containing goblet cells, and “intermediate” cells. The mucosa varies in thickness from

The maxillary sinus is lined with a mucous membrane of the respiratory type however it is somewhat thinner than that lining the nasal cavity. The antral mucous membrane is formed of an epithelial layer resting on a basement membrane and a subepithelial connective tissue layer (Chamanza et al., 2016).

2.1.7.1 The epithelial layer:

The epithelial layer of the maxillary sinus lining is thinner than that of the nasal cavity composed predominantly of pseudostratified columnar ciliated cells derived from the olfactory epithelium of the middle nasal meatus, in addition to columnar non ciliated cells, basal cells and mucous producing and secreting goblet cells(Chamanza and Wright, 2015).

The pseudostratified columnar ciliated epithelial cells have nucleus and electronlucent cytoplasm containing numerous mitochondria, enzyme containing organelles and basal bodies. The later serve to attach the ciliary microtubules to the apical cell membrane. Structurally the cilia are composed of 9 + 1 pairs of microtubules which provide the mucociliary motile function to the sinus epithelium, which moves the debris, microorganisms, and the mucous film lining the epithelial surface of the sinus into the nasal cavity through the ostium maxillary The cilia beat automatically; they are not under nervous control(Weeden and Degner, 2016).

The goblet cell is a unicellular gland; it is mucous synthetizing and secreating cells. It resembles an inverted wine glass with a short stack like basal end containing the nucleus and a swollen apical end containing mucin. It is an apocrine gland, i.e. it pours its secretion through rupture of its apical cell membrane that gets regenerated. So it has all the criteria of the synthesizing and secreting cells(Bui et al., 2015).

2.1.7.2. The subepithelial connective tissue layer (lamina propria):

The lamina propria of the maxillary sinus lining is much thinner than that of the nasal mucosa. It is formed of connective tissue cells, and intercellular substance of collagen bundles and few elastic fibers. It is moderately vascular. The lamina propria contains subepithelialantral glands composed of mixed glands formed of serous and mucous acini or seromucousacini as well as myoepithelial cells. The antral glands are more concentrated in the lamina propria located around the ostiummaxillare. The mixed secretory products of the antral glands reach the sinus cavity through their excretory duct (Rossie, 2005).

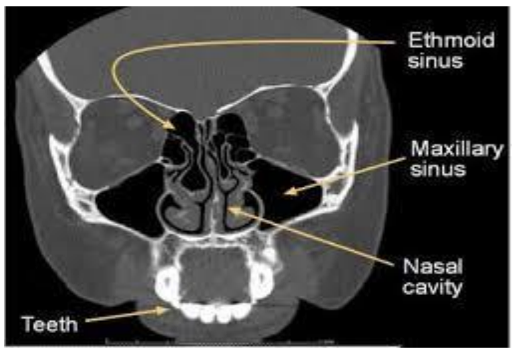

Figure 2.1 coronal CT image illustrate paranasal sinuses (Snell, 2000)

2.1.8Nasal cavities:

The anterior part of the nasal cavity opens interiorly in the nostril while the nose communicates posterior with the rhino pharynx. Usually, authors divide the nasal cavity into three parts: the nasal vestibule, the olfactory region and the respiratory region. The junction of the vestibule with the nasal cavity is called the internal nasal valve. It is situated between the caudal end of the upper alar cartilage laterally, and the septum medially. Its apical angle has angulations of less than 15'.It is the narrowest site of the nasal cavity, only 0.3 cm2 on each side(Rossie, 2005).

2.1.9 Nasal septum:

The septum divides the nasal cavity into two halves. Depending on the expansion of the perpendicular plate and the vomer, i.e. the bony parts of the septum, the cartilaginous septum reach adult dimensions at the age of **2** years. The bony part of the septum consists of the perpendicular plate of the ethmoidal bone and the vomer while the cartilaginous part is formed by the quadrilateral cartilage. The anterior part defines the columella and the postero-superior angle has contact with the sphenoid bone. The nasal septum lays in the crista nasalis of the bony palate (Xie et al., 2001).

2.1.10 Turbinate:

The lateral nasal wall supports the three turbinate (inferior, middle, superior and sometimes there is even a supreme) that divide this lateral wall into three meats (inferior, middle, superior). Before 9 weeks of gestation, three soft tissue elevations (the pre turbinate) can be identified within the nasal cavity; they are orientated both in size and position in a similar way to the inferior, middle and superior turbinate in the adult. The turbinates contain cartilage at 9 weeks of gestation. The inferior turbinate ossification appears to proceed that of the middle turbinate (17 week‘s **vs**19weeks of gestation)**.** The head of the inferior turbinate interferes directly with the entering airflow and its tail, in case of hypertrophy, can significantly reduce the choanalsize. The middle turbinate covers the ostium of the major sinuses medially, while the supreme turbinate is not always present(Sobiesk and Munakomi, 2020).

Figure 2-1 Coronal CT Image illustrate turbinate and nasal septum (David Sutton, 2002)

2.2Imaging techniques of paranasal sinuses:

2.2.1 Conventional X-rays:

The conventional imaging techniques have included Water's (occipitomental view), Caldwell (occipitofrontal view), lateral (cephalometric), basal and oblique and submentovertex radiographies for the sinuses. Sinus X-rays are still frequently used in the evaluation of paranasal sinuses. The conventional diagnostic tools of two-dimensional X-rays have shown various advantages such as low amount of radiation doses, simple and quick, noninvasive and low-cost advantages. According to recent studies, a low-dose high-resolution three-dimensional scans might be given more accurate diagnostic data for certain conditions such as surgical intervention, anatomic variations and nasal and osteomeatal unit evaluation. However, appearance of new digital two-dimensional systems with numerous features of image enhancement, in addition to the mentioned advantages, might represent digital two-dimensional radiography as a simple and acceptable modality in this field (Ebrahimnejad et al., 2016).

The Water's view is also known as the occipitomental view, where the X-ray beam is angled at 37° to the canthomeatal line. The radiographic plate is placed positioning towards the face and perpendicular to the midsagittal plane. It is commonly used to view of maxillary sinuses.

Lateral X-ray images show the osteogenic border of maxillary, sphenoid and frontal sinuses. It specially is used to survey the skull and facial bones for evidence of disease, trauma and developmental anomalies in orthodontics. Lateral cephalograms is also used for assessing facial growth.

Caldwell's view projects the osteogenic border of frontal sinus well. It has also included excellent capability in illustrating pacified frontal sinuses and ethmoidal air cells as well as nasal septum deviation (Ebrahimnejad et al., 2016).

Submentovertex view often is used for evaluating fractures and displacement of fractured zygomatic arch. However, this view is contraindicated with the cases suspected for spinal injury. On the other hand, it reveals the position of the condyles, sphenoid sinus, and the lateral wall of maxillary sinuses, which is an obvious advantage of visualizing of paranasal sinuses' air and fluid levels for sphenoid sinus. But, the view could be ineffective to reveal the degree of chronic inflammatory diseases especially for ethmoid sinuses. Yet some findings such as opacification of the sphenoid sinus in mucocele, the radiographic identification is usually possible. Such inconstancies emphasize the need for more detailed tomography (Aygun and Zinreich, 2010).

2.2.2. Computed tomography:

Computed tomography (CT) is currently the modality of choice in the evaluation of paranasal sinuses. A variety of CT scans such as conventional and/or cone beam

CT techniques offer certain advantages and disadvantages even in comparison with other imaging techniques. Therefore, a primary concern to the clinician evaluating the paranasal sinuses should be conceiving an effective methodology (Aygun and Zinreich, 2010). CT imaging of the sinuses has been acquired in the axial, antero-posterior, and coronal planes as well as three-dimensional visual images using contiguous scans. Either two-dimensional or three-dimensional usage of CT scans brings various advantages such as displaying bone and soft tissue anatomy and extent of diseases related with paranasal sinuses and around the paranasal sinuses. In contrast, the conventional X-ray imaging methods, CT scans, can guide clearly visualization of the sinus anatomy, ostiomeatal channels, which is extremely useful in the pre-operative planning and in post-operative follow-up in cases of surgical interventions. Thus, the combination of CT scans with additional imaging methods such as functional endoscopy will bring significant advantage to treat particular cases more effectively, facilitating reduced morbidity and complications(Fatterpekar et al., 2008).

It is well stated that current multi-slice multi-channel CT scanners can acquire slices as thin as 0.5-mm images in any desired plane. In some special conditions, such as lack of availability of multi-channel CT scan, scanning might be routinely finalized with contiguous 3-mm-thick images(Aygun and Zinreich, 2010). Although the diagnostic quality of CT scanning is accepted as sufficient, the radiation dose may be controversial. Therefore, numerous considerable reduction techniques in radiation exposure alternatives have been the most challenging issue for the manufacturer. Recently, cone beam computed tomography (CBCT) was introduced for dental and maxillofacial imaging. CBCT has several advantages over traditional CT, including lower radiation dose, higher image resolution and lower cost of machine. CBCT scans can be as thin as 0.125 mm, compared to 0.5–3 mm for CT(Scarfe et al., 2006).

2.2.3. Cone beam computed tomography:

CBCT was first described in 1980 and was first applied to dentomaxillofacial radiology in 1998. CBCT is accepted as one of the pioneering tool assessing paranasal sinuses by dentists, maxillofacial radiologists and otolaryngologists. The technique has several advantages as mentioned above such as higher resolution and lower radiation doses(Shemesh and Cohenca, 2015).

2-3 Previous studies:

The study conducted by (Prabhat et al., 2016)at Mumbai .The aim of the study to identify of human body or remains after death .The length, width. Height and volume of the maxillary sinuses together with other bones could be used for gender determination with fair degree of accuracy when the whole skeleton is not available.

Another study done by (NahidAbdalla, 2013) in Sudan; the aim of the study to characterize the maxillary sinuses in 49 patient with normal maxillary sinuses The study showed height of the left maxillary sinus (29.1 ± 4.24)mm and the height of the right side (29.04 ± 4.99) also the study was found the left width of maxillary sinus (23.12± 4.54)mm and the right side width (23.01± 4.59).

The study conducted by (Sharma et al., 2014)in Gwalior (India)region on comparison of dimension between males and females, there was equal dimensions in height, width and depth of the maxillary sinuses for males and females but the depth of maxillary sinus different for males.

Another study done by(Teke et al., 2007), the aim of study to determine gender by measuring the size of the maxillary sinuses in computed tomography scans .The study concluded that the computed tomography measurements of maxillary sinuses may be useful to support gender determination in forensic medicine.

The study conducted by (Balaji Babu Bang, 2017) the aim of study to determine the accuracy of gender determination using maxillary sinus with CT. Materials and Methods. CT images were used to measure the mediolateral, superoinferior, and anteroposterior dimensions and the volume of the maxillary sinuses in 100 patients (50 males and 50 females) to determine the gender of an individual for forensic identification, Discriminative analysis was done using the values derived and the -test for independent samples was used to compare these values in males and females Results. The accuracy rate was found to be 84% in males and 92% in females with the mean accuracy of 88%.

Chapter Three

Materials and Methods

3.1 Materials:

3.1.1 Subjects:

The sample consisted of 60 patients (30 men and 30 women) with age range from 20 to 40 years. They were referred to Radiology Department in Al Neleen hospital and Alragi hospital for the purpose of paranasal sinuses imaging. Edentulous patients or patients who had history of trauma, surgery, or pathological lesions in maxillofacial region were not included in this study.

3.1.2 Machine used:

The study was carried out using (Toshiba Aquillion, 64 slices) made by Toshiba medical system corporation in Japan 2007.CT scan of maxillary sinuses has conventionally being performed with continuous 3mm coronal and axial slices. High resolution multiplaner scanners have made reformatted images possibility . These scanners enable imaging in three planes.

3.2 Methods

3.2.1 Study design:

The study was a descriptive, conducted in period from March 2019 to December 2019.

3.2.2 Technique used:

CT head was performed in supine position. Axial paranasal sinus were obtained in parallel projection on to the orbitomeatal line, with a (0.5 mm) slice thickness and a (0.6 mm) reconstruction interval. Reconstruction of the Axial images using slice thickness equal to (3mm), the measurement were performed on coronal and sagittal images. Maxillary sinuses dimensions measurements were taken as follows; Height was measured on axial reconstructed image between the lowest points of the sinus floor to the highest point of the sinus roof .The maximal width was measured on axial reconstructed image between medial walls of sinus to the outermost point of lateral wall of sinus. The maximal AP diameter was measured on coronal reconstructed image between the most anterior points to the most posterior point of the sinus and distance between sinuses was measured on coronal reconstructed image between lateral borders of left sinus to lateral border of right sinus.

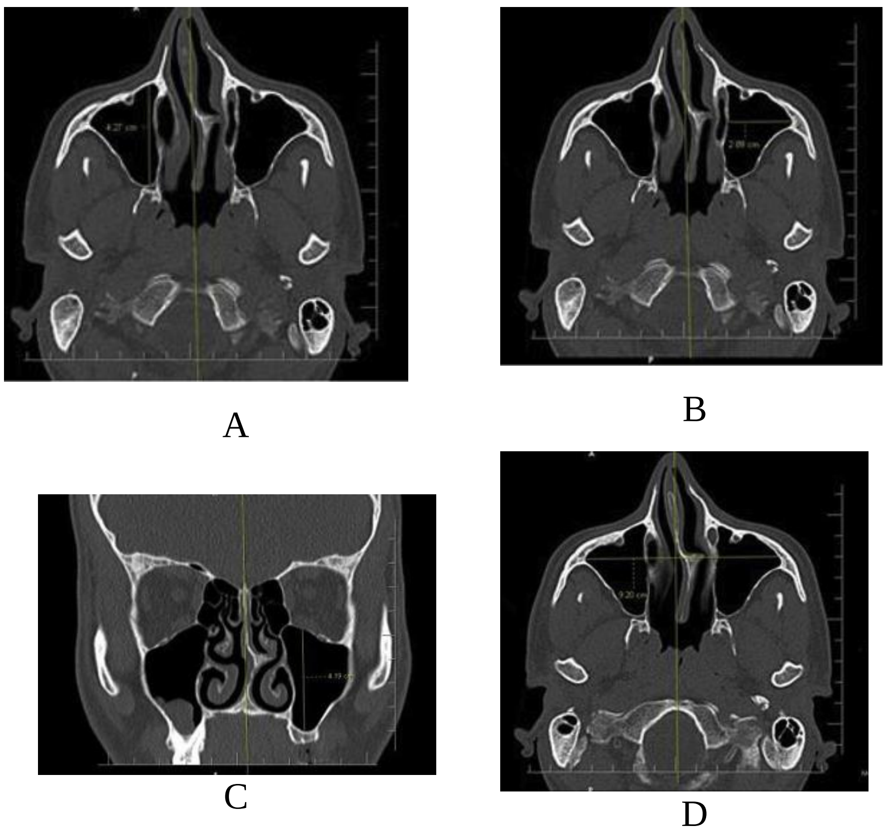

Figure 3-1 Measurements of height, width, AP diameter and distance between maxillary sinuses respectively.

3.2.3 Image interpretation:

CT images were interpreted by one Radiological Technologists and two Radiologists.

3.2.3 Data collection and analysis:

All subjects were examined by multislice CT scanner of adult Sudanese population and data collected on data collecting sheets. Data was analyzed using statistics package for social sciences (SPSS) to identify normal measurement range and frequency distribution for all variables.

Chapter Four

Results

4.1 Results:

Table 4.1: The distribution of group age for all participants

Age Group	Male		Female	
	Frequency	Percentage	Frequency	Percentage
20-25	12	40	6	20
26-30	4	13.4	6	20
31-35	7	23.3	10	33.3
36-40	7	23.3	8	26.7
Total	30	100	30	100

Table 4 -2 Descriptive statistics for measurement of right and left maxillary sinuses indices for all participants

	N	Minimum	Maximum	Mean	Std. Deviation
RT maxillary height	60	2.53	4.70	3.767	0.417
RT maxillary width	60	1.06	4.17	2.749	0.635
RT maxillary AP Diameter	60	2.07	4.83	3.389	0.633
LT maxillary height	60	1.71	4.78	3.683	0.641
LT maxillary width	60	1.05	3.94	2.675	0.578
LT maxillary AP Diameter	60	2.05	4.85	3.343	0.676

Table 4.3 Descriptive statistics of age and distance between maxillary sinuses for both genders

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Age	Male	30	28.67	6.89	1.257
	Female	30	31.77	6.75	1.231
Distance between sinuses	Male	30	3.14	0.43	.07939
	Female	30	3.08	0.34	.06305

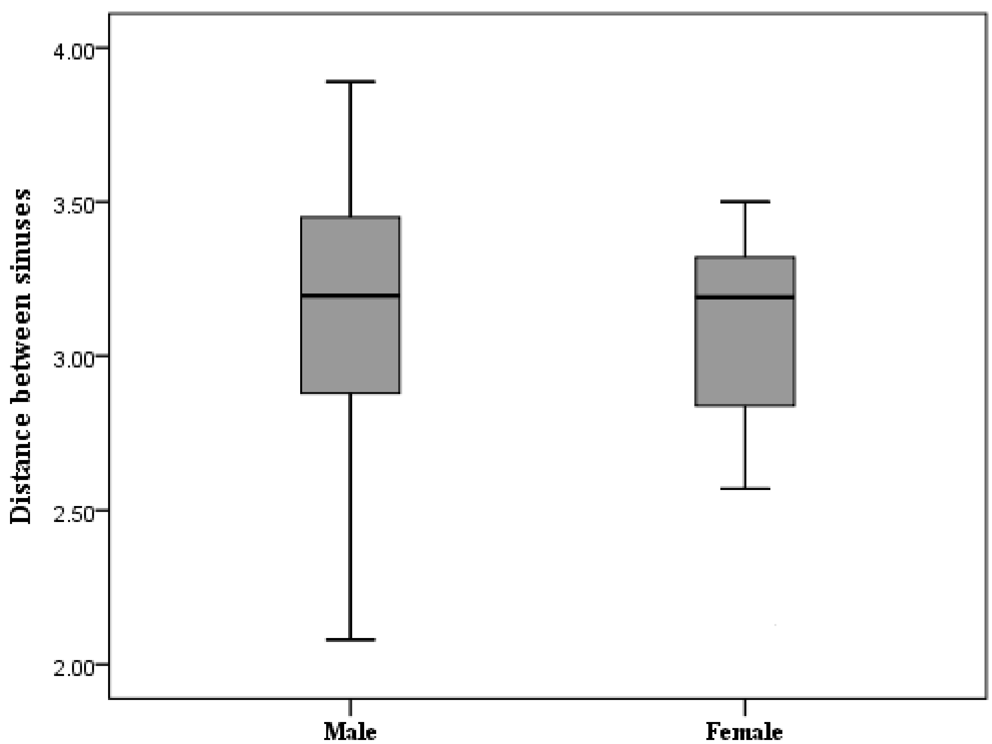

Figure 4-1 Shows comparison between male and female mean of distance between maxillary sinuses

Table 4-4 Comparison between male and female measurement of right maxillary sinuses indices

	Gender	N	Mean	Std. Deviation	*P* value
RT Height	Male	30	3.822	0.419	.107
	Female	30	3.639	0.447	.107
RT width	Male	30	2.796	0.553	.580
	Female	30	2.706	0.697	.580
RT AP Diameter	Male	30	3.562	0.632	.013
	Female	30	3.160	0.578	.013

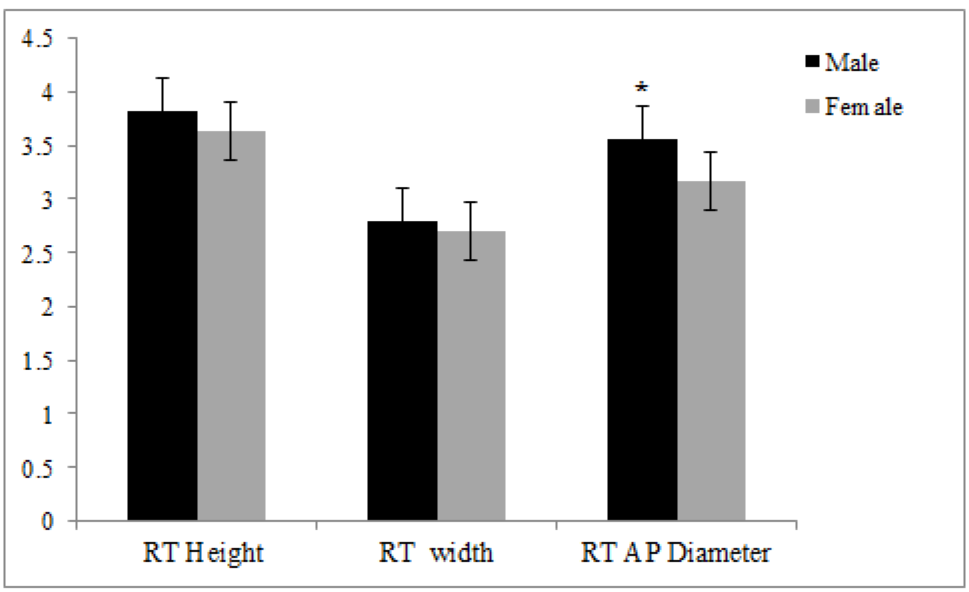

Figure 4-2 Comparison between male and female measurement of right maxillary sinuses indices

Table 4-5 Comparison between male and female measurement of left maxillary sinuses indices

	Gender	N	Mean	Std. Deviation	*P* value
LT height	Male	30	3.778	0.640	0.415
	Female	30	3.651	0.559	0.415
LT width	Male	30	2.761	0.524	0.583
	Female	30	2.683	0.561	0.583
LT AP Diameter	Male	30	3.544	0.662	0.028
	Female	30	3.165	0.637	0.028

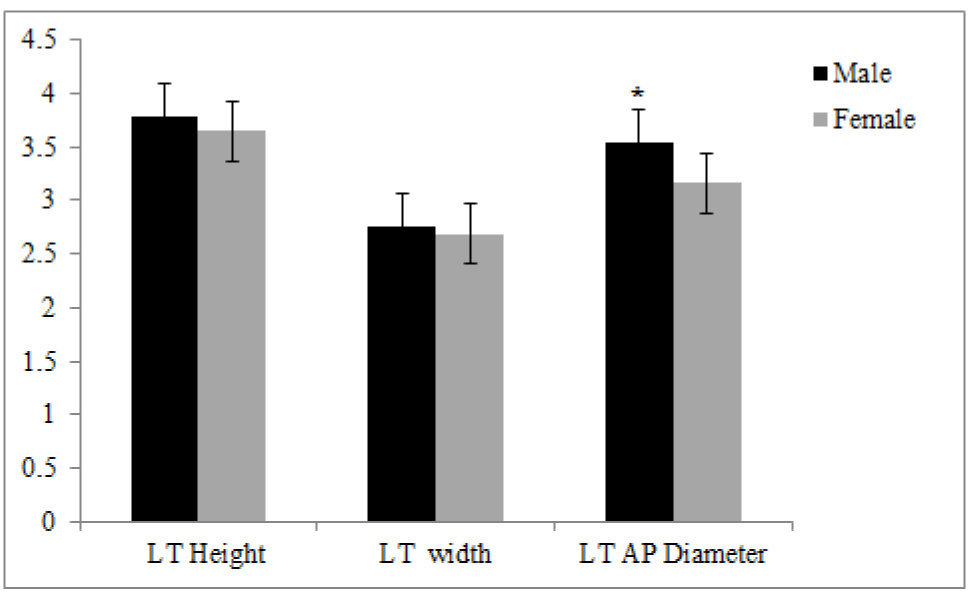

Figure 4-3 Comparison between male and female measurement of left maxillary sinuses indices

Table 4.6 Comparison between right and left sides of maxillary sinuses indices

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	RT Maxillary Height	3.730	60	0.439	0.057
	LT Maxillary Height	3.714	60	0.599	0.077
Pair 2	RT Maxillary Width	2.751	60	0.625	0.081
	LT Maxillary Width	2.722	60	0.539	0.070
Pair 3	RT Maxillary AP Diameter	3.361	60	0.633	0.082
	LT Maxillary AP Diameter	3.354	60	0.672	0.087

Chapter five

Discussion, conclusion and recommendations

5.1 Discussion:

Identification on skeletal and decomposing human remains is one of the most difficult skills in forensic medicine. Sex determination is also an important problem in the identification. When the skeleton exists completely, sex can be determined with 100% accuracy. This estimation rate is 98% in existence of pelvis and cranium, 95% with only pelvis and long bones, and 80–90% with only long bones. However, in explosions, warfare and other mass disasters like aircraft crashes, identification, and sex determination are not an easy task (Badger et al., 1998). Next to the pelvis, the skull is the most easily sexed portion of the skeleton, but the determination of the sex from the skull is not reliable well until after puberty.

The present study aimed to evaluate the anthropometric indices of maxillary sinus for gender determination among adult Sudanese using computed tomography.

The study showed that the mean and standard deviation of Right and Left height, width and maximum A-P diameter of maxillary sinuses for male were(Right: 3.843 ± 0.43 cm, 2.827 ± 0.55 cm, 3.563± 0.62963 cm. Left: 3.808 ± 0.61 cm, 2.734 ± 0.53cm, 3.534 ± 0.67 cm)respectively. The Right and Left height, width and maximum A-P diameter of maxillary sinuses for female were (Right: 3.684 ± 0.39 cm, 2.657 ± 0.695 cm, 3.129 ± 0.561cm, Left: 3.599 ± 0.586 cm, 2.699 ± 0.567 cm, 3.117 ± 0.642 cm) respectively. The distance between maxillary sinuses for male was 3.14 ± 0.43 cm and for female was 3.08 ± 0.34cm.

In general the measurements of men were greater than in women, but the significant difference between men and women only detected in the maximum A-P diameter of the right and left maxillary sinuses in all participants. The study also revealed that there was no significant difference between right and left side measurement. The mean maximum height, width of the right and left sinuses in our population was more than that reported in Turkishpopulation (Teke et al., 2007),more than that in Swedish population (Sahlstrand-Johnson et al., 2011). This could denote the effect of ethnicity on the morphometry of the sinuses or it could be due to different methodologies applied in those studies.

(Akhlaghi et al., 2017) found in their study about gender determination from CT measurements of maxillary sinus that the parameters of height, width, anterior-posterior diameter of sinuses and the maximum distance between the right and left maxillary sinuses are partially valuable for sex determination. In this study only the AP diameter was the parameter that could give gender determination, this result could be compared to (Uthman et al., 2011) study which stated that the best variables for sex determination were the height and anterior-posterior diameter of the left maxillary sinus, these differences might be due to the smallest sample size in this study.

5.2 Conclusion:

This study showed difference in maxillary sinuses measurements between males and females and the maxillary sinuses dimensions in male is bigger than female. The study showed that there was no significant difference between the right and left maxillary sinuses height, width and AP diameter.

The study concluded that regardless of age, the maximum A-P diameter of maxillary sinuses is partially valuable for sex determination among Sudanese.

5.3 Recommendation:

- CT is more valuable tool in the imaging and measurement of maxillary sinus.
- Future studies of the maxillary sinuses measurement could be conducted with different tribe and larger sample size among Sudanese to aid in forensic medicine.

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Appendix

Image 1: Coronal CT view for female (32 years) show AP diameter and distance between right and left sinuses.

Image 2: Axial CT view for male (32 years) show height and width of right and left sinuses.

Image 3: Axial CT view for female (22 years) show height and width of right and left sinuses.

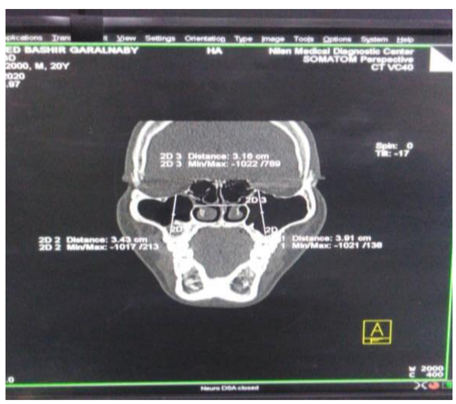

Image 4: Coronal CT view for male (20 years) show AP diameter and distance between right and left sinuses.

Image 5: Coronal CT view for male (20) show AP diameter and distance between right and left sinuses.

Image 6: Axial CT view for female (40 years) show height and width of right and left sinuses.