A Cross Sectional Study on determination of Sex from Plain CT scan imaging of Maxillary sinus dimensions

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Dr. Ravindra S Honnungar M.D.,
Professor and Head
Department of Forensic Medicine
& Toxicology,
J. N. Medical College,
Nehru Nagar Belagavi - 590010

Date: 22/06/2024
Place: Belagavi.

Dr. (Mrs.) N. S. Mahantashetti MD
Principal
J. N. Medical College,
Nehru Nagar Belagavi - 590010

Date: 24/6/24
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Website: http//www.jnmc.edu
E-Mail : dome@jnmc.edu

Phone: (+ 91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref No.MDC/JNMCIEC/ 19 **Date: 27/09/2022**

To,
BF0121001
PG Student in Forensic Medicine & Toxicology,
J. N. Medical College,
BELAGAVI.

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Nehru Nagar, Belagavi- 590 010, Karnataka, INDIA

0831 - 2471350 0831 - 2470759 www.jnmc.edu principal@jnmc.edu

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Chairperson-Antiplagiarism Committee &
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J. N. Medical College, Belagavi.

To,
Reg. No. BF0121001
Postgraduate Student,
2021-22 Batch,
Department of Forensic Medicine,
J. N. Medical College, Belagavi.

LIST OF ABBREVIATIONS USED

Abbreviations	Full forms
MS	Maxillary Sinus
INTERPOL	International Criminal Police Organization
DNA	Deoxyribo-Nucleic acid
CT	Computed Tomography
CBCT	Cone Beam
PCR	Polymerase Chain Reaction
SRY	Sex-determining Region Y protein
MDCT	Multi Detector Computed Tomography
MRI	Magnetic Resonance Imaging
PNS	Para Nasal Sinuses
IEC	Institutional Ethical Committee
SD	Standard Deviation
CNS	Central Nervous System
DICOM	Digital Imaging and Communications in Medicine
Xm	Mean male maxillary sinus dimension
Xf	Mean female maxillary sinus dimension
SPSS	Statistical Package for the Social Sciences
AP	Anteroposterior

ABSTRACT

Introduction:

It can be hard to figure out how to identify someone, but it's often very important in mistakes like car accidents, plane crashes, fires, and criminal investigations. A key part of forensic research is comparing unique features found on a dead body with information that was written about the person while they were alive. This can be achieved by analysing fingerprints, comparing DNA, using anthropological procedures, applying radiological technologies, and utilising other tactics that assist in identifying the age and sex of the subject. One way to find out a person's gender is to use sinus radiography. So, considering various dimensions of the maxillary sinus (MS) to figure out a person's gender using coronal view and the axial view of a plain computed tomography (CT) scan is being looked into.

Objectives:

To determine the sex of an individual from the analysis of Maxillary sinus dimensions.

Materials and Methods:

The research project looked at 106 cases, with an equal number of men and women (53 males and 53 females). All these subjects were taken from the Radiology Department at KLES Dr. Prabhakar Kore Hospital & MRC in Belagavi, Karnataka. Plain CT images were used to measure the diameters of the right and left maxillary sinuses in 106 subjects. Afterwards, a statistical analysis was conducted.

Results:

Statistics indicate significant differences were found in the width, height, and the volume of the MS on either side. These differences were especially high in terms of volume. Width (mediolateral) of MS alone was found to have no statistically significant role in identifying sex.

Conclusion:

The precise diagnostic parameters for diagnosing an individual's sex are the depth, height and volume of the right maxillary sinus.

Keywords:

Computed tomography, forensic identification, maxillary sinus, sexual dimorphism, sex determination.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF GRAPHS

INTRODUCTION

Forensic anthropology is the use of physical anthropological examination to help with the administration of justice in crimes. In the realm of forensic science and technology, identifying people who are living, recently deceased, or whose remains are often located at crime scenes is a primary emphasis of forensic personal identification. This is done utilising a variety of appropriate techniques. In a legal setting, forensic science-based evidence is admissible and is crucial in identifying people who are visually unrecognisable.[1]

The International Criminal Police Organisation (INTERPOL) recognises fingerprint analysis, DNA, and forensic odontology as the three main forms of identification. A personal description of the missing individual, anthropological data, circumstantial evidence, documentation, and medical procedures carried out are examples of secondary ways of identification.[2] Forensic anthropology thus becomes the preferred technique to aid in the identification process when the remains are burned or decomposed, when the DNA is lost, or when there are no prior dental records.[3]

The first step in an anthropological study is determining a person's sex because it is a crucial stage in the post-mortem profile. Age and stature assessment techniques come next.[4] In this way, the analysis of the skeleton and its remains can yield insightful data. There are methods available to determine an individual's sex, and the accuracy of this determination depends on the level of inherent sexual differences in the population and the skeletal remains.[5]

However, it is frequently not possible to recover the full body; only specific body parts can be obtained.[6]

With an accuracy of over 92%, the pelvis and skull are the anatomical regions that exhibit greater sexual dimorphism. This suggests that one necropsy of their anatomical components, which can be supplemented with imaging tests, is preferable.[7] The maxillary sinuses are cavities located within the maxillary bone, surrounded by orbital floor, nasal passage wall, and alveolar ridge, are among these structures. They are also closely related to the posterior teeth roots and the maxillary tuberosity, which is connected to the infratemporal and pterygomaxillary fossa.[8] Furthermore, there are circumstances in which the skull itself has only partially recovered, making it possible that not all of the standard markers needed for sex determination are accessible.[9] Because the maxillary sinus's structure may withstand significant injury to the skull and other bones, it can be helpful to evaluate it in certain circumstances.[10] The maxillary sinuses are two cavities in the maxillary bone that are filled with air. Walls of these structures are slender and reach full development in humans around the age of 20, coinciding with the complete growth of the majority of permanent teeth.[10] The size, shape, and location of these sinuses can vary not only across individuals but also between the same person's two sides.[11]

It performs a variety of tasks, including reducing the weight of the skull, enhancing voice resonance, shielding the face from blows, insulating the teeth and eyes from temperature changes, humidifying the air that is inhaled, and promoting maxillary growth.[12] Since the maxillary sinus reaches full development by the second decade of life, radiographic images can be used to make accurate measurements.[13] According to a number of researchers, conventional radiography are dependable, affordable, and capable of producing 80–100% accuracy. Excellent, sufficient, and precise measures for maxillary sinuses may be obtained from plain CT scan pictures.[14,15]

An excellent imaging technique for assessing the sinuses of skull, the extent of pneumatization of these sinuses, and bones of face is a computed tomography (CT) scan. They provide more detailed information than may be obtained from ordinary radiography. As a result, determining a person's gender will benefit from maxillary sinus CT readings.

There is a dearth of research on the assessment and comparison of maxillary sinus size using CT in relation to gender disparities. The primary goal of this study was to ascertain an individual's gender by analysing different measurements of the maxillary sinus from a Plain CT scan in various planes. The research sought to contemplate the precision of utilising the maxillary sinus for sex identification and explore the potential use of specific measurements, such as height (maximal craniocaudal diameter), width (maximum medio-lateral diameter), depth (anteroposterior diameter), and capacity (volume) of the same, in identifying the sex of a person.

OBJECTIVES

- To determine the sex of an individual from the analysis of Maxillary sinus dimensions.

RIEVEW OF LITERATURE

Identification is the process of assessing a person's uniqueness based on specific physical traits. Identification is a prerequisite:

1. **Live people pertain to:**

Table 1: Role of identification in criminal and civil cases

Criminal case	Civil cases
Individuals accused of assault, homicide, or sexual assault	Matrimony
Hospital mix-up of newborn infants	Identification documents
pretend to be another person	Patrimony
Fleeing military personnel and felons	Claim for insurance
	Untraceable individuals
	Controversial gender

2. **Deceased individuals:**

i. If an accident, fire, or explosion occurs.

ii. When an unidentified corpse is found in a body of water, on a train car, in a field or on a road.

iii. When a body has decomposed.

iv. When a body is disfigured.

v. Skeletons.

<u>Data for identification, both for the live and the deceased, are</u>:[16]

1. Religion & race.

2. Gender

3. Age

4. Dentition

5. Overall growth

6. Measuring anthropometrically

7. Traces left by lips, fingers, and footprints

8. External characteristics, such as a tattoo or scar;

9. Hair;

10. Personal effects, such as attire and pocket money

<u>The following are the only living identification factors</u>:

1. Handwriting

2. Oratory and vocalisation

3. Gait, demeanour, and habit.

4. Recall & schooling

The primary features of identification are age, size, and sex; these qualities remain constant even after death.

Identification of the Sex[16]

It is a term from biology that refers to an individual's genetic, physiological, and anatomical traits, which allow us to categorise people as "males" or "females." Sociological concept that describes how a person identifies in accordance with societal norms (social roles, status, and conduct), depending on the characteristics that individual displays as "masculine" or "feminine." It is a person's sexual identity from birth through adolescence and adulthood. The term "sex verification tests," rather than "tests for gender verification" is the right terminology for determining an individual's biological sex.

In normal cases, in the living:

- In most scenarios, among the living: Possession of the testes in males and ovaries in females is the most reliable indicator of sex.
- The existence of well-developed breasts and vagina in females, and masculine distribution of hair and penis in males, is a strong indication of sexual activity.
- Presumptive sex evidence includes the external look of specific qualities, such as facial shape, clothing, voice, and body.

The following justifies the need for sex determination:

- Identification in the living: Sex has a significant role in determining a person's uniqueness and identification data chain.

- Engaging in sports: Men's prolonged exposure to natural hormones during puberty leads to physiological differences from women, which forms the foundation for gender-based separation in sports.
- To determine an individual's ability to exercise certain civil rights that are only granted to one gender.
- The resolution of issues pertaining to legitimacy, separation, fatherhood, wedding, impotence, sexual assault, and affiliation.

Currently, the 3 common situations where determining an individual's gender has become necessary are:

- Sports
- Pre-employment
- Crimes specific to a particular gender.

Usually, when a person is born, their biological sex is determined by examining their external genitalia (phenotype sex). This involves checking if they have a penile and scrotal region (in males) or pudenda (in females).

Identifying the gender of any person will pose challenges in the following cases:

- Individuals with intersex traits
- Transvestism
- Transgender individuals
- Transsexuals
- Cases where the gender is concealed
- Advanced decomposition and skeletal remains

Identifying the biological sex in cases of hidden gender and cross-dressing can be readily accomplished with a physical examination. However, difficulties arise when dealing with ambiguous genitalia, where the external genitalia display characteristics of both genders.

Tests for verifying an individual's biological sex[16]

1. Physical structure or form.
2. Nuclear sexing, sometimes referred to as sex chromatin or microscopic test, entails the microscopic analysis of epithelium of buccal cavity or hair follicles to identify the existence of a structure known as the 'Barr body'.
3. Gonadal biopsy is a conclusive technique used to determine an individual's sex by detecting the existence of testicles and XY sex chromosomes in men, or ovaries and XX sex chromosomes in women.
4. Polymerase Chain Reaction (PCR) method detects the existence of the SRY gene (sex-determining section of the Y-chromosome) and/or the DYZ1 region of the Y chromosome. The SRY gene exhibits specific expression in a restricted subset of somatic cells during the process of gonadogenesis. The main purpose of this is to control the production of a specific cell membrane component found only in males, called the H-Y antigen. Moreover, it plays a pivotal function in the process of cell differentiation, namely in the transformation of these cells into Sertoli cells.
5. Measuring testosterone levels is also useful for determining an individual's sex. Females should maintain levels below 10 nmol/l.

Usually, a series of these tests is performed to ascertain the gender of the individual. However, issues related to sexual development consistently provide a barrier in the context of sex verification testing.

Skeletal Remains Sex Determination

Sexual dimorphism becomes apparent with the onset of puberty, with the exception of the pelvis. In the pelvis, sexual characteristics are autonomous and can even be contradictory to each other.

The gender from elongated bones can be determined by analysing medullary index obtained in the humerus, radius, ulna & tibia. The sternal bone has a limited utility. The table 2 provided (as reported by Krogman) illustrates the level of accuracy in determining the sex of adult skeletal remains.

Table 2: Precision of determination sex of a human from skeletal remains

Precision of determination sex of a human from skeletal remains	
Corporeal remains	**Precision in determining sex (%)**
Complete skeletal structure	100%
Cranium + Hip bones	98%
Pelvic bone only	95%
Only the Skull bone	92%
Elongated bones	80–85%
Elongated bones + pelvis	98%

Graph 1: Accuracy of sexing from the available skeletal remains

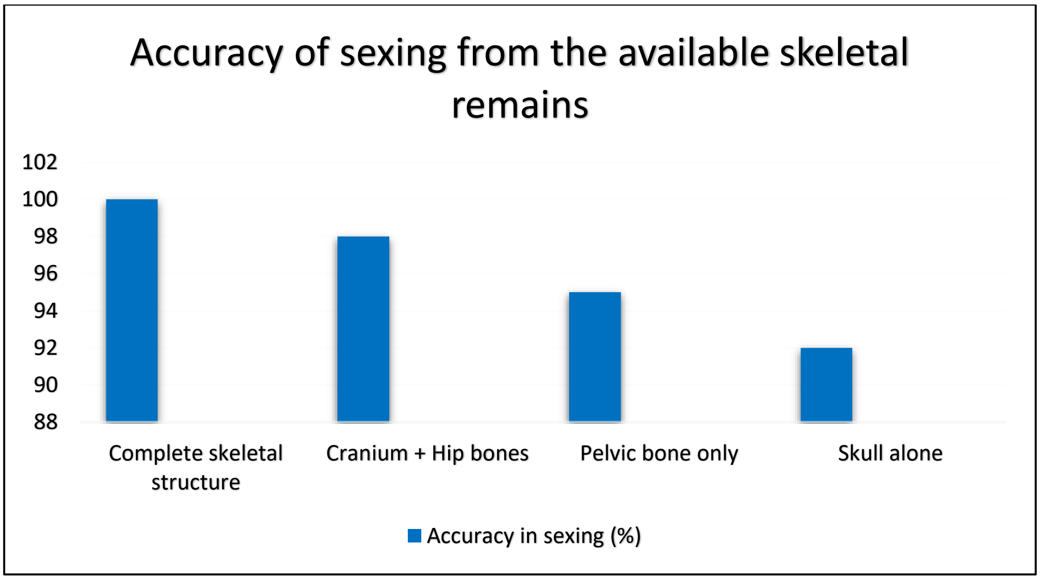


Figure 1: Overview of Distinctive characteristics of the male and female skull

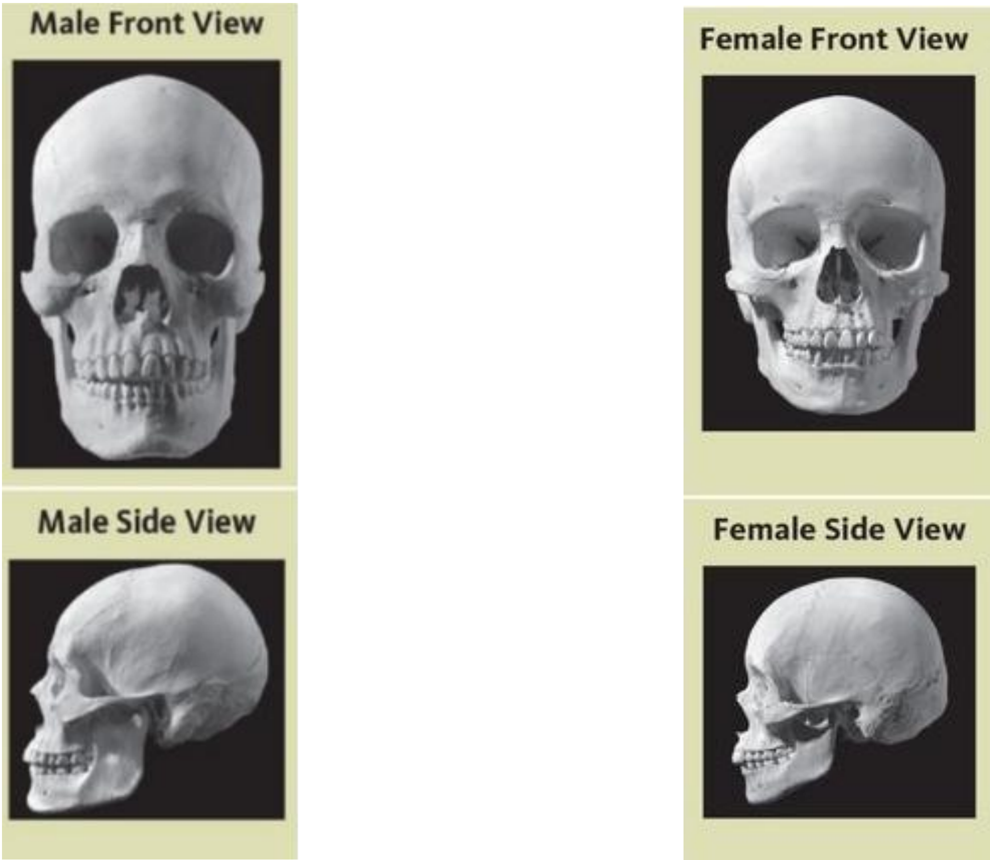


Table 3: Difference between Male and Female skull

Characteristic	Skull of a male	Skull of a female
Overall physical presentation	increased size, weight, durability, and prominent muscular ridges	Reduced in size, weight, wit thinner and smoother walls
Frontal	Retreating, uneven, coarse, less smooth	Perpendicular, round, plump, juvenile, sleek
Capacity of Cranial vault	More spacious	More spacious
Glabella	Notable	Less Notable
Supraorbital ridge	More appreciable	Less appreciable
Frontonasal junction	Clear angular deviation	Gently arched
Orbit of eye	The shape is square with rounded edges and is small in size.	Round shape with distinct, pointed edges and is of considerable size.
Frontal and parietal bone prominence	Less	More
Arch of Zygoma	More appreciable	Less appreciable
Occipital protuberance	Protuberant	Not Protuberant
Mastoid process	Big, round, blunt	Sleek, tapered
Palatal arch	Spacious, "U" shaped, wide	Smaller, parabola shaped
Great occipital foramen	Significantly enormous, extended	Petite, circular

Figure 2: Distinct Landmarks of Female skull

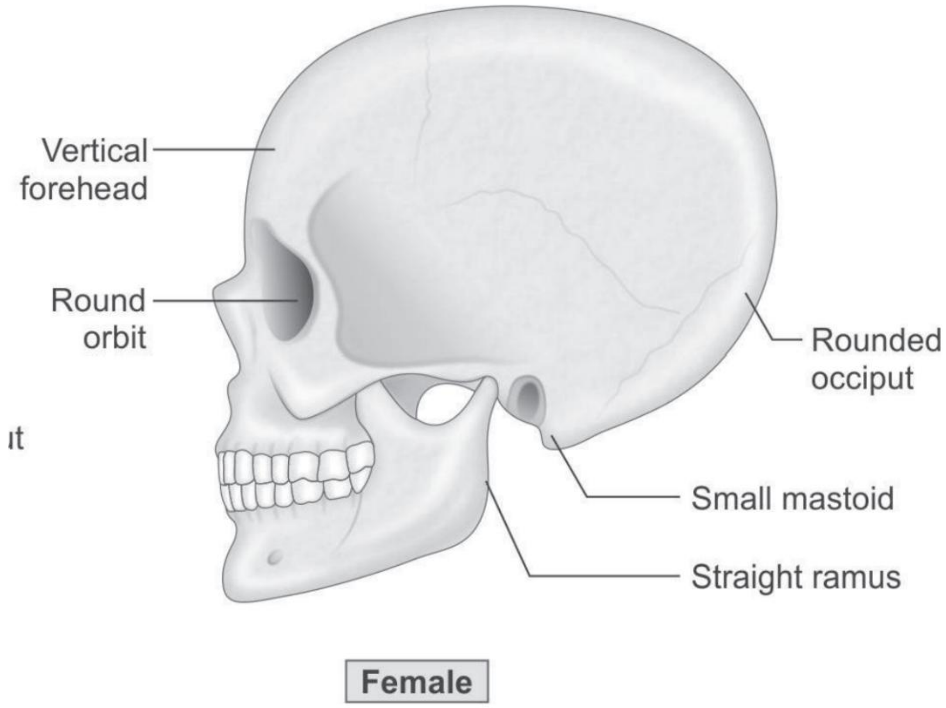
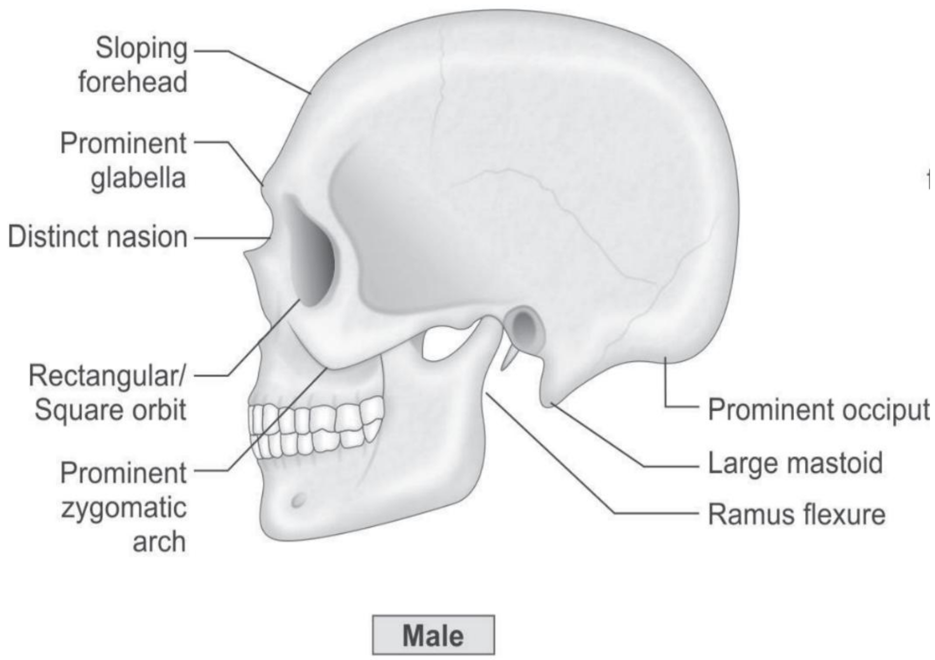


Figure 3: Distinct Landmarks of Male skull



Sex determination plays a key role in forensic identification. The initial step in medico-legal assessment is ascertaining the gender of wounded and mutilated deceased corpses or skeletal remains.[4]

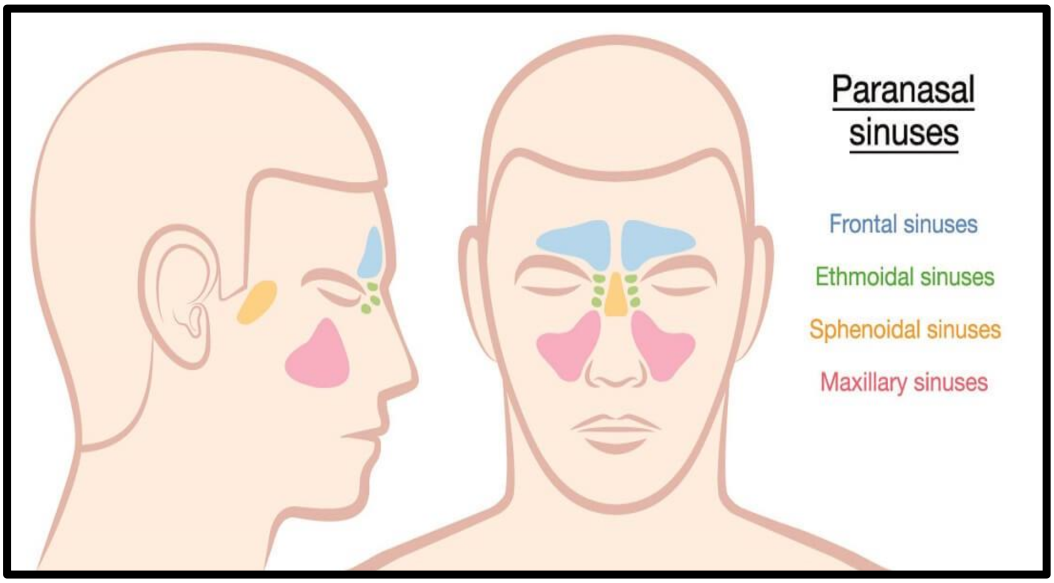
A crucial component of forensic research entails establishing a correlation between unique traits observed on deceased individuals and the data gathered during their lifetime. These objectives can be achieved using diverse methodologies including fingerprint analysis, DNA matching, anthropological procedures, radiological technologies, and other approaches that assist in determining the individual's age and sex.[3]

The Paranasal sinuses:

The primary concept of this study involves utilising plain CT scans to ascertain an individual's sex by examining the paranasal sinus.

The paranasal sinuses (PNS) are in 4 pairs, namely: ethmoid, maxillary, sphenoid, and frontal sinuses. Sinuses are air cavities situated in the Cranium and facial area. The interior of these cavities is lined with mucosa. The nose and paranasal sinuses are integral parts of the respiratory system, together with, serving both functional and vital roles. Sinuses of skull evolves within the bones of the viscerocranium. Maxillary sinus does be 1st to develop among all the four pairs of sinuses.[17]

Figure 4: Anatomical location of various paranasal sinuses in human skull



History of Maxillary Sinuses:

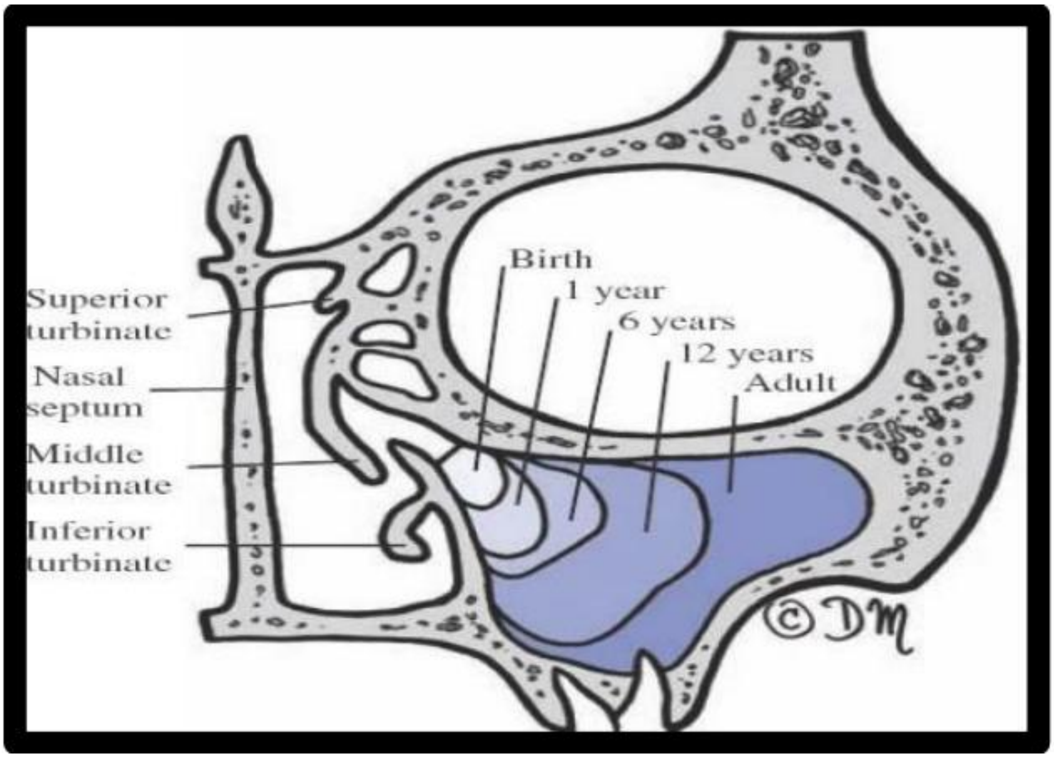
Leonardo da Vinci initially depicted and characterised the maxillary sinuses in 1489, and subsequently Nathaniel Highmore, an English anatomist, documented them in 1651. The alveolar process region of the maxilla bone functions to give dental support and acts as the lower boundary of the sinus.

The maxillary sinus, also known as the biggest paranasal sinus, is the first to form throughout development. Embryonic development begins at 17 weeks in the uterus. At birth, the individual has a simple opening that is filled with air or fluid. This opening is oriented in the longest direction from front to back and has a volume of 60-80 mm^3. It is located below and towards the middle of the eye socket.[18] It is typical for the maxillary sinus to become partially or completely opaque during the early years of life.[17]

Development of Maxillary sinuses:

Development of the maxillary sinuses begins by the week 17 in the womb. Upon delivery, there is a simple opening filled with air or fluid that is oriented in the longest front-to-back direction. It has a volume of 60-80 mm^3 and is located below and towards the middle of the eye socket.[18] It is typical for the maxillary sinus to become partially or completely opaque during the early years of life.[17]

Figure 5: Developmental pattern of maxillary sinus



Development of maxillary sinus is closely linked to the development of the facial bones. Both instances happen sequentially, with the initial phase taking place within the initial 3 years of life: the sinus expands laterally towards the infraorbital canal by the conclusion of this phase.[18,19]

Figure 6: Axial view of CT scan of Head showing the age wise changes in different age groups

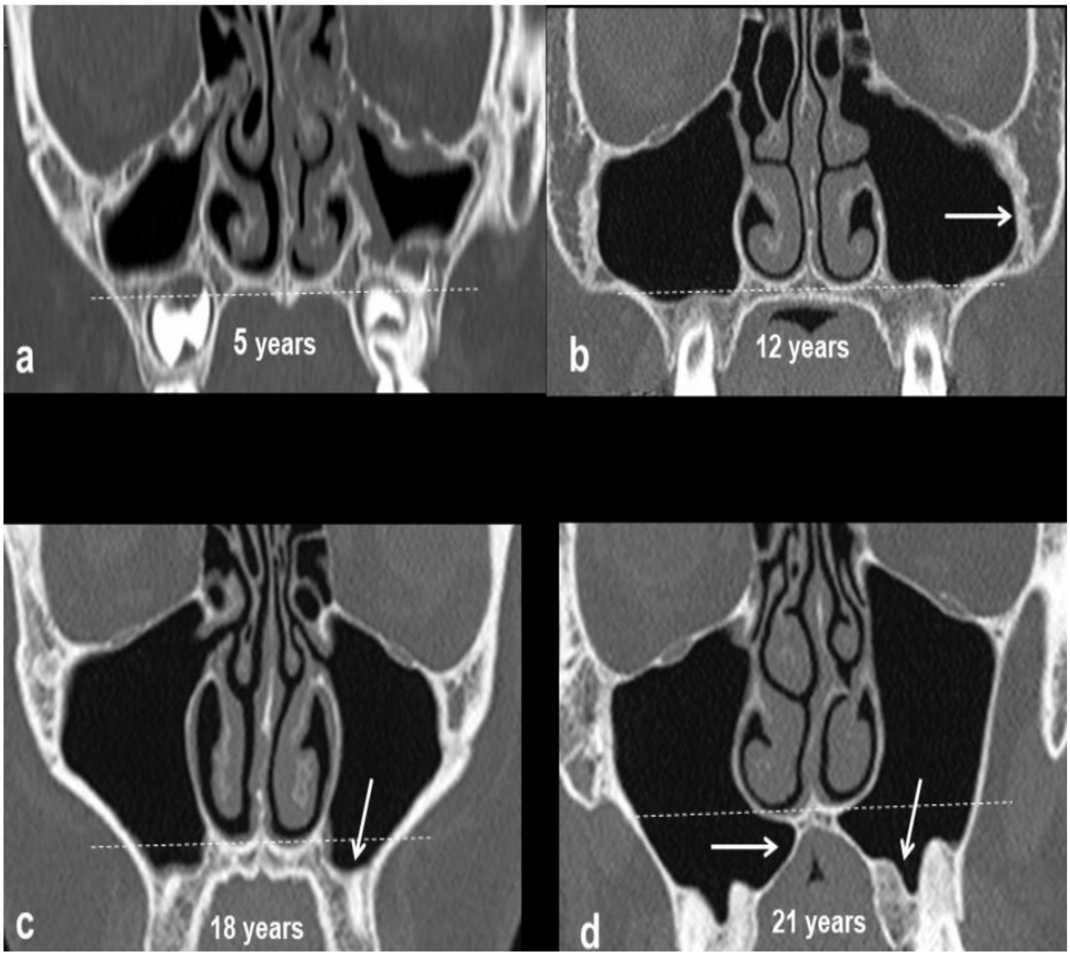


Figure 6 & 7 depicts the development of MS. Up to 12 years of life, the maxillary sinus mostly expands laterally towards the zygoma, resulting in the formation of the zygomatic recess (shown by the whitish arrow in the figure b), and perpendicular to the hard palate. Afterwards, the sinus goes down beneath the level of the nasal floor (shown by whitish arrows in the figure c and d).

During the second phase of growth, which takes place between years 6 and 12, the maxilla extends laterally to the zygomatic recess and inferiorly to the level of the hard palate by the age of 9. The expansion of the sinus during the third phase occurs as a result of the maxillary alveolus becoming filled with air due to the eruption of permanent molar and premolar teeth. This results in a displacement of the sinus floor, positioning it 4-5 mm under the nasal cavity floor.[17,20]

Summary of some contradictory data about the maxillary sinuses:

The progression of growing MS has been assessed continuously the last 2 decades by analysing axial 2D CT scans, conducting titrimetric analysis of 3D images produced by MDCT and utilising MRI. Despite the presence of conflicting evidence, the results can be succinctly described as follows:

1) The height of the MS consistently rises till the age of 18 years. By the age of 12, length (anteroposterior dimension) and the width of the MS have reached the same dimensions as those of an adult.[21]
2) The MS experiences its most rapid growth between the ages of 0 and 4, followed by a more moderate increase in size between the ages of 4 and 8.[18]
3) After the age of 8 years, there is a disparity in the size of MS between genders. In females, the size plateaus, while in males, it gradually increases until 18 years of age.[18]
4) The maturation of the Maxillary sinus progresses till the age of 30 years in men and till the age of 20 in women.[18]
5) In most studies, the average volume of the fully developed MS is generally much higher in males comparatively. However, this distinction is typically not statistically substantiated.[18,21]

6) The average volumes of the MS differ depending on ethnic variations and used to be greater in Korean and Japanese individuals.[18,20]
7) Research has shown that the size of the maxillary sinus remains constant regardless of the existence or nonexistence of premolars or molars. However, it does shrinks as a person ages. It is worth noting that the expansion of the maxillary sinus is not as effective after losing a last lying upper jaw tooth maxillary tooth, especially the 1st permanent molar at the sixth position of each quadrant.[20]
8) The measurements of the fully developed MS show significant variance across multiple investigations, with lengths ranging from 38 to 45 mm, breadths ranging from 25 to 35 mm, and heights ranging from 36 to 45 mm. The average volume of many studies on many MS is 150 mm^3, with a range of 100–250 mm^3.[22]

<u>Role of Identification in mass disaster</u>:

Determining an individual's identification from skeletal remains is complex, and a substantial portion of forensic literature is dedicated to this subject. Human identification is crucial in the context of both natural disasters and accidents.[23] In addition to the humanitarian aspects, identification is crucial for the proper processing and validation of official documents, including death certificates, probates of wills, and disbursements of benefits and insurance.[24] The precision of determining an individual's sex varies based on factors such as age, fragmented conditions, and biological traits.[25] The skeletal structure often endures both natural and manmade processes, allowing for radiography examination in almost all cases. Likewise, radiographs acquired for clinical reasons consistently encompass skeletal characteristics. Thus, it is generally feasible to get antemortem and postmortem radiographs for the purpose of identification.

Role of radiography in mass disaster:

The utilisation of radiography in regular and mass disaster identification has been established for a considerable period of time, and its implementation in necro identification is efficient, rapid, and comparatively straightforward. Comparing radiographs taken before and after death is a widely used practice in forensic facilities worldwide to identify unidentified human remains.[26]

History of use of radiology of maxillary sinuses in mass disaster:

The method of radiological identification was first recorded in 1926 by Culbert and Law.[27] They claimed that by analysing the morphology of sinuses and mastoid air cells in radiographs captured pre- and postmortem, they could irrefutably establish identification. The accuracy of identifications made by the comparison of cranial and postcranial radiographs is universally acknowledged.[28,29] Forensic experts and radiology professionals concur that specific components of the human skeleton can serve as skeletal identifiers for identifying human remains. Furthermore, bones exhibit a uniqueness akin to fingerprints.[30] Approximately 72% of identifications in modern forensic science are accomplished by comparing radiographs captured prior to and after death, as indicated by reports.

While it is possible to use several sections of the body for definite identification, radiographs of the skull, dental, chest, and abdominal areas are the most commonly employed.[31] This is likely due to the fact that the distinctiveness and originality of the characteristics in these regions have been previously examined. Achieving positive radiographic identification involves carefully comparing the details found in the radiographs. Nevertheless, the presence of a minimal number of points of comparison is not necessary to establish identification. Typically, the presence of one to four distinct matching characteristics and the absence of any inconsistencies are seen sufficient evidence for confirming identification.

Radiographic identification is achievable when there is a clue regarding the potential identity of the victim. Usually, this process entails comparing an anthropological profile, which includes characteristics like as gender, age, height, and ethnic background, with records of missing individuals provided by law enforcement or the military. The precise radiographic identification of the deceased is highly dependent on the similarity between the antemortem and postmortem radiographic films. Forensic expert ideally tries to replicate as closely as feasible the antemortem angulation, beam centering, and representation, so positioning and exposure of the radiographs for comparison is crucial. Proposed is computer modelling of antemortem X-ray pictures utilising a CT scanner.[29]

Most frequent bone markers in skull:

The most commonly observed bone markers in cranial roentgenograms are the maxillary and frontal sinuses, which are large anatomical features,[27,30,32] typical differences in body structure and dental repairs, as well as the arrangement of bone tissue.[33] Schuller first observed the distinct variations in size and structure of the frontal and sphenoid sinuses, as well as the mastoid air cells, in 1921. Subsequent studies have since examined their individual characteristics.[34]

Importance of paranasal sinuses in mutilated bodies:

Identification of charred or damaged bodies from events like aeroplane crashes is greatly aided by studying paranasal sinuses. Due to their position in a relatively rigid region of the skull, the sinuses have a greater capacity to endure pressure. Moreover, the sinuses are unique, hence even with identical twins, no two people have the same sinus airway patterns.[35]

Evaluating the various dimensions of MS is an essential and supportive factor in determining sex.[36]

The accuracy of determining sex from bones differs among various ethnic population due to the influence of ethnicity on the structure and morphology of the human skeleton. This results in differences in the specificity and sensitivity of anthropometric indices.[37]

Forensic literature contains numerous studies that focus on different ethnic groups and their paranasal sinuses,[38,39] particularly maxillary sinus. These studies also analyse several anthropometric parameters that are utilised to ascertain the gender of individuals. The majority of these investigations have utilised radiography of the maxillary sinuses, while just a small number have utilised CT scan imaging.[40]

Hacer et al. discovered that utilising maxillary sinus measurements resulted in a specificity of 69.4% in males and 69.2% in females for determining the sex of individuals in Turkey.[10] Yet another inquiry revealed that the precision rate for establishing gender with CT images of sinuses was 71.6%.[41]

Sexual dimorphism is important to determine identify of a deceased person. The reported accuracy rates for sex determination are as follows: the skeleton contributes 100% to the overall identification, with 98% coming from both the pelvis and the skull. When considering simply the pelvic bone or the pelvis along with elongated bones, the contribution is 95% and 98% in precision for the latter. The combination of the skull and the long bones accounts for 90-95% of the identification, while the long bones alone contribute 80-90%.[10]

The cranium is the second most readily distinguishable component of the skeletal structure for establishing the gender, following the pelvis. However, the accuracy of determining sex based on skull is not dependable until adolescence.[42] Nonetheless, the maxillo-facial parts have the benefit of being primarily formed of durable hard texture.[43] Previous research has identified a significant discrepancy with dimensions of the MS among both the genders, with males displaying greater sinus size.[10] In this study, a comparison of characteristics between the males and female groups revealed that the latter Exhibited significantly reduced measurements for the width, height, and depth dimensions of both the right and left sinuses of maxilla.

A research investigation was done to ascertain the gender of persons based on the dimensions of the maxillary sinus. The study comprised 88 participants between the ages of 20 and 49. CT scans were employed to quantify the dimensions of the sinuses, including breadth, depth, height, and the total distance spanning both sinuses. The findings demonstrated that the altitude of the maxillary sinus was the most influential factor in differentiating between genders, the whole precision rating is 71.6%.[41] The present investigation has confirmed that the height of the maxillary sinus is the most dependable factor in determining sex. The correct measurement of the height of the right sinus was determined with an accuracy of 90%, while the accuracy of determining the height of the left sinus was 83.3%. A research investigation was carried out on 33 reconstructed computed tomography of PNS in a group of Korean individuals. The maxillary sinuses were classified into six types based on their outer aspects and the morphology of their floor walls. The sinus measurements, including volume, depth, width, and height were found to be greater in males compared to females, which aligns with our research results.[44]

Fernandes conducted a gender-based differentiation analysis by using measurements of the MS dimensions, nasal cavity width, total sinuses distance, head circumference, head breadth, and skull bizygomatic width. The analysis resulted in an accurate classification of 79.2% of the skulls.[45]

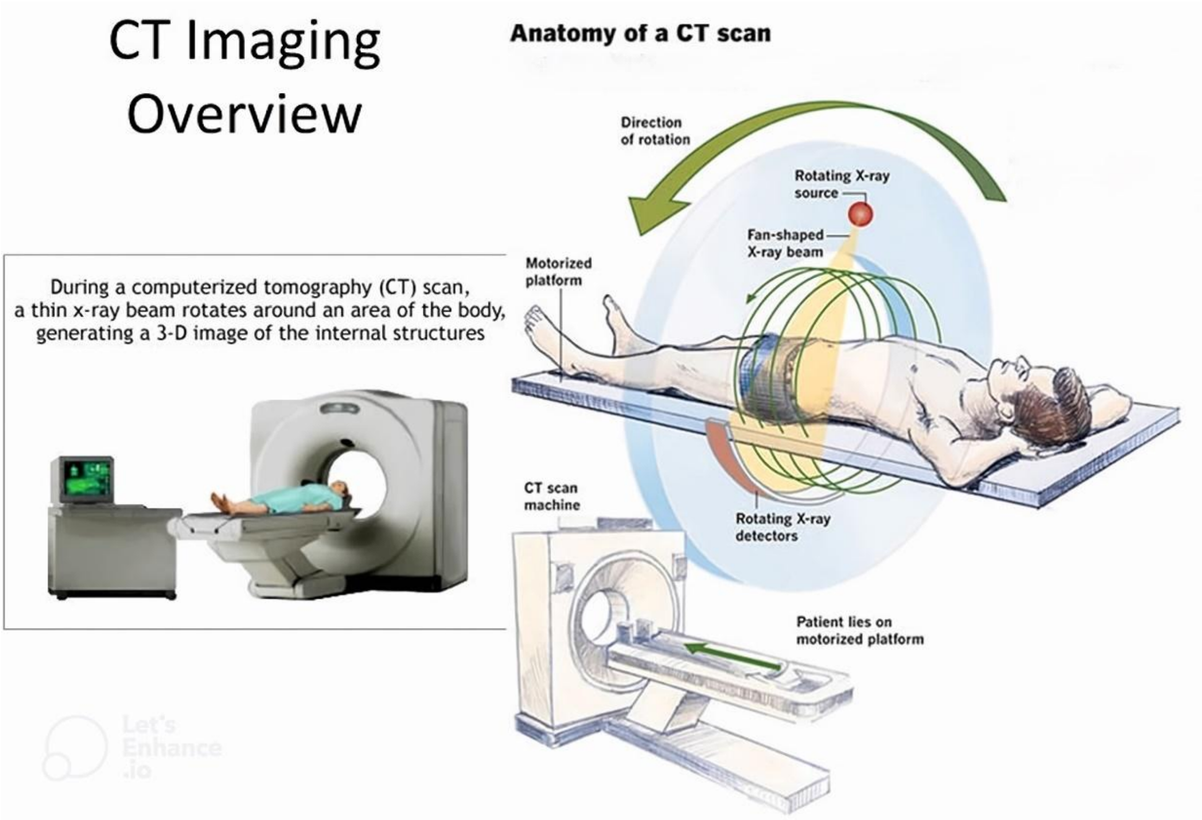
As far as we know, all previous investigations on the sexual differences in the maxillary sinus have utilised CT scan pictures. No research using CBCT imaging have been reported thus far. CBCT scans are increasingly utilised in the dental and medical industry for a variety of purposes, making them more accessible for instances requiring personal identification. Without any magnification, the images provide a 1:1 depiction and are less influenced by metallic artefacts compared to traditional CT scans.[46] This imaging technique has the capacity to function as a tool for ascertaining the gender of individuals in large-scale disasters or in situations where highly putrefied and charred cadavers are present.

Cone Beam CT could therefore provide benefits & function to be an easily accessible substitute for CTs in certain forensic scenarios.[47] Evidence suggests that the maxillary sinuses remain undamaged even in cases where the skull and other bones are severely deformed due to full incineration. As a result, the maxillary sinuses will be valid for purposes of identification. Jovanovic S et al., claimed that the maxillary sinuses reach their maximum diameters at the age of 20 years.[48]

Factors affecting the change in shape of maxillary sinus:

During the adult stage, their physical forms and dimensions undergo alterations, primarily as a result of tooth loss. Environmental variables, hereditary disorders, or post-infections can influence the size of the maxillary sinus.[49]

Figure 7: Anatomy of a CT scan



Effectiveness of CT scan in evaluating maxillary sinuses:

CT, or computed tomographic imaging, is a highly effective technique for evaluating the maxillary sinus.[50] CT scans, which provide detailed cross-sectional and three-dimensional data, have been utilised in the examination of fossil skulls due to their widespread availability in hospitals.[50–52] The CT scan can be utilised to determine gender by measuring the maxillary sinus when other procedures are ambiguous, although it is not completely devoid of errors.

Gender identification in major catastrophes is 80–90% accurate when using only long bones, 98% when using both the pelvis and the skull, and 95% when using the pelvis and long bones. The most trustworthy structure is the pelvis, which is followed by the skull, which becomes dependable after puberty.[53]

Anatomical indicators, such as differences in size, form, and symmetry, are used in forensic anthropology to collect scientific data. Around the nose are paired air-filled chambers called the nasal sinuses, which include the maxillary, frontal, sphenoid, and ethmoid.[54]

The maxillary and frontal sinuses are excellent instruments for examining gender dimorphism because of their individual variability.[55]

Although CBCT has advantages including quicker imaging, cheaper costs, and less radiation, its application in forensics is constrained by its limited data capacity, restricted vision, poor greyscale distinction, and imprecise Hounsfield unit measurement.[56,57]

Saccucci et al. found maxillary sinuses in CBCT imaging unreliable for determining sex in corpse identification.[58]

30 dry craniums from South India were the subject of a 2013 study by Vidya et al., the researchers found that male skulls had much larger maxillary sinuses than female skulls.

MATERIALS AND METHODS

The current study was carried out with approval from the Institutional Ethics Committee, KAHER's Jawaharlal Nehru Medical College, Belagavi.

STUDY DESIGN:

This cross-sectional study was conducted to ascertain the sex of an individual by examining the Maxillary sinus from Plain CT images of Para Nasal Sinuses reported from different departments for inquiry, to the Department of Radiology, in KLES Dr Prabhakar Kore Hospital & MRC, Belagavi, Karnataka.

STUDY PERIOD:

The study was done for a duration of one year, spanning from August 2022 to August 2023.

STUDY AREA:

The research was conducted in the Department of Radiology, located in KLES Dr Prabhakar Kore Hospital & MRC, Belagavi, Karnataka.

ELIGIBILITY CRITERIA

INCLUSION CRITERIA:

- All Paranasal sinus CT scan images taken of peoples with age group between 20 to 60 years.
- Patients who came for evaluation of
- Headache for Evaluation
- Stroke – Ischemic / Embolic
- Any Head injury cases without Facial Trauma
- CNS Infections
- Hypertensive Emergencies
- Encephalopathy – Hepatic/Uremic
- Otitis media

EXCLUSION CRITERIA:

- Patients investigated with Diseases of Maxillary sinus including,
- Inflammatory conditions
- Cysts
- Polyps
- Neoplasms
- Congenital anomalies
- Trauma and
- Fractures.

SAMPLE SIZE:

$$\text{Sample size (n)} = \frac{(Z_{1-}\alpha/2)^2 \times \sigma^2}{d^2} \times 1.1$$

$(Z_{1-}\alpha/2)$ = Constant value 1.96

σ = Standard deviation of a selected Parameter

d = Expected error 20% of the given standard deviation

Table 4: Model Mean & Standard Deviation of Individual Parameters for sample size calculation[14]

	Mean Values in Male	SD in Males	Mean Values in Female	SD In Female
Height	4	±0.22	3.09	± 0.13
Length	3.76	±0.35	3.12	±0.14
Width	2.63	±0.41	2.23	±0.19
Volume	39.93	±9.16	21.53	±2.69

Considering Standard deviation of Height of Maxillary Sinus in males i.e. 0.22 as "σ" for sample size calculation.

$$n = \frac{(1.96)^2 \times (0.22)^2 \times 1.1}{(20\% \text{ of } 0.22)^2}$$

$$= \frac{3.8416 \times 0.0484 \times 1.1}{0.001936} = 105.6 \quad = 106$$

SAMPLING METHOD:

The study participants were selected using a convenient sampling method from the CT scans of patients who met the eligibility criteria. The participants were chosen from the Department of Radiology at KLES Dr Prabhakar Kore Hospital & MRC, Belagavi. The study was conducted after obtaining clearance from the institutional ethical clearance (IEC), which waived the need for consent from the participants.

STUDY TOOLS:

The samples were obtained by the chief investigator from the CT Scan machine GE Revolution Evo 128 Slice, utilising Software release CHDAS_MERC_64 and Software version REVO_EVO 1.1. The DICOM format was used to export soft copies of CT scans of patients referred for CT-Paranasal Sinuses onto a hard disc. The study involved measuring various dimensions of CT scans of Paranasal sinuses from 106 Patients who satisfied the clearly defined criteria for what is included and excluded. The purpose was to ascertain the sex of the humans based on the maxillary sinus.

DATA COLLECTION PROCEDURE:

The study included CT scans of 106 patients (53 males and 53 females) who recently underwent CT-Paranasal Sinuses at the Department of Radiology, KLES Dr Prabhakar Kore Hospital & MRC in Belagavi, Karnataka. Every patient satisfied the required inclusion and exclusion criteria.

Samples were taken from all patients who met the specified inclusion and exclusion criteria, from a CT Scan machine model GE Revolution Evo 128 Slice, utilising Software release CHDAS_MERC_64 and Software version REVO_EVO 1.1.

Maximal craniocaudal diameter - Height

Maximal medio-lateral diameter - Width

Maximal Anteroposterior diameter - Depth

was measured for both sides of each samples using software.

Figure 8: Coronal view of computed tomography image showing maximum vertical measurement of the maxillary sinus.: (A) Right side, (B) Left side[14]

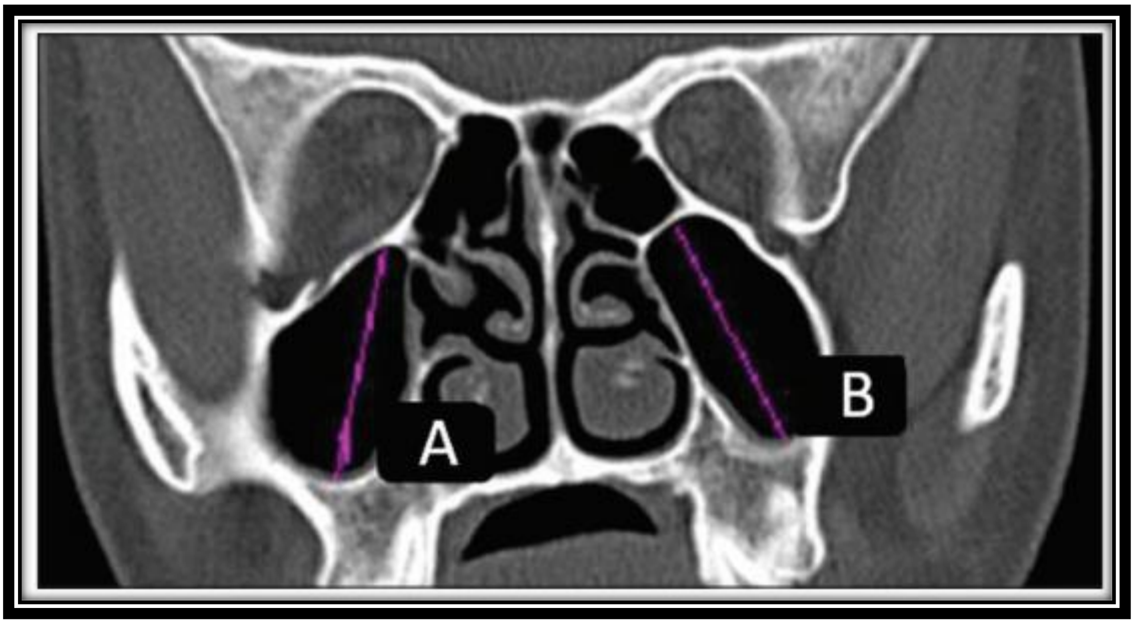


Figure 9: Axial view of computed tomography image showing maximal anteroposterior diameter of maxillary sinus: (C) Right side, (D) Left side[14]

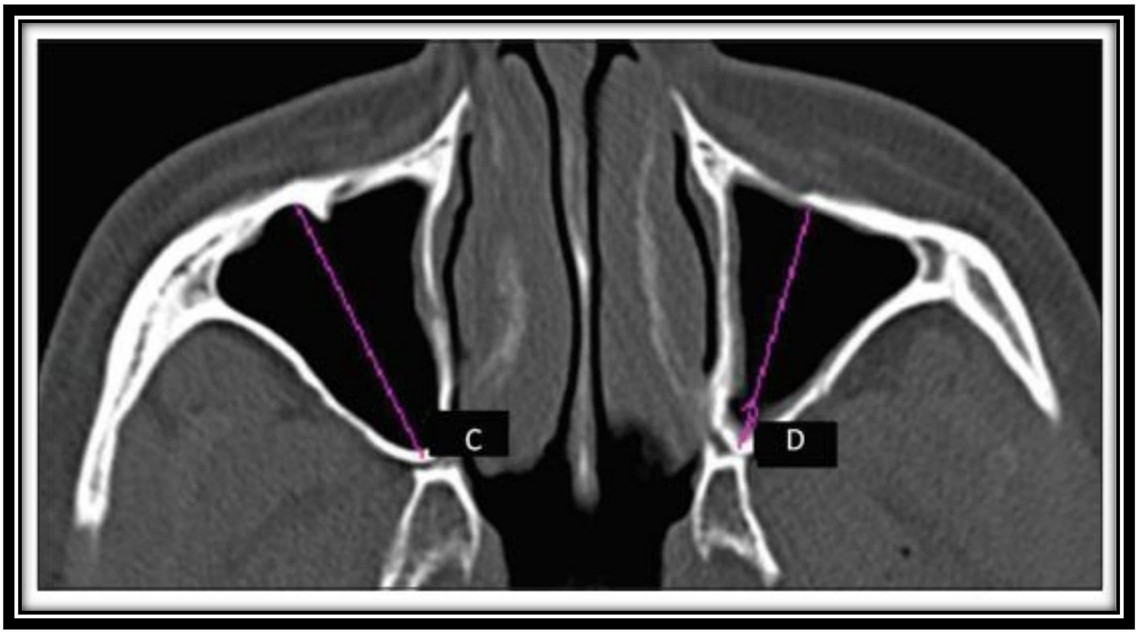
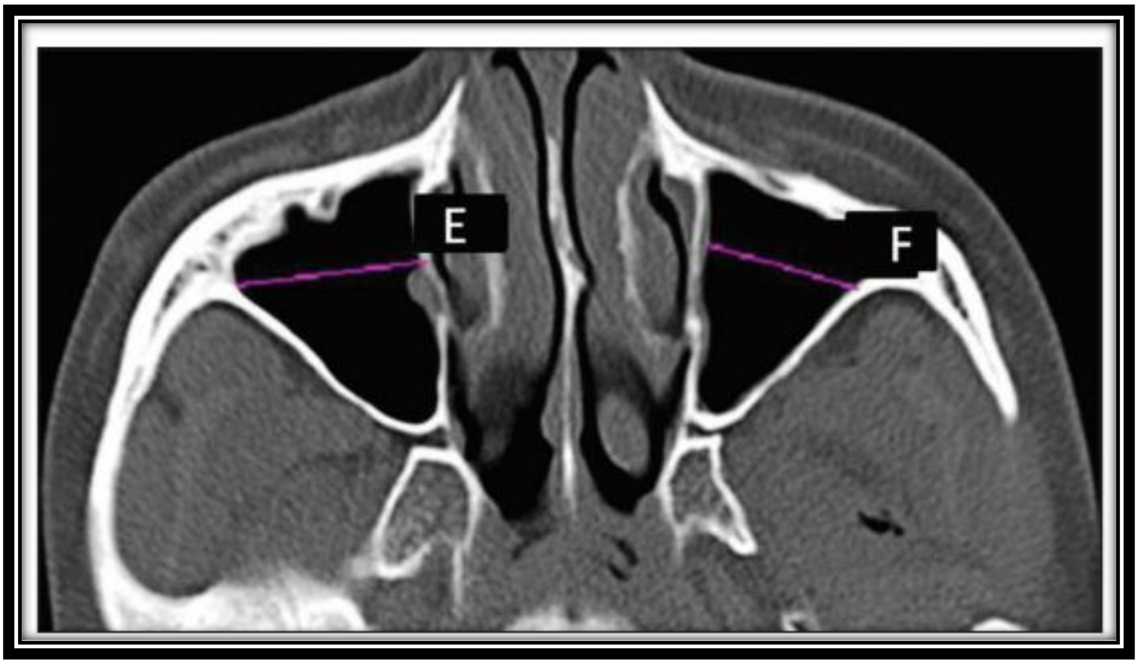


Figure 10: Axial view of computed tomography image showing maximal mediolateral diameter of maxillary sinus: (E) Right side, (F) Left side[14]



Volume of each side is calculated using the formula,

Volume = Height x Width x Depth x 0.5

A bar diagram was created to compare the maximum values of each parameter separately for each side.

A non-parametric statistical test called the Mann-Whitney U test is used to compare two independent groups and assess if their distributions differ significantly. When determining whether one group tends to have larger or lower numbers than the other, it is especially helpful.

Hence the statistical analysis for the male and female individuals were compared using the Mann-Whitney U-test to analyse differences in height, depth, width, and volume of bilateral maxillary sinus. The calculation of the percentage of sexual dimorphism is determined using the following formula.

Sexual dimorphism percentage = $\{(Xm/Xf) - 1\} \times 100$

Xm: Average dimension value of MS in males

Xf: Average dimension value of MS in females

Hence, the objective of the research was to evaluate the reliability and accuracy of measuring the dimensions of the maxillary sinus for the purpose of determining the gender of unidentified individuals.

STATISTICAL ANALYSIS

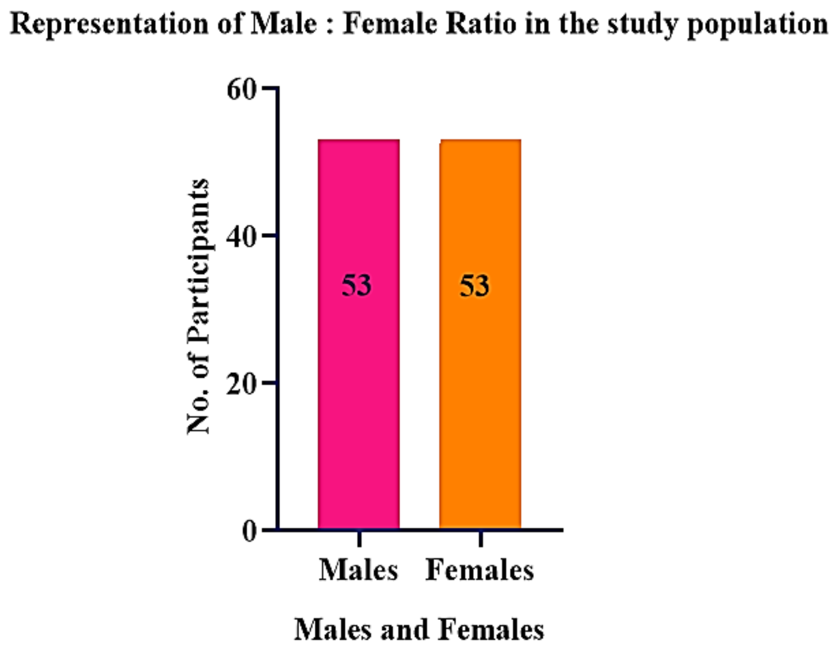
The results were examined using SPSS software version 20 by the following:

- The exploratory data analyses check the distribution of values and present the results as the mean and standard deviation (SD).
- Comparisons between male and female group were performed using Mann–Whitney U-test.
- A significance level of $P < 0.05$ was used to determine statistical significance.

RESULTS

The total sample composed of 106 subjects with 53 males and 53 females respectively. Male individuals exhibited higher values for the majority of the parameters examined in the maxillary sinuses compared to females, across all subjects.

Graph 2: Male: Female participants



Graph 2 represents the number of male (n= 53) and female (n= 53) participants in the current study.

Table 5: Distribution of age groups of male participants in the study

Age	No. of peoples	Percentage
20yr-30yr	16	30%
31yr-40yr	15	28%
41yr-50yr	14	27%
51yr-60yr	8	15%

Graph 3: Distribution of age groups of male participants in the study

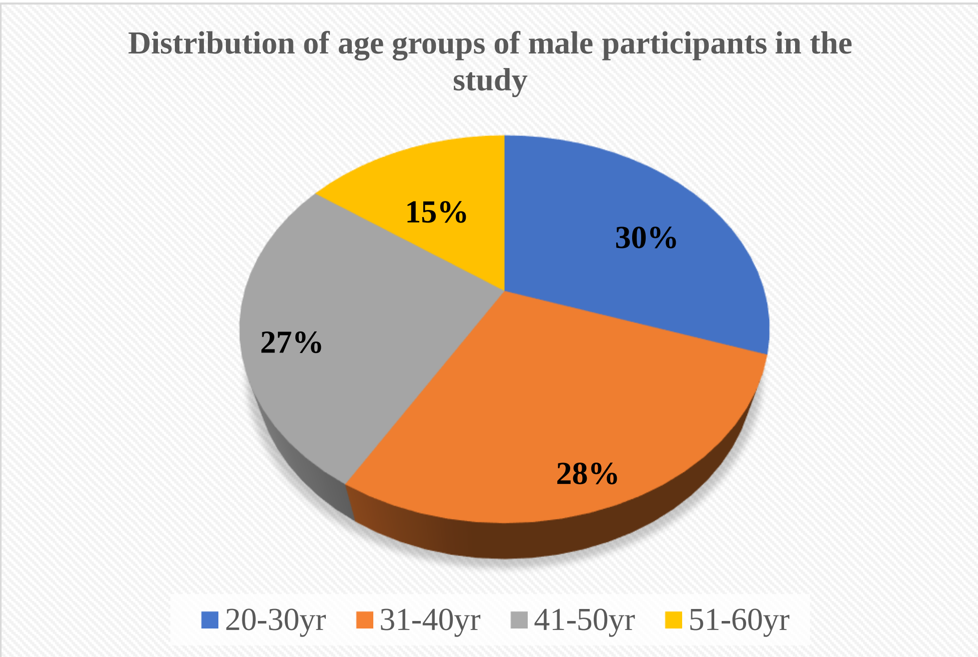


Table 5 and graph 3 represents distribution of age groups of male participants in the study. The majority of the participants fell within a specific age range of 20yr-30yr corresponding to 30% (n= 16) and the age group with fewest participants are in 51yr-60yr corresponding to 15% (n= 8).

Table 6: Distribution of age groups of female participants in the study

Age	No. of peoples	Percentage
20yr-30yr	15	29%
31yr-40yr	14	24%
41yr-50yr	16	31%
51yr-60yr	8	16%

Graph 4: Distribution of age groups of female participants in the study

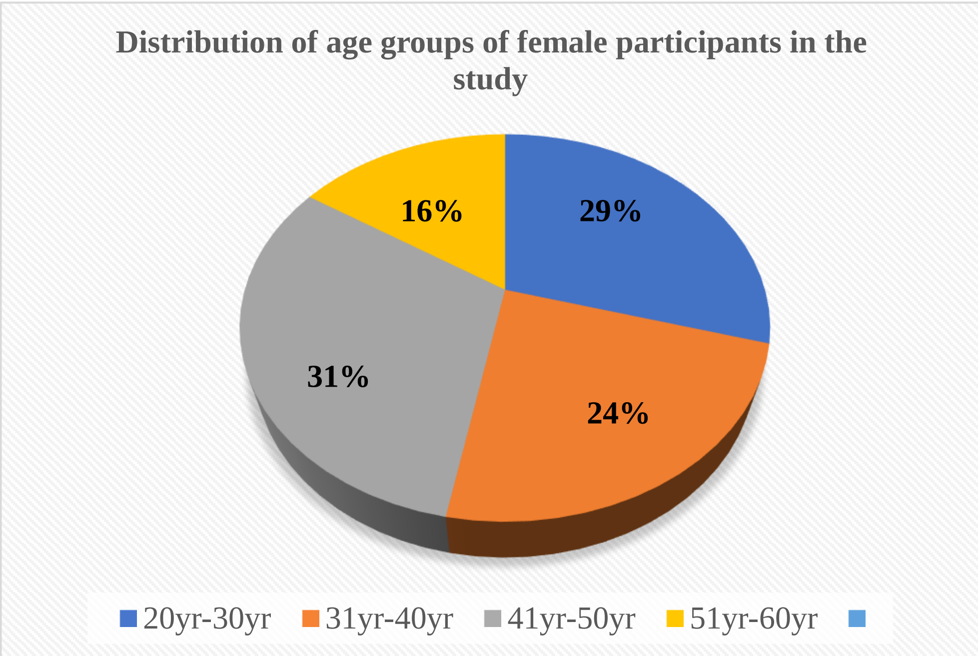


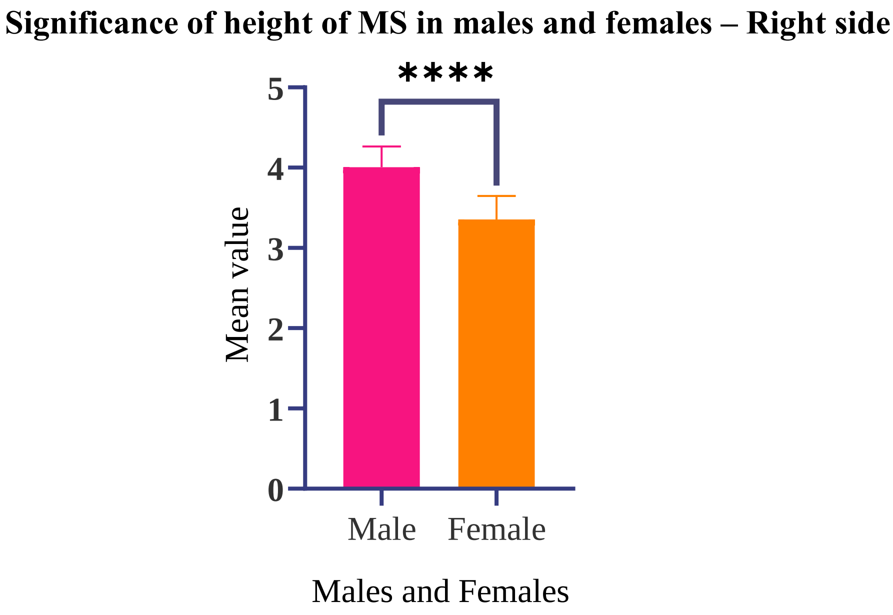
Table 6 and graph 4 represents distribution of age groups of female participants in the study. The majority of the participants fell within a specific age range of 41yr-50yr corresponding to 31% (n= 16) and the age group with fewest participants are in 51yr-60yr corresponding to 16% (n= 8).

TABLE 7. COMPARISON OF RIGHT SIDE CRANIOCAUDAL DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	4.59	3.56	4.01	0.26	<0.0001
	Females	53	3.87	2.78	3.36	0.29	

Table 7 reveals the craniocaudal diameter (height) of right side MS in males (n=53) and females (n=53). The mean & SD in males and females was 4.01 ± 0.26 and 3.36 ± 0.29. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their sexes with p value <0.0001.

Graph 5: Significance of height of MS in males and females – Right side



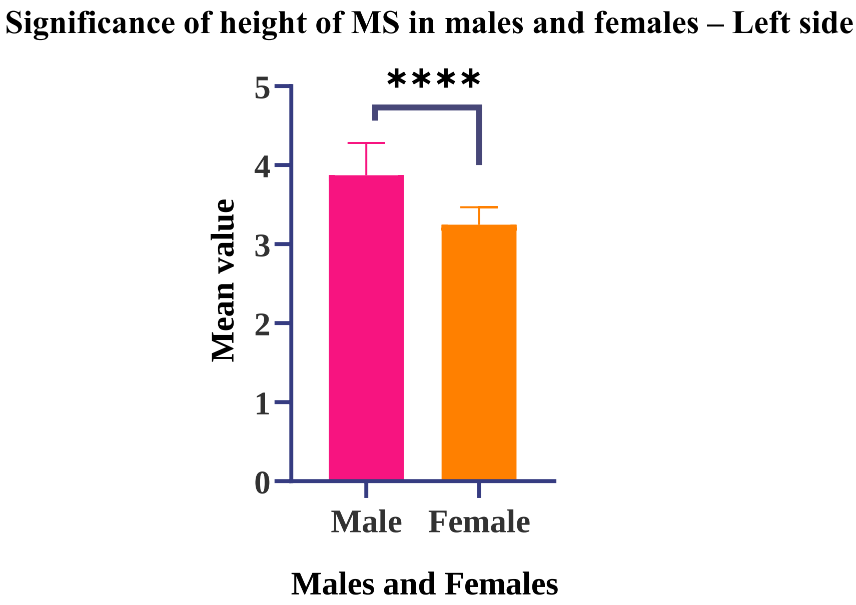
The bars in Graph 5 show the differences in the height of the right maxillary sinus between men and women. The X-axis shows the numbers of men and women, and the Y-axis shows the average height of the right maxillary sinus between men and women. Both bar diagrams are compared and is marked with "****" indicating that the significant statistical difference was observed between both the sexes.

TABLE 8. COMPARISON OF LEFT SIDE CRANIOCAUDAL DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	4.57	3.06	3.87	0.408	<0.0001
	Females	53	3.5	2.53	3.25	0.22	

In Table 8, the left-side MS diameter (height) of the skull is shown for 53 males and 53 girls (n=53). The average and standard deviation for both men and women were 3.87 ± 0.408 and 3.25 ± 0.22. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their ages with p value <0.0001.

Graph 6: Significance of height of MS in males and females – Left side



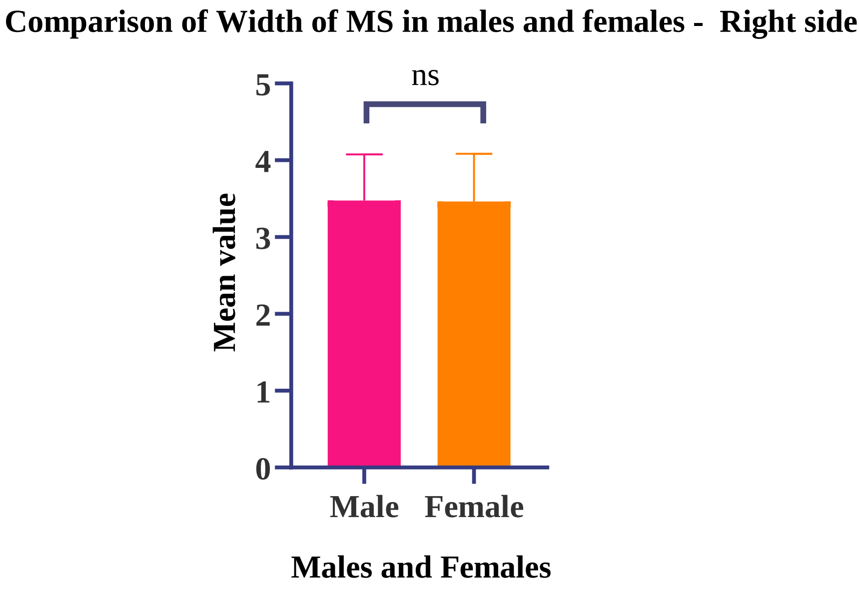
Graph 6 represents the bar diagram of comparison of height of the left side maxillary sinus of males & females with X axis reading the males and females, whereas the Y axis reading the obtained mean values of maxillary sinus height in left side for males and females. Both bar diagrams are compared and is marked with "****" indicating that the significant statistical difference was observed between both the sexes.

TABLE 9. COMPARISON OF RIGHT SIDE MEDIOLATERAL DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Mediolateral diameter	Males	53	4.73	2.5	3.48	1	0.8862
	Females	53	4.63	2.5	3.47	1	

Table 9 reveals the mediolateral diameter (width) of right side MS in males (n=53) and females (n=53). Average and SD in males & females was 3.87 ± 1 and 3.47 ± 1. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded no significant statistical difference between their ages with p value 0.8862.

<u>Graph 7: Comparison of width of MS in males and females – Right side</u>



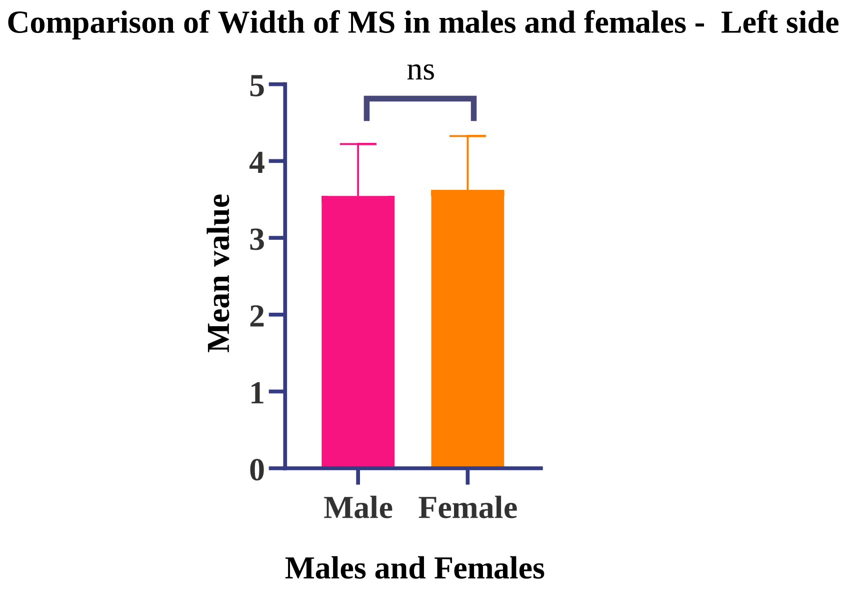
Graph 7 represents the bar diagram of comparison of width of the right MS in males & females with the X axis reading males & females, whereas the Y axis reading the obtained mean values of maxillary sinus width in right side for males and females. Both bar diagrams are compared and is marked with "ns" indicating no significant difference was appreciated between both sexes statistically.

TABLE 10. COMPARISON OF LEFT SIDE MEDIOLATERAL DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Mediolateral diameter	Males	53	4.89	2.58	3.55	0.67	0.5828
	Females	53	4.88	2.55	3.63	0.70	

Table 10 reveals the mediolateral diameter (width) of left MS in males (n=53) and females (n=53). Average and SD in males & females was 3.55 ± 0.67 and 3.63 ± 0.70. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded no significant statistical difference between their ages with p value 0.5828.

<u>Graph 8: Comparison of width of MS in males and females – Left side</u>



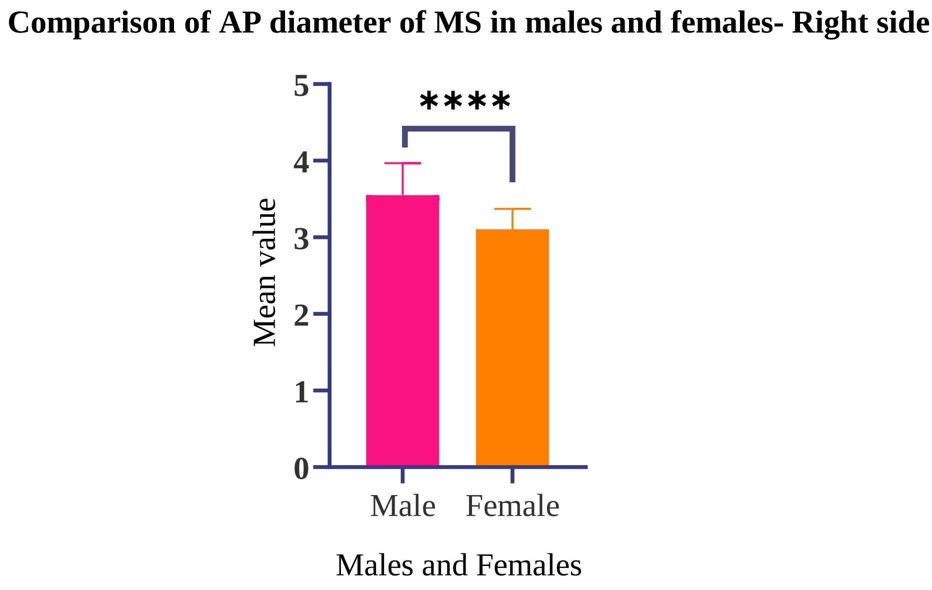
Graph 8 represents the bar diagram of comparison of width of left side MS in males & females with X axis reading the males and females, whereas the Y axis reading obtained average values of width of left side MS in males & females. Both bar diagrams are compared and is marked with "ns" indicating no significant difference was appreciated between both sexes statistically.

TABLE 11. COMPARISON OF RIGHT SIDE ANTERO-POSTERIOR DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	4.19	2.89	3.55	0.42	<0.0001
	Females	53	3.75	2.72	3.11	0.26	

Table 11 reveals the antero-posterior diameter (depth) of right-side MS in males (n=53) and females (n=53). Average and SD in males & females was 3.55 ± 0.42 and 3.11 ± 0.26. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their sexes with p value <0.0001.

<u>Graph 9: Comparison of AP diameter of MS in males and females- Right side</u>



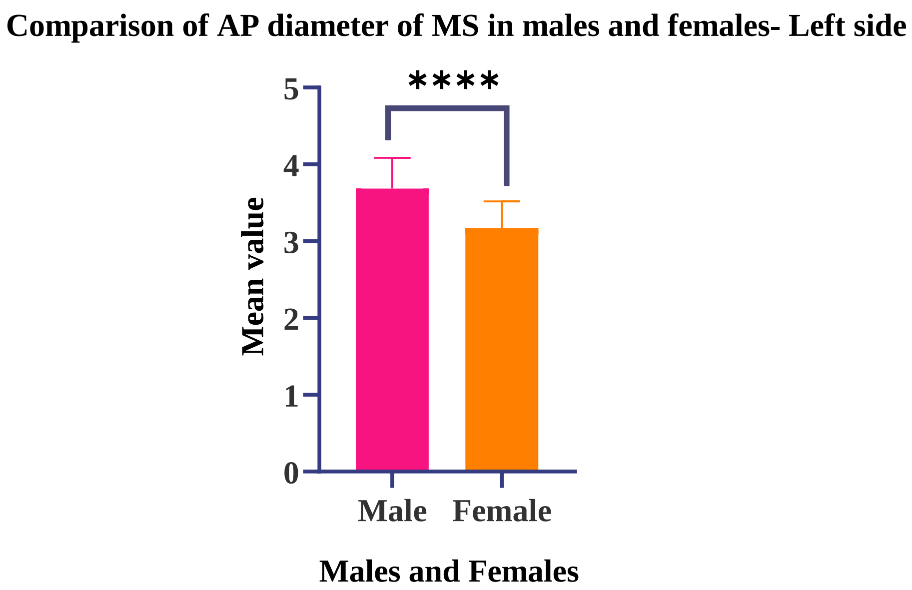
Graph 9 represents the bar diagram of comparison of depth of right side MS in males & females with X axis reading the males & females, whereas the Y axis reading the obtained mean values of the depth of right side maxillary sinus in both men and women. Both bar diagrams are compared and is marked with "****" indicating that the significant statistical difference was present between both sexes

TABLE 12. COMPARISON OF LEFT SIDE ANTERO-POSTERIOR DIAMETER (mm) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	4.32	2.94	3.69	0.4	<0.0001
	Females	53	3.89	2.64	3.17	0.34	

Table 12 reveals the antero-posterior diameter (depth) of left side MS in males (n=53) & females (n=53). Average and SD in males & females was 3.69 ± 0.4 and 3.17 ± 0.34. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their sexes with p value <0.0001.

Graph 10: Comparison of AP diameter of MS in males and females– Left side



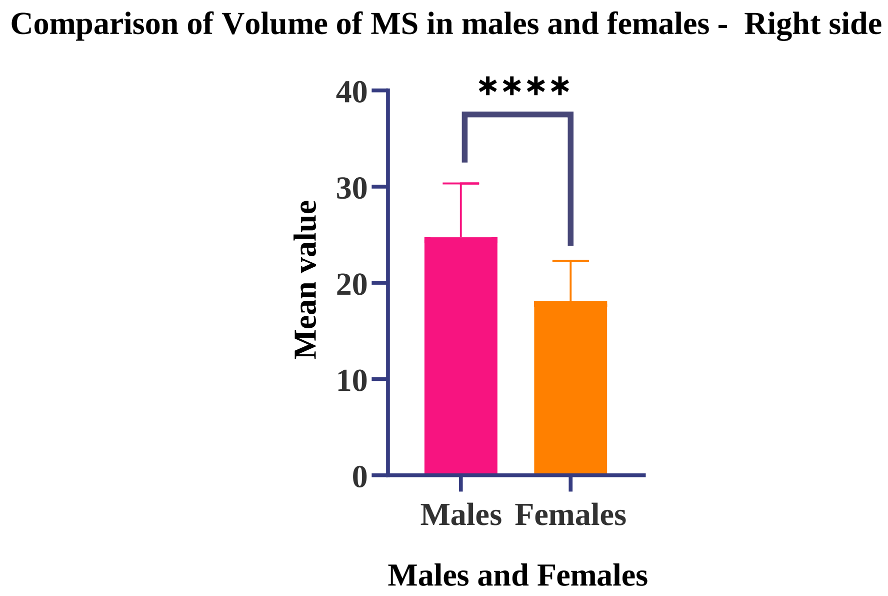
Graph 10 represents the bar diagram of comparison of depth of left side MS in males & females with X axis reading males & females, whereas the Y axis reading the obtained mean values of depth of left MS in males & females. Both bar diagrams are compared and is marked with "****" indicating that the significant statistical difference was seen between both sexes

TABLE 13. COMPARISON OF RIGHT SIDE VOLUME (mm^3) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	39.47	16.11	24.74	5.61	<0.0001
	Females	53	26.1	10.19	18.13	4.14	

Table 13 reveals the volume of right side MS in males (n=53) & females (n=53). The average and SD in males & females were 24.74 ± 5.61 and 18.13 ± 4.14. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their sexes with p value <0.0001.

Graph 11: Comparison of Volume of MS in males and females – Right side



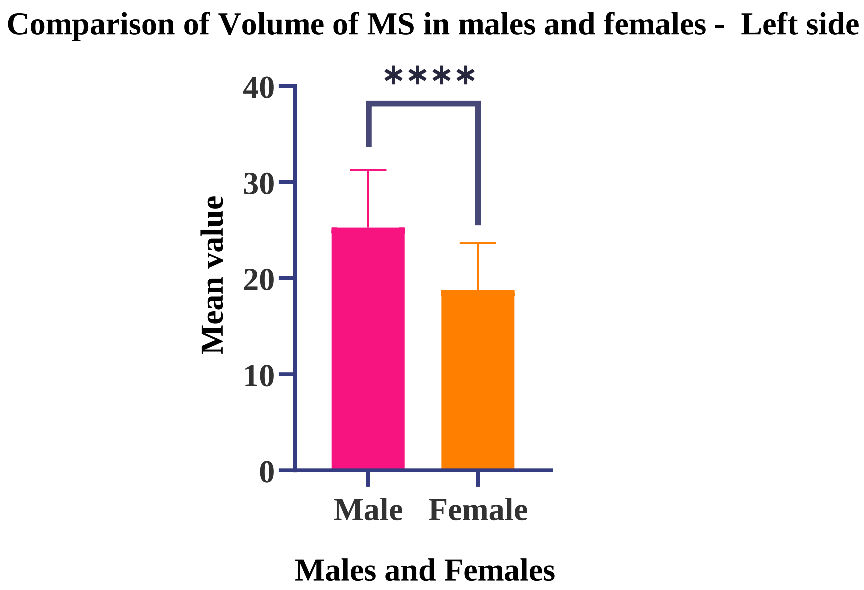
Graph 11 represents the bar diagram of comparison of volume of right side MS in males & females with the X axis reading the males and females, whereas the Y axis reading the obtained mean values of volume the maxillary sinus is present on the right side in both males and females. Both bar diagrams are compared and is marked with "****" indicating that the significant statistical difference was observed between both the sexes

TABLE 14. COMPARISON OF LEFT SIDE VOLUME (mm^3) OF MAXILLARY SINUS IN MALES AND FEMALES

Parameters	Sex	Number	Maximum Size	Minimum Size	Mean	SD	P Value
Craniocaudal diameter	Males	53	40.11	14.58	25.29	5.96	<0.0001
	Females	53	30	11.8	18.79	4.85	

Table 14 reveals the volume of left MS in males (n=53) & females (n=53). The AVERAGE & SD in males & females was 25.29 ± 5.96 and 18.79 ± 4.85. In order to determine if the samples for each sex were comparable, Mann-Whitney U test between the females and males was run, which yielded a significant statistical difference between their sexes with p value <0.0001.

<u>Graph 12: Comparison of Volume of MS in males and females – Left side</u>



Graph 12 represents the bar diagram of comparison of volume of the left side MS in males & females with X axis reading males & females, whereas the Y axis reading the obtained mean values of volume the maxillary sinus is present on the left side in both males and females. Both bar diagrams are compared and is marked with "****" indicating that on comparing the sexes, there was a statistically significant difference.

CALCULATION OF PERCENTAGE OF SEXUAL DIMORPHISM OF ALL PARAMETERS ON BOTH SIDES OF IN MALES AND FEMALES

TABLE 15: Calculation of right side sexual dimorphism % in maxillary sinus

Parameter	Mean ± SD		*P* Value	Dimorphism (%)
	Male	Female		
Height	4.01 ± 0.26	3.36 ± 0.29	<0.0001	19.34 %
Width	3.87 ± 1	3.47 ± 1	0.8862	11.52 %
Depth	3.55 ± 0.42	3.11 ± 0.26	<0.0001	14.4%
Volume	24.74 ± 5.61	18.13 ± 4.14	<0.0001	33.33 %

Table 15 represents the sexual dimorphism of height, depth, width and volume of the right side MS are 19.34 %, 11.52 %, 14.4% and 33.33 % respectively. Thereby depicting that volume of MS of right side shows the highest sexual dimorphism (33.33 %), whereas mediolateral diameter of right MS shows the least sexual dimorphism (11.52 %) among all the 4 measured parameters of the right side maxillary sinuses of male and female participants.

TABLE 16: Calculation of left side sexual dimorphism % in maxillary sinus:

Parameter	Mean ± SD		*P* Value	Dimorphism (%)
	Male	Female		
Height	3.87 ± 0.408	3.25 ± 0.22	<0.0001	19.07 %
Width	3.55 ± 0.67	3.63 ± 0.70	0.5828	2.2 %
Depth	3.69 ± 0.4	3.17 ± 0.34	<0.0001	16.4%
Volume	25.29 ± 5.96	18.79 ± 4.85	<0.0001	34.6 %

Table 16 represents the sexual dimorphism of height, width, depth and volume of left MS are 19.07 %, 2.2 %, 16.4% and 34.6 % respectively. This shows that volume of left MS is the highly sexually dimorphic (34.6 %) among all, whereas width of the left MS shows least sexual dimorphism (2.2 %) among all the 4 measured parameters of the left MS of male & female participants.

Table 17: Analysis of the height, depth, width, and volume of the right side of the maxillary sinus in the males and females conducted using the Mann-Whitney U-test.

Variables	**Sex**	**n**	**Min**	**Max**	**Mean**	**SD**	***P***
Height	Male	53	4.59	3.56	4.01	0.26	<0.0001
	Female	53	3.87	2.78	3.36	0.29	
Depth	Male	53	4.19	2.89	3.55	0.42	<0.0001
	Female	53	3.75	2.72	3.11	0.26	
Width	Male	53	4.73	2.5	3.48	1	0.8862
	Female	53	4.63	2.5	3.47	1	
Volume	Male	53	39.47	16.11	24.74	5.61	<0.0001
	Female	53	26.1	10.19	18.13	4.14	

Table 17 shows the overall comparison of height, width, depth, and volume in right MS in males and females by Mann-Whitney U-test for statistical analysis, which shows all the parameters are statistically significant for sex determination (P value < 0.0001), whereas the width (mediolateral) of right side alone is not statistically significant (P value = 0.8862), making it not reliable to determine sex.

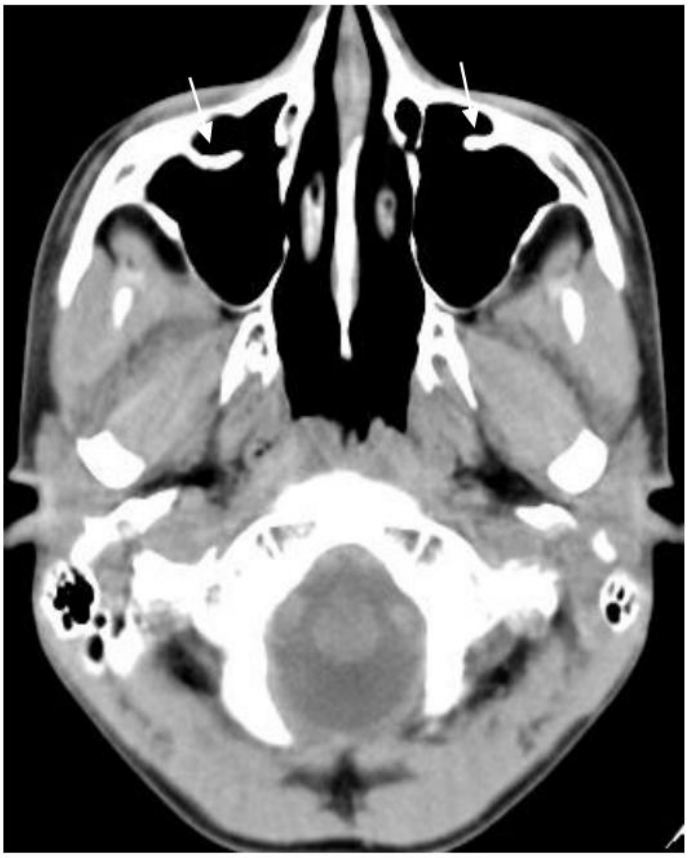
<u>Table 18: Analysis of the height, depth, width, and volume of the left side of the maxillary sinus in the males and females conducted using the Mann-Whitney U-test.</u>

Variables	Sex	n	Min	Max	Mean	SD	*P*
Height	Male	53	4.57	3.06	3.87	0.408	<0.0001
	Female	53	3.5	2.53	3.25	0.22	
depth	Male	53	4.32	2.94	3.69	0.4	<0.0001
	Female	53	3.89	2.64	3.17	0.34	
Width	Male	53	4.89	2.58	3.55	0.67	0.5828
	Female	53	4.88	2.55	3.63	0.70	
Volume	Male	53	40.11	14.58	25.29	5.96	<0.0001
	Female	53	30	11.8	18.79	4.85	

Table 18 shows the overall comparison of height, width, depth, and volume in right MS in males and females by Mann-Whitney U-test for statistical analysis, which shows all the parameters are statistically significant for sex determination (P value < 0.0001), whereas the width (mediolateral) of left side alone is not statistically significant (P value = 0.5828), making it not reliable to determine sex.

ANATOMICAL VARIATIONS NOTED DURING THE STUDY

Figure 11: Axial view CT PNS showing presence of septa within maxillary sinus



Two white arrow heads denote the presence of septa along the anterior walls of both sides of the maxillary sinus, which was excluded from the study as it has potential to alter the accuracy of the measurement of maximal anteroposterior diameter (depth) of the maxillary sinus which could alter the results outcome.

UNCOMMON FINDINGS NOTED AND EXLUDED DURING THE STUDY

Figure 12: Coronal view CT PNS showing presence of Bilateral maxillary polypoidal sinusitis

CT scan of a 45 years old male revealed the presence of Bilateral maxillary polypoidal sinusitis with obliteration of bilateral osteo-meatal complex and a central heart shaped filling defect on the left side, which was excluded from the study.

Figure 13: Axial view CT PNS showing presence of polypoidal lesion on left side maxillary sinus

CT scan showing the presence of a polypoidal growth along the lateral wall of left side maxillary sinus was encountered during the study, which was also excluded as it affects the accuracy of measuring the highest mediolateral diameter (width) of the maxillary sinus, which could alter the results outcome.

DISCUSSION

Forensic anthropology, a specialised field under physical anthropology, is dedicated to analysing human remains in order to determine important details such as identity, age, sex, and cause of death. Forensic anthropology primarily focuses on the analysis of skeletal remains, with particular emphasis on the skull bone. The skull bone is crucial for individual identification due to its unique characteristics.

Gender identification is a crucial aspect of forensic anthropology since it plays a significant role in the process of identifying individuals based on their skeletal remains. Forensic anthropologists mostly use skeletal analysis to determine an individual's biological sex. However, gender analysis can provide additional information that aids in accurate identifications.

When a victim has both a pelvis and a skull, 98% of the time, it is possible to figure out what gender they are in mass calamities such as aviation accidents, terrorist assaults, avalanches, seismic waves, blasts, and war. It is 95% accurate when the victim only has a pelvic bone and the elongated bones, but only 80-90% accurate when the victim only has long bones. After the pelvis, the skull is the most dependable bone for distinguishing gender, although its reliability is not established until puberty.[53]

Forensic anthropology utilises anatomical markers to gather scientific information, including individuality and variations in size, shape, symmetry, and durability. The nasal sinuses, including the maxillary, frontal, sphenoid, and ethmoid sinuses, are four sets of paired, air containing cavities surrounding the nose.[54]

Variability of the maxillary and frontal sinuses among people makes them great tools for investigating gender dimorphism.[55]

Various approaches are presently employed in forensic science to ascertain the identity of an unidentified individual, with DNA analysis being the most dependable method. Nevertheless, this approach is both laborious and costly, and it might not be successful in situations where the remains have undergone significant degradation or have been exposed to severe environmental conditions. In such instances, alternative techniques such as radiological assessment of the sinuses of maxilla and frontal can be employed, particularly when just the skull remains are accessible.

The role of sinuses, namely the maxillary sinuses, in determining gender is a crucial feature of forensic anthropology. Research has demonstrated that the dimensions of the maxillary sinuses can be valuable indicators for determining the gender in criminal investigations. This research's goal is to ascertain which dimension of maxillary sinus is the most dependable indicator for determining an individual's gender.

The gender identity of 106 patients was determined based on CT scans, with 53 identified as men and 53 identified as females. The Maxillary sinus parameters encompass:

- Height- maximal craniocaudal diameter
- Width- maximum mediolateral diameter
- Depth- anteroposterior diameter
- Volume of maxillary sinus

While CBCT has advantages such as decreased radiation exposure, decreased cost, increased accessibility, and faster image acquisition in comparison to CT and MRI, its ability to completely demonstrate its potential in forensic research is still limited. These drawbacks stem from its limited capacity to differentiate between different shades of grey, its narrow range of vision, its constrained ability to capture a large volume of data, and its inability to accurately measure Hounsfield units.[56,57]

Research carried out by Saccucci et al., concluded that the use of maxillary sinuses in CBCT imaging is not a reliable method for distinguishing sexual differences in corpse identification.[58]

STUDY RESULTS OF THE MAXIMAL ANTEROPOSTERIOR DIAMETER (DEPTH) OF MAXILLARY SINUS:

This study examines the average and variability of the anteroposterior (AP) diameter, also known as depth, of the right medial sulcus (MS) in both females and males are 3.11 ± 0.26 cm and 3.55 ± 0.42 cm, which was significant statistically ($p < 0.0001$) and also the average and SD of depth of left side maxillary sinus for males & females were, 3.69 ± 0.4 cm and 3.17 ± 0.34 cm accordingly, which was statistically significant ($p < 0.0001$). Therefore, statistical significance was found in both sides, when compared to the males and females correspondingly, thereby proving it to be a valuable tool for determination of sex using plain CT scans of maxillary sinus.

Jehan et al.,[59] did a study on a sample of 191 individuals (106 males and 85 females) from the population of Madhya Pradesh in India. They found that the average AP (Anteroposterior) diameter of the maxillary sinus was 3.643 ±

0.426 cm for men and 3.493 ± 0.414 cm for women. Their study also showed that the AP diameter of both sides was statistically significant in both males and females, which aligns with our own findings. Baweja et al.,[60] reported an average sinus AP of 34.1 ± 5.1 mm for males and 33 ± 5.6 mm for females, which closely aligns with our findings due to the similarity in the study location.

Uthman et al.,[41] found that the anteroposterior diameter of the right MS in men was 39.3 ± 3.8 mm, whereas men on the left side had a length of 39.4 ± 3.7 mm. The measurement on the right side for women was 36.9 ± 3.8 mm, while on the left side it was 37 ± 4 mm, indicating a smaller value compared to the mentioned measurement. The disparity between the two groups was statistically significant, with a p-value of less than 0.05.

Paknahad et al.,[61] performed a research investigation involving 100 patients in Iranian population (females and males, 50 each) aged between 20 to 54 years. The study used CBCT to measure the AP diameter (depth) on either side of the MS. The average and variability in depth of the right-side maxillary sinus in males were 40.32 ± 3.06 mm, whereas in females, it was 37.81 ± 3.70 mm. The observed difference was statistically significant at a level of $p < 0.001$. Similarly, the average depth and variability of the left side maxillary sinus were 40.10 ± 2.82 mm for males and 37.62 ± 3.59 mm for females. The observed discrepancy was statistically significant, as indicated by a p-value of less than 0.001. The research's mean values exceeded ours slightly. This could be because of differences in race and ethnicity.

Teke et al.,[10] conducted a study in the USA where they analysed 127 CT scans of the patients (65 males and 62 females) who had no detectable pathological findings. In their findings, it was determined that the maxillary sinus had a depth of 43.7 ± 7.78 mm on the left and 42.58 ± 7.9 mm on the right in men. This depth was much greater than what was observed in women. The average maximum depth for females was 37.6 ± 6 mm on the left and 37.8 ± 5.69 mm on the right. The disparity between males and females was statistically significant, with a p-value of less than 0.05. The observed values in our research are moderately elevated compared to our findings, possibly because to variations in ethnicity, race, and the size of the sample.

STUDY RESULTS OF THE MAXIMAL CRANIOCAUDAL DIAMETER (HEIGHT) OF MAXILLARY SINUS:

In this study, the average and standard deviation of craniocaudal diameter (height) of right-side maxillary sinus for males & females were, 4.01 ± 0.26 cm and 3.36 ± 0.29 cm, which was statistically significant (p <0.0001) and also the mean and standard deviation of height of left side maxillary sinus for females & males were, 3.25 ± 0.22 mm and 3.87 ± 0.4 mm, which was statistically significant (p <0.0001). Therefore, statistical significance was found in both sides, when compared to the males and females correspondingly, thereby proving it to be a valuable tool for determination of sex using plain CT scans of maxillary sinus.

Based on a study by Uthman et al.,[41] in Iraq, 88 cases, (43 men and 45 women), had been examined at. The age range of the patients was between 20 and 49 years. The researchers found that the sinus had a mean height in the male populace of 43.3 ± 4.8 mm on the right and 45.1 ± 4.1 mm on the left. The size of the female group was much larger than typical, measuring 39.9 ± 5.2 mm on the right side and 40 ± 4.8 mm on the left side. Only the male group exhibited a statistically significant difference.

In their study, Paknahad et al.,[61] examined 100 patients in Iranian population (females and males, 50 each) aged between 20 to 54 years. They measured the height of right MS and found that the mean and standard deviation for males were 39.03 ± 6.07mm, while for females it was 33.74 ± 4.63 mm. The observed difference exhibited statistical significance ($p < 0.001$). They also measured the depth of the left side maxillary sinus and found that the mean and standard deviation for males were 38.76 ± 6.21 mm, while for females it was 33.53 ± 4.66 mm. The distinction noticed exhibited statistical significance ($p < 0.001$), which aligns with findings of our study.

According to Teke et al.,[10] the average maximum height of the MS males was 47.2 ± 6.5 mm on the left and 47.6 ± 6.4 mm on the right side. These were higher than the females' measurements of 45.1 ± 4.6 mm on the right side and 43.6 ± 4.4 mm on the left. The difference between the male and female measurements was statistically significant ($p < 0.05$). Once again, our data indicate that these values are slightly elevated, possibly as a result of variations in ethnicity, race, and the size of our sample.

STUDY RESULTS OF THE MAXIMAL MEDIOLATERAL DIAMETER (WIDTH) OF MAXILLARY SINUS:

In this study the average and variability (standard deviation) of mediolateral diameter (width) of right side maxillary sinus for males & females were, 3.48 ± 1 cm and 3.47 ± 1 cm, which does not show any Statistically relevant difference (*P* value- 0.8862) and the average and SD of width of left maxillary sinus for males & females were, 3.55 ± 0.67 mm and 3.63 ± 0.70 mm, which also does not show a change that is statistically significant (*P* value- 0.5828). Therefore, no statistical significance was found in both sides, when compared to the males and females correspondingly, thereby making it not a valuable tool for determination of sex using plain CT scans of maxillary sinus.

Jehan et al.[59] found that the average sinus width for men was 2.404 ± 0.471 cm and for women it was 2.39 ± 0.438 cm. These values are relatively smaller than the mean values seen in our investi[62]gation. However, the difference was not determined to be statistically significant, which is consistent with our findings.

Baweja et al[62] reported an average sinus width of 21.8 ± 3.4 mm in males, whereas 21.6 ± 3.7 mm for females, which is less when compared to our results.

Uthman et al.[40] found that the most common MS thickness in men was 24.7 ± 4 mm on the right side and 25.6 ± 4.4 mm on the left. Females exhibited significantly low values for both the right side (22.7 ± 3.2 mm) and the left side (23 ± 4 mm) ($p < 0.05$). The disparity between the right and left sides was notable just among the male participants.

In their study, Paknahad et al.,[61] examined 100 patients in Iranian population (females and males, 50 each) aged between 20 to 54 years. They measured the width of the right-sided MS and found that the mean and standard deviation for males were 30.72 ± 4.35 mm, while for females it was 29.95 ± 4.24 mm. There wasn't a notable difference between the two groups (p value = 0.37). Similarly, they found out the depth of the maxillary sinus on the left side and found that the mean and standard deviation for males were 31.62 ± 3.91 mm, while for females it was 30.62 ± 3.8 mm. Once more, the difference between the two groups was not very important (p = 0.23). The mean values of both sides in both males and females are somewhat smaller compared to the results obtained in our investigation. The variation in results can plausibly be ascribed to the ethnic and racial heterogeneity within the sample populations in both investigations. However, the width of both sides in the male and female groups does not exhibit any significant differences, which aligns with the findings of the present study.

According to Teke et al.,10, the average maximum width of the MS in men was found to be 27.19 ± 5.46 mm on the right side and 26.89 ± 5.52 mm on the left side. The measurements of females on both sides were considerably low, with values of 24.44 ± 3.61 mm and 24.27 ± 3.98 mm correspondingly ($p < 0.05$).

<u>STUDY RESULTS OF THE VOLUME OF MAXILLARY SINUS</u>:

According to the study, the mean volume of the maxillary sinus on the right side was 24.74 ± 5.61 cm^3 for both boys and females. Similarly, the mean volume of the maxillary sinus on the left side was 25.29 ± 5.96 cm^3. These differences in volume were statistically significant ($p < 0.0001$). Similarly, the standard deviations for the right-side maxillary sinus were 18.13 ± 4.14 cm^3 for males and females, and 18.79 ± 4.85 cm^3 for the left-side maxillary sinus, which were also statistically significant ($p < 0.0001$). Therefore, statistical significance was found in both sides, when compared to the males and females correspondingly, thereby proving it to be a valuable tool for determination of sex using plain CT scans of maxillary sinus.

Research conducted by Ariji et al.,[63] reported a range of maxillary sinus volume from 4.56 cm^3 to 35.21 cm^3, which aligns taking into account the range in this investigation, which can be considered comparable. According to Chang-Hee et al.,[64] the average volume determined was 21.9 cm^3, which was higher than the findings of this experiment. This discrepancy could be ascribed to the restricted number of samples or possible structural and ethnic variations.

In 1999, Kawarai et al.,[65] measured the size of 20 healthy paranasal sinuses in Japanese people using three-dimensional CT imaging. It was discovered that the paranasal sinuses exhibited greater size in males as opposed to females, both on an individual basis and as a collective unit. This discovery is consistent with the findings of the present investigation.

Various authors have recorded disparities in the dimensions of maxillary sinuses between men and women. Sahlstrand-Johnson et al.[66] conducted a study in which they analysed the measurements of 120 maxillary and frontal sinuses by utilising head CT scans. The average volume of the maxillary sinus was 15.7 + 5.3 cm^3, and it was shown to be significantly greater in males compared to females, which contradicts the results of our study. There was no statistically significant correlation observed between age or side and the size of the maxillary sinuses. Emirzeoglu et al.[67] did a study in which they evaluated the coronal CT scans of 77 patients from Turkey. The patients' ages ranged from 18 to 72 years, and the group included 38 women and 39 men. There was a significant disparity in the volumes of the maxillary sinuses in men and women. The volume of males was 19.8 ± 6.3 cm^3, whereas the volume of females was 16 ± 5 cm^3. The different sizes of the maxillary sinuses may help explain why the structure and shape of a man's and a woman's face are different, especially in the middle of the face.

Karakas et al.,[68] did a study using CT scans on 91 Turkish people, ages 5 to 55 (47 men and 44 women). The study found that sinuses in men are bigger than sinuses in women. There was a significant disparity in the average size of MS in men and women. In men, the volume on the left side was 14.55 cm^3 and the volume on the right side was 14.74 cm^3 plus or minus 5.79 cm^3. The right side had a volume of 14.29 ± 3.42 cm^3 and the left side had a volume of 13.78 ± 3.41 cm^3.

In their study, Uthmann et al.,[41] investigated the precision and dependability of measuring maxillary sinus dimensions as a means of categorising individuals based on their gender. They used rebuilt helical CT scans of 88 people, 43 men and 45 women, between the ages of 20 and 49. With an accuracy rate of 71.6%, the researcher found that the most effective method for examining variations is to measure the height of the maxillary sinus. 74.4% of sinuses in men and 73.3% of sinuses in women were accurately recognized.

Amusa et al.[69] studied 24 dry skulls from Nigerians by using endoscopy (a camera) to look at the paranasal sinuses and rate how well they were filled with air. The width, depth, height, and volume of the sinuses were analyzed. The maxillary sinus was the sole sinus in which the left side exhibited greater size than the right side. Other paranasal sinuses of the right exhibited greater size compared to the left side. During our investigation, we observed that the size of the left side maxillary sinus was larger than the right side, however, the disparity did not reach statistical significance.

Sahlstrand-Johnson et al.,[66] conducted a retrospective review of head CT scans and discovered that men often have larger sinuses than women, which can be attributed to their larger overall size. The researchers noted a disparity in the dimensions of maxillary sinuses between men and women in an entire group of 60 consecutive individuals, comprising 32 females and 28 males, ranging in age from 18 to 65 years.

Fernandes et al.,[70] analysed 53 CT scans of skulls belonging to Zulu and Europeans. Their research findings indicated that there was no statistically noteworthy disparity in the diameter of the maxillary sinus between the two parties with regards to sexual distinctions. Nevertheless, there were significant differences in the dimensions of MS, including height, depth and volume, between females and males. There were clear differences based on race and gender. In the end, the discriminant analysis was able to correctly predict 90% of the time when it came to raciality and 79% of the time when it came to gender, which outperformed the results of our study. The differences between our results and Fernandes' are due to differences in sample size and the locations of the people who were studied.

A study conducted by Amin MF et al.,[71] discovered that using MDCT measures of the length from the chin to the base of the skull and the size of the left maxillary sinuses can help figure out what gender an Egyptian person is. 96 Egyptians between the ages of 20 and 70 were part of the study. There were 48 men and 48 women. The cephalo-caudal diameter and the size of the left MS exhibited statistically significant disparities. The study found that the exact predicted accuracy for men was 70.8% and for women it was 62.5%, which is very similar to what we found.

Kim et al., (2019)[44] conducted a study on 33 hemi-sectioned Korean CT scans. The sinuses of men were bigger and filled up more than those of females. The sinus had a maximum anteroposterior (AP) length of 39.3 ± 4.2 mm, with males having a length of 40.7 mm and females having a length of 37.4 mm. The sinus reached a peak height of 37.1 ± 5.6 mm, while its maximum width measured 32.6 ± 65 mm. The mean capacity of the sinuses was 15.1 ± 6.2 ml.

The research conducted by Etemadi et al.,[72] in the Iranian population employed CBCT scans to examine the maxillary sinuses bilaterally in a cohort of 70 patients, consisting of 35 females and 35 males who were at least 18 years of age. The results revealed a significant association between gender and the size of the maxillary sinus ($P < 0.05$). Nevertheless, the ROC curve's area was 0.627 or 62.7%, falling short of the 0.70 requirement. Hence, the measurement of the maxillary sinus volume cannot be regarded as a conclusive and dependable determinant of an individual's gender.

In 2013, Vidya et al.,[73] performed a research investigation on 30 dry craniums from South India. The researchers discovered that the maxillary sinuses were much bigger in male skulls than in female skulls.

The variations in both the volume and size of the maxillary air cavities found in this study can be ascribed to multiple reasons. These factors encompass variations in racial and ethnic groups, differences in body stature, skeletal size, height, and physique among individuals, the size of the sample being studied, genetic and environmental influences, anatomical differences in the sinus, discrepancies in osteoclastic and osteoblastic activity, and the process of sinus pneumatization in different age and sex groups, as well as prior infections.

STUDY RESULTS OF THE PERCENTAGE OF SEXUAL DIMORPHISM OF MAXILLARY SINUS

The sexual dimorphism percentages for each parameter of the maxillary sinus over right side are as follows: 19.34% for height, 11.52% for width, 14.4% for depth, and 33.33% for volume. And for the left, the percentages are 19.07% for height, 2.2% for width, 16.4% for depth, and 34.6% for volume. Among all the characteristics examined, volume exhibited the greatest degree of sexual dimorphism, whereas the breadth of the maxillary sinus displayed the least sexual dimorphism on both sides.

Kanthem et al.,[14] conducted a study on CT scans of 30 patients in Khammam, Andhra Pradesh. The analysis revealed that the maxillary sinus exhibited the greatest degree of sexual dimorphism, with a percentage of 85.46% on the right side and 78.38% on the left side. In contrast, the breadth of the maxillary sinus had the lowest degree of sexual dimorphism, measuring 17.93% on the right side and 15% on the left side. The results of our study align with these findings, since we also observed that the volume and width of the MS exhibited the greatest and least differences between sexes, respectively.

As per Uthman et al.,[42], out of all the parameters that were assessed, the maxillary sinus height was shown to be the most effective variable for distinguishing between the sexes.

Urooge A et al., in 2017,[74] conducted a descriptive study using CBCT on hundred subjects (50 males and 50 females) aged between 20 to 50 years attending the Department of Oral Medicine and Radiology at The Oxford Dental College and Research Centre, Bengaluru, Karnataka and after testing each factor for its ability to tell the difference between men and women, the left MS width was identified as the most accurate at 60%, which is higher than the study's sexual dimorphism percentage and suggests that it can be used to accurately identify sex.

CONCLUSION

Computed tomography (CT) is an excellent method to visualize the craniofacial region. According to literature, it has been observed that the skull remains undamaged even when other bones are deformed. Forensic science primarily focuses on personal identification. Consequently, a CT scan was utilised in the study to obtain precise measurements of the size of the maxillary sinus and to rule out any small changes that might be caused by disease that could affect how accurate the study's results are. An in-depth analysis of the paranasal sinuses of 106 patients was carried out after the CT scan. The study included an equal number of boys and females, with 53 individuals of each gender.

Research has confirmed that males have larger and more voluminous maxillary sinuses compared to females. Statistical significance was only detected for the depth (anteroposterior diameter), height (craniocaudal diameter), and volume of MS. The mediolateral diameter of the MS alone was identified as a statistically significant factor in identifying sex. The findings that were reported were similar to those of the prior investigations. Computerised Tomography (CT) scans are superior to conventional radiography in terms of accuracy when it comes to identifying and quantifying Craniometric sites, particularly the dimensions of the maxillary sinus. Hence, CT scans of the maxillary air sinus can serve as a valuable resource in the fields of investigative anthropology and investigations into crimes, especially when other identification methods produce uncertain outcomes, by assisting in the determination of gender. The results indicate that the maxillary sinus, because of its structural variety and consistent preservation in circumstances of trauma or mass disasters, can be used as a dependable diagnostic factor for determining the sex of an individual. Using advanced imaging techniques like cone-beam computed tomography (CBCT) to evaluate the dimensions of the maxillary sinus enhances the precision and reliability of gender identification in forensic investigations. In summary, the maxillary sinus is an important anatomical characteristic that plays a key role in accurately determining gender in forensic situations.

LIMITATION

1. The study on gender determination by the maxillary sinus is limited due to its preliminary nature and the fact that it was conducted on a specific population, which may not accurately represent larger demographics.
2. Additional research employing bigger sample sizes is required to definitively verify the reliability and generalizability of utilising maxillary sinus measures for accurately predicting gender.
3. Additionally, variations in research results can be ascribed to factors such as variances in skeletal dimensions, stature, built, genic and geographical effects, structural irregularities of the sinus, and changes in the activity of osteoclasts and osteoblasts.
4. These variances underscore the intricacy of utilising maxillary sinus measurements for gender identification and stress the necessity for more extensive research to tackle these aspects and improve the precision and practicality of this technique in forensic anthropology.

SUMMARY

The accurate determination of persons is a crucial element of forensic science, particularly in situations involving mass disasters, vehicle accidents, air crashes, fires, and criminal investigations. Forensic identification is based on the comparison of distinct features of a deceased corpse with previously recorded paperwork. The identification process utilises a range of techniques, such as fingerprint analysis, DNA comparisons, anthropological methods, and radiological techniques. The potential of sinus radiography in determining an individual's sex has been investigated. Our research aims to utilise maxillary sinus measurements as a means of determining an individual's gender. This will be achieved by analysing the coronal and axial views of a typical CT scan.

The main goal of the research is to ascertain the gender of an individual by assessing the measures of the maxillary sinus. Our research comprised a sum of 106 patients, with an equal distribution of 53 males and 53 females. These patients were picked from the Department of Radiology at KLES Dr Prabhakar Kore Hospital & MRC in Belagavi, Karnataka. The diameters of the right and left maxillary sinuses were measured for each subject using plain CT images. The measurements encompassed the vertical dimension, horizontal dimension, and capacity of the sinuses. Subsequently, a statistical analysis was performed on the gathered data to assess the importance of the disparities between males and girls.

The study found that the maxillary sinuses of males and girls were statistically different in terms of their height, depth, and volume. The dimensions displayed a greater level of sexual dimorphism, especially in

relation to sinus volume. Out of them, the mediolateral diameter of the maxillary sinus exhibited notable disparities between genders, highlighting its potential as a dependable factor for determining sex. The results make it clear that the size of the mandibular sinus is a strong sign of sexual differences.

The study concludes that the precise diagnostic characteristics for sex determination in forensic science are the depth, height, and volume of maxillary sinuses. The observed statistically valid variation in these metrics between the females and males establish a strong foundation for utilising maxillary sinus dimensions as a dependable technique for sex identification. This approach has the potential to supplement current forensic methods and improve the precision of individual identification in different forensic situations.

This research highlights the significance of radiological approaches in forensic science, especially in situations where other identification techniques may be degraded or unavailable. The study provides a dependable technique for determining sex based on maxillary sinus measures obtained from CT scans. This essential tool enhances the accuracy and efficiency of identification procedures in complex forensic investigations, benefiting forensic practitioners.

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ANNEXURE I – WAIVER OF CONSENT

From,

1st YEAR POST GRADUATE STUDENT,

MD FORENSIC MEDICINE AND TOXICOLOGY,
KAHER, JNMC,
BELAGAVI-590010, KARNATAKA

To,

The Institutional Ethical Committee,

KAHER, JNMC,

BELAGAVI-590010, KARNATAKA

Respected sir/madam,

Sub: Reg. Waiver of consent for my Dissertation.

I, **BF0121001** 1st year post graduate student (2021-2022 batch) am doing Dissertation titled, **"A Study on determination of Sex from Plain CT scan imaging of Maxillary sinus dimensions"** with my guide Dr. Somashekhar S. Pujar, Professor, Department of Forensic Medicine and Toxicology and co-guide Dr. Santosh D. Patil, Professor, Dept. of Radiology, for which the samples obtained will be the CT images of para nasal sinuses in DICOM format as soft copy in a hard disk, from the Department of Radiology, in KLES Dr Prabhakar Kore Hospital & MRC, Belagavi, Karnataka. I assure that privacy of the patients will be maintained and no details will be disclosed in any manner. Since the patients will not be examined or investigated in my study, their consent will not be required. And hereby I request to provide me a certificate for **"Waiver of Consent"** for my study. Kindly do the needful.

Thanking you

Date: 15.06.2022

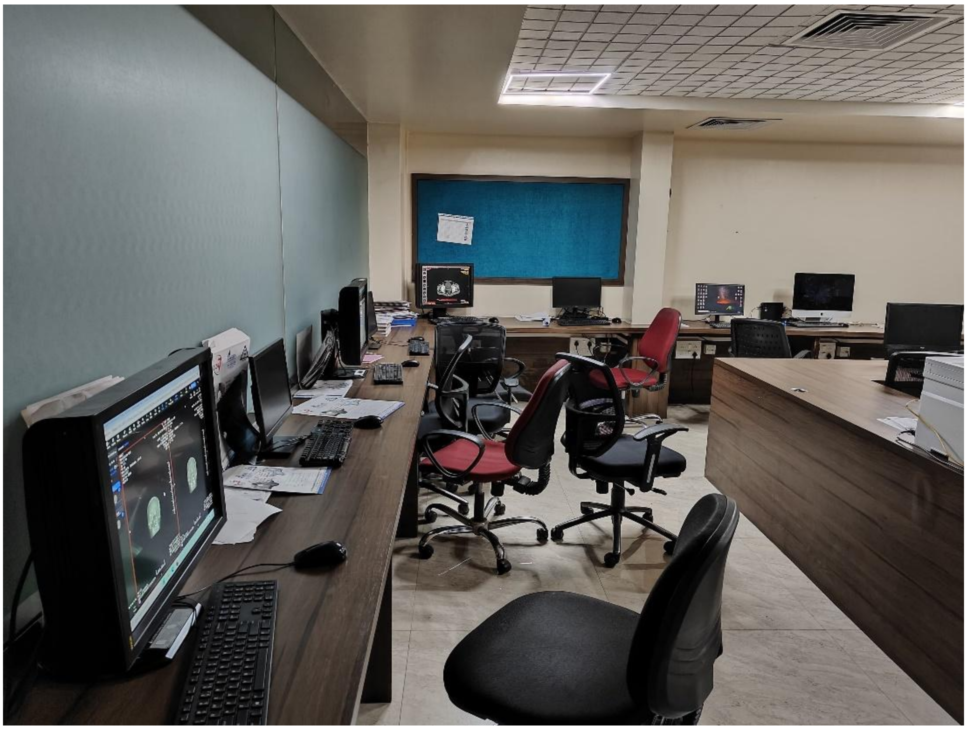
Belagavi

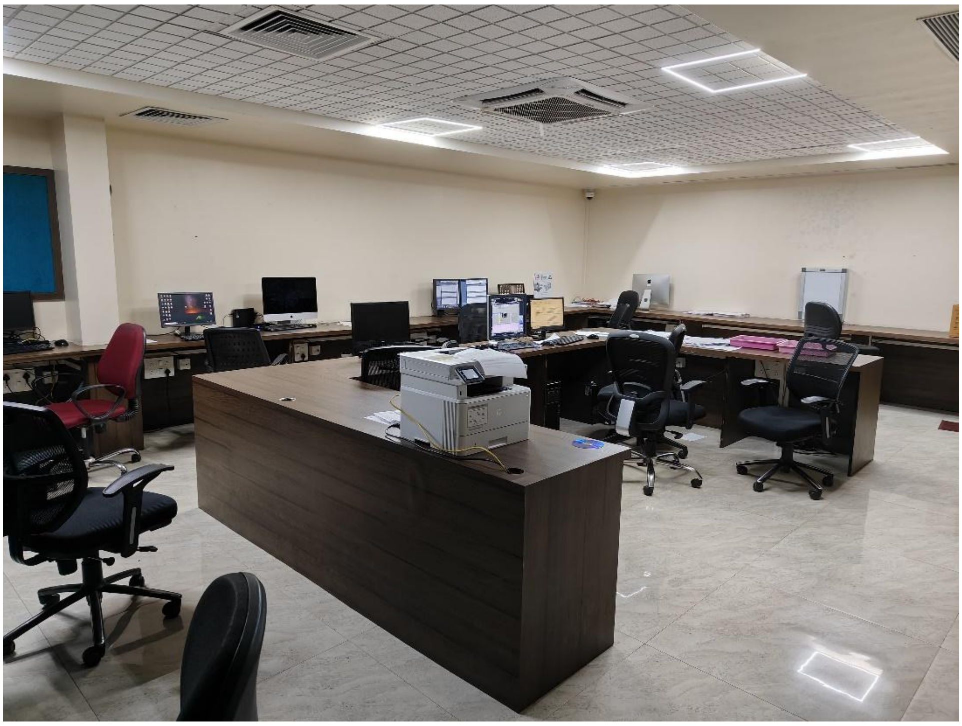
Yours faithfully

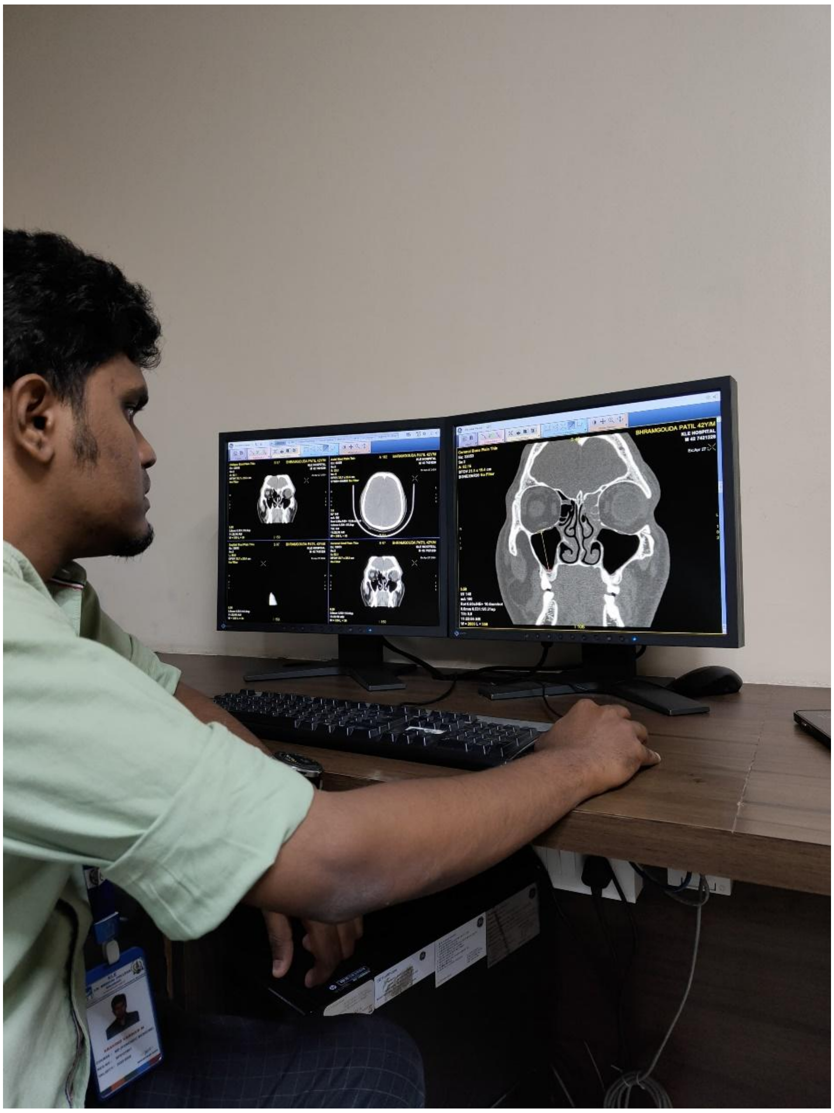
Forwarded by

Professor & HOD
Department of Forensic Medicine and Toxicology

ANNEXURE II – PHOTOGRAPHS






BHRAMGOUDA PATIL 42Y/M
KLE HOSPITAL

ANNEXURE III – KEY TO MASTER CHART

i. Sex: 1) Male 2) Female

ANNEXURE IV –MASTER CHART

No	Sex	Age	Craniocaudal - Height (mm)		Mediolateral – Width (mm)		Anteroposterior – Depth (mm)		Volume (mm^3)	
			Right	Left	Right	Left	Right	Left	Right	Left
1	2	56	2.83	3.09	3.24	2.76	2.98	3.32	13.66	14.16
2	1	23	4.14	3.42	3.73	2.90	3.00	2.94	23.16	14.58
3	2	51	3.67	3.30	3.79	3.48	3.63	3.20	25.25	18.37
4	2	34	3.25	3.18	4.00	4.88	2.82	3.29	18.33	25.53
5	1	45	3.77	4.31	3.81	2.58	3.01	4.25	21.62	23.63
6	1	34	4.20	3.76	2.70	4.70	4.02	3.81	22.79	33.67
7	2	23	3.51	3.48	2.58	4.33	3.63	3.89	16.44	29.31
8	2	57	3.65	3.37	3.10	4.85	3.50	3.25	19.80	26.56
9	2	35	3.28	3.12	2.76	3.71	3.26	2.71	14.76	15.68
10	2	45	3.87	3.37	4.21	3.34	3.13	2.68	25.50	15.08
11	2	33	3.28	3.49	2.80	3.94	2.81	3.12	12.90	21.45
12	2	19	3.42	2.86	3.98	2.75	3.29	3.00	22.39	11.80
13	1	25	4.17	3.38	3.85	2.90	3.98	4.20	31.95	20.58
14	2	38	3.41	3.35	3.25	4.61	3.40	3.41	18.84	26.33
15	2	51	2.84	2.85	4.50	3.96	2.85	3.39	18.21	19.13
16	1	43	3.79	3.45	3.30	4.19	4.03	3.92	25.20	28.33
17	1	27	3.66	4.51	2.71	4.04	3.75	3.91	18.60	35.62
18	2	45	3.57	3.34	4.61	4.38	3.00	2.79	24.69	20.41
19	1	49	4.28	3.81	3.60	2.67	3.03	3.21	23.34	16.33
20	1	51	3.66	3.78	3.49	4.16	3.75	3.61	23.95	28.38
21	1	29	3.73	3.42	4.48	4.11	3.07	4.20	25.65	29.52
22	2	30	3.10	3.41	2.90	2.61	3.75	3.26	16.86	14.51
23	2	42	3.56	3.41	4.02	2.90	3.24	3.49	23.18	17.26
24	1	34	3.71	3.81	2.98	2.96	3.60	4.14	19.90	23.34
25	2	23	2.97	3.26	3.52	4.15	3.09	2.67	16.15	18.06
26	2	58	2.78	3.48	3.10	4.15	2.91	3.25	12.54	23.47
27	1	34	4.41	4.12	2.63	3.27	2.98	3.50	17.28	23.58
28	1	45	3.93	4.01	3.50	3.45	3.86	3.76	26.55	26.01
29	2	34	3.87	3.15	4.16	3.60	3.24	3.21	26.08	18.20
30	1	19	4.07	4.00	2.64	3.10	3.82	3.40	20.52	21.08
31	1	25	4.59	4.43	3.73	4.74	3.90	3.82	33.39	40.11
32	1	38	3.59	3.97	3.09	3.86	2.98	3.22	16.53	24.67
33	2	52	3.26	3.35	2.72	3.85	2.94	3.38	13.03	21.80
34	1	43	4.32	3.50	2.90	2.89	3.25	3.29	20.36	16.64
35	2	27	3.66	3.50	3.64	3.18	3.20	2.75	21.32	15.30
36	2	45	3.32	3.38	2.57	2.80	2.87	3.81	12.24	18.03
37	1	49	4.13	4.13	2.70	4.56	3.16	3.11	17.62	29.29
38	2	41	3.46	3.33	3.63	3.57	2.74	3.15	17.21	18.72
39	2	35	3.69	3.42	4.52	2.65	3.13	3.25	26.10	14.73
40	1	27	3.89	3.58	2.76	2.76	3.27	4.22	17.55	20.85

41	1	44	3.67	3.50	2.80	3.13	3.70	3.81	19.01	20.87
42	2	57	3.54	3.32	3.75	4.82	3.37	3.75	22.37	30.00
43	1	35	4.37	4.19	4.03	3.52	4.19	3.44	36.90	25.37
44	1	32	3.62	3.26	4.10	2.80	3.72	3.90	27.61	17.80
45	1	20	4.09	3.72	4.73	4.01	4.08	4.12	39.47	30.73
46	2	29	3.60	3.49	3.38	4.41	3.06	3.82	18.62	29.40
47	2	43	3.41	3.31	4.30	2.91	2.80	2.67	20.53	12.86
48	1	18	3.68	4.24	4.31	2.91	3.06	3.11	24.27	19.19
49	2	22	3.70	3.42	3.24	4.00	2.94	3.26	17.62	22.30
50	2	28	3.42	3.22	3.60	3.61	2.91	2.77	17.91	16.10
51	1	33	3.82	4.29	3.25	3.18	4.01	3.21	24.89	21.90
52	1	38	4.10	3.39	3.74	3.10	3.76	3.63	28.83	19.07
53	2	41	3.19	3.16	2.79	4.72	3.52	3.33	15.66	24.83
54	1	56	3.89	3.79	2.90	3.85	3.65	3.30	20.59	24.08
55	1	27	3.86	3.89	4.22	3.43	3.34	3.32	27.20	22.15
56	1	45	3.90	4.28	3.00	3.66	3.67	3.55	21.47	27.81
57	2	49	3.63	3.34	3.29	2.89	3.29	2.73	19.65	13.18
58	2	41	3.35	3.25	4.51	3.67	3.19	3.87	24.10	23.08
59	1	35	4.08	3.65	4.09	3.66	4.05	3.99	33.79	26.65
60	2	27	2.82	3.20	3.10	4.17	3.46	3.47	15.12	23.15
61	2	44	2.97	3.31	3.50	3.42	2.72	2.85	14.14	16.13
62	1	57	3.74	3.42	4.01	4.00	3.40	3.22	25.50	22.02
63	1	35	4.14	4.18	3.60	3.01	4.11	4.23	30.63	26.61
64	2	32	3.47	2.89	2.55	3.75	3.07	2.70	13.58	14.63
65	1	20	4.36	4.29	3.75	3.30	3.94	4.29	32.21	30.37
66	1	29	3.94	3.10	4.16	4.89	3.30	3.26	27.04	24.71
67	1	43	4.05	4.15	3.65	3.56	2.97	3.67	21.95	27.11
68	2	18	3.27	3.12	3.08	2.73	2.75	2.90	13.85	12.35
69	1	22	4.13	4.19	3.55	3.54	3.50	3.35	25.66	24.84
70	1	28	4.34	4.01	3.40	3.04	3.66	3.29	27.00	20.05
71	1	33	4.03	3.41	4.10	3.22	4.10	4.21	33.87	23.11
72	2	38	3.66	3.00	4.44	3.04	2.88	3.10	23.40	14.14
73	2	41	2.80	3.40	2.60	4.52	2.80	3.06	10.19	23.51
74	1	56	3.56	4.36	2.50	2.72	3.62	4.15	16.11	24.61
75	2	27	3.13	3.29	2.91	4.20	3.22	2.95	14.66	20.38
76	2	45	3.48	3.38	2.79	2.80	3.40	3.79	16.51	17.93
77	1	49	4.07	3.08	2.96	3.73	3.83	3.84	23.07	22.06
78	1	41	3.71	3.59	2.89	4.73	4.10	4.13	21.98	35.07
79	2	35	2.79	3.05	3.64	3.98	2.90	3.39	14.73	20.58
80	1	27	4.24	4.40	3.80	3.88	2.89	4.11	23.28	35.08
81	2	44	3.37	3.12	3.79	3.30	3.28	3.03	20.95	15.60
82	1	57	3.67	3.06	4.41	4.38	2.90	3.40	23.47	22.78
83	1	35	4.17	4.01	3.61	4.81	3.81	3.73	28.68	35.97
84	1	32	3.94	3.18	4.48	2.69	2.91	3.43	25.68	14.67
85	2	20	3.39	3.16	3.74	3.19	2.80	3.23	17.75	16.28
86	2	29	3.43	3.46	2.78	3.22	3.16	2.90	15.07	16.15
87	1	43	4.08	4.06	2.80	3.83	2.96	3.21	16.91	24.96

88	2	18	3.00	2.53	2.50	3.28	2.99	3.35	11.21	13.90
89	2	22	3.61	3.42	3.88	3.80	2.82	3.32	19.75	21.57
90	1	28	3.93	3.96	2.60	3.42	3.40	3.31	17.37	22.41
91	1	33	4.22	4.50	3.95	2.70	4.04	3.82	33.67	23.21
92	2	38	3.22	2.64	3.85	4.87	3.23	2.99	20.02	19.22
93	1	41	4.23	4.15	3.80	2.60	2.94	3.55	23.63	19.15
94	2	52	3.65	3.41	3.71	4.88	2.88	3.11	19.50	25.88
95	2	27	3.19	2.85	4.63	2.77	2.91	3.09	21.49	12.20
96	1	45	4.40	4.57	3.20	3.29	3.96	3.88	27.88	29.17
97	2	49	3.47	3.00	3.53	2.98	2.88	2.64	17.64	11.80
98	2	41	3.73	3.32	3.66	3.74	3.53	3.38	24.10	20.98
99	1	35	4.46	4.28	2.56	3.97	3.58	4.25	20.44	36.11
100	1	27	3.92	3.85	2.90	3.93	2.98	3.15	16.94	23.83
101	2	44	3.74	3.25	2.90	3.28	3.16	3.35	17.14	17.86
102	1	57	4.01	3.71	3.88	2.90	3.82	4.32	29.72	23.24
103	2	35	3.13	3.44	2.80	3.42	3.40	2.82	14.90	16.59
104	2	32	3.22	3.50	3.95	2.55	3.04	2.82	19.33	12.58
105	1	20	3.98	4.14	3.85	4.87	3.76	3.71	28.81	37.40
106	2	29	3.23	3.37	2.90	2.79	2.94	3.55	13.77	16.69