"A STUDY OF VARIATION OF ETHMOIDAL ARTERIES IN NASAL CAVITY USING COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES – A ONE YEAR OBSERVATIONAL STUDY"

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LIST OF ABBREVIATIONS

GLOSSARY	ABBREVIATIONS
CT	Computed tomography
PNS	Paranasal sinuses
CT-PNS	Computed tomography scan of paranasal sinuses
AEA	Anterior ethmoidal artery
MEA	Middle ethmoidal artery
PEA	Posterior ethmoidal artery
AES	Anterior ethmoidal sulcus
AEF	Anterior ethmoidal foramen
AEC	Anterior ethmoidal canal
PEC	Posterior ethmoidal canal
SOEC	Supra-orbital Ethmoidal Cell
FESS	Functional endoscopic sinus surgery
DNE	Diagnostic nasal endoscopy
CBCT	Cone beam computed tomography
FS	Frontal sinus
SB	Skull base
SD	Standard deviation
SO	Superior oblique
MR	Medial rectus

ABSTRACT

Title: A study of variation of ethmoidal arteries in nasal cavity using computed tomography scan of paranasal sinuses – A one year observational study

Objectives:

- To study the anatomical course of the ethmoidal arteries and its variations.
- To assess which sections in Computed Tomography Scan of Paranasal Sinuses is ideal for identification and study of the course of the ethmoidal arteries.

Methods:

A one year study was undertaken and 60 computed tomography scans of paranasal sinuses were evaluated and anatomical variations of anterior ethmoidal artery, middle ethmoidal artery and posterior ethmoidal artery were studied.

Results:

The study had a male predilection in cases with 32 males (53.33%) and 28 females (46.67%). Anterior ethmoidal artery and posterior ethmoidal artery was found in all sides in all scans studied while middle ethmoidal artery was found in 19.16% of the total sides studied. Anterior ethmoidal foramen and anterior ethmoidal sulcus were found in all sides assessed and are reliable landmarks to identify anterior ethmoidal artery. Anterior ethmoidal artery was found in 50.83% of the sides and in mesentery in 49.17% of the sides. In mesentery position, anterior ethmoidal artery was found to travel at an average distance of 3.81 mm away from skull base with an average anterior ethmoidal canal length of 4.62 mm. In cases where supraorbital pneumatisation was present, anterior ethmoidal artery ran in mesentery position.

Anterior ethmoidal artery was found to nearly always run in skull base. Posterior ethmoidal artery was found in skull base in 93.33% of the sides studied, and in long mesentery in 6.67% of the sides studied. The posterior ethmoidal artery was found at an average distance of 7.62 mm from the optic canal. In the sides that middle ethmoidal artery was present, it ran in skull base in 95.65% of the sides and in mesentery in the remaining 4.35% of the sides. The middle ethmoidal artery was located at an average distance of 8.27 mm and 4.2 mm from anterior ethmoidal artery and posterior ethmoidal artery respectively.

Conclusion:

Ethmoidal arteries are prone to traumatic injury during endonasal surgeries and endoscopic skull base surgeries. Anatomy of these arteries can be assessed by radiological imaging which helps in preventing damage to these vessels, and also if damaged, to localise the vessels to control bleeding and reduce risk of complications.

Keywords: Anterior ethmoidal artery, Middle ethmoidal artery, Posterior ethmoidal artery, CT-PNS, Anatomical variations, Endonasal surgery.

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INTRODUCTION

The ethmoidal arteries begin their course from ophthalmic artery and irrigates nasal septum, the lateral wall of nose and air cells of ethmoid. They act as location markers to vital structures like the base of the skull and the optic nerve during endonasal procedures. There are three ethmoidal arteries which run in the nasal cavity: anterior, middle and posterior ethmoidal artery. Middle ethmoidal artery is uncommonly encountered and is thought to be an accessory ethmoidal artery and its anatomy has not been extensively studied. It is essential for the surgeon to realise the possibility of encountering middle ethmoidal artery during a surgical procedure and to take precautions to avoid damage to this structure or inadvertently cause complications.[1]

Anterior ethmoidal artery branches from ophthalmic artery, is characterized by three segments: an intra-orbital segment, an intra-ethmoidal, and an intra-cranial segment. It is most prone to injury in the ethmoidal segment.[2]

The posterior ethmoidal artery, which has its origin in ophthalmic artery, irrigates dura covering sphenoid bone, septum of nose, and posterior ethmoidal air cells. During anterior skull base surgery, posterior ethmoidal artery should be located and ligated or coagulated. Posterior ethmoidal artery is more difficult to clip than anterior ethmoidal artery because of its closer proximity to optic nerve.[3]

Middle ethmoidal artery arises in between anterior and posterior ethmoidal arteries and irrigates septum of nose and ethmoidal air cells.

Due to the location of ethmoidal arteries within the nasal cavity, it can be easily injured by the operating surgeon during endonasal surgery. Injury to anterior ethmoidal artery can cause its retraction into the orbit leading to retrobulbar haematoma or haemorrhage. Compartment syndrome of the optic nerve can occur which can lead to blindness. Coagulation of posterior ethmoidal artery carries an increased risk of damage to the optic nerve.[4]

In cases of uncontrolled epistaxis, ligation of anterior or posterior ethmoidal artery is a modality of treatment. If bleeding is still not controlled, possibility of an accessory ethmoidal artery being present must be considered, the artery traced and ligated. Hence the operating surgeon should have anatomical knowledge of all ethmoidal arteries as well as its variations.[1,5]

Computed tomography (CT) imaging of paranasal sinuses have long been used by otorhinolaryngologists as a diagnostic modality and as a tool for preoperative planning for precise assessment of certain areas of nasal cavity that are difficult to visualise endoscopically and are prone to injury. The scans help to accurately visualise both soft and bony tissue in the nasal cavity in detail. This is useful to identify the landmarks to visualise the ethmoidal arteries, assess their relation with skull base and distance from optic canal. Radiological anatomy in the coronal section of the scans is similar to what the operating surgeon will encounter during endoscopic dissection. Acquaintance of the anatomy of the vessels and its variations ahead of the surgery, will guide the surgeon during endoscopic sinus surgery.[6,7]

There is a lacuna in the research literature on the CT imaging of ethmoidal arteries; in particular, their location and their anatomical variations in cross sectional images. While adequate studies have been done on anatomy of anterior ethmoidal

artery and posterior ethmoidal artery, middle ethmoidal artery has not been well studied. The need to correlate radiological features which can help surgeons while planning for endonasal surgeries, and reduce perioperative complications needs to be addressed.[1]

Our study assesses anatomy of anterior, middle and posterior ethmoidal arteries using CT-PNS. The study identified the landmarks or pointers in the scan to help identify the ethmoidal arteries, studied its relation to skull base and other vital structures encountered in endoscopic sinus surgery. Incidence of middle ethmoidal arteries in all scans were studied, along with its relation to skull base, anterior and posterior ethmoidal arteries. This helps the surgeon to be aware of the location and precise course of the ethmoidal arteries preoperatively, so that during the surgery, iatrogenic damage to the vessels and its complications do not occur.

OBJECTIVES

- To study the anatomical course of the ethmoidal arteries and its variations.
- To assess which sections in Computed Tomography Scan of Paranasal Sinuses is ideal for identification and study of the course of the ethmoidal arteries.

REVIEW OF LITERATURE

COMPUTED TOMOGRAPHY SCANNING:

Computed tomography (CT) is an investigation modality which uses ionising radiation where multi-slice helical scanners that acquire 32 to 64 slices are used. The X-ray tube moves around the patient in a longitudinal axis, allowing the x-rays to pass through the body in multiple different projections. The electronic detectors measure the strength of the x-rays after they have traversed the body. It provides a versatile and superior picture of the structure being scanned with decreased movement and artefact due to rapid acquisition of images. Each slice contains information which is stored in the computer. The image acquired are in one plane, and the structures of interest can be studied in other planes by multiplanar reconstruction technique. CT scans allow evaluation of bony and soft tissue structures in multiple planes.[6]

ADVANTAGES:

- Fast imaging
- Multi-planar reconstruction
- Detailed cross-sectional imaging with good bony and soft tissue details.
- Less artifacts and blurring due to movements compared with conventional radiography.

DISADVANTAGES:

- Relatively costly compared to conventional radiography techniques.
- Higher radiation exposure.
- Artifacts due to implants and fillings

- Contrast study cannot be done in cases of allergy to contrast or in cases of kidney failure.

COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES (CT-PNS):

CT-PNS is the most commonly used investigation modality by an otorhinolaryngologist as a tool for preoperative planning for precise assessment of certain areas of nasal cavity that are difficult to visualise endoscopically and are prone to injury and as a diagnostic modality for chronic sinusitis and evaluation of nasal masses. The scan is done from tip of nose anteriorly till posterior limit of sphenoid sinus posteriorly. Coronal section is preferred for evaluation as it closely mimics the view obtained during nasal endoscopy.[7]

The uses of CT-PNS are:[7]

- Study of sinonasal anatomy.
- For detection and assessment of sinus inflammatory disease and fungal sinusitis.
- Assessment of granulomatous diseases of the nose.
- Detection and assessment of sinonasal polyps and masses.
- Detection and assessment of sinonasal neoplasms.
- Assessment of facial trauma and for detection of site of CSF leaks.

DEVELOPMENT OF THE NOSE AND THE NASAL CAVITIES:

Development of the face occurs during the 4^{th} to 8^{th} weeks of gestation, wherein a mass of undifferentiated swellings at the cranial end of the foetus grows and undergoes remodelling. It begins to develop from 5 swellings surrounding the stomodeum at end of fourth week. They comprise of a single, central frontonasal process, two maxillary and two mandibular processes.[8]

In the 5th week of intrauterine life, a pair of ectodermal thickenings commonly known as nasal placodes appear on the frontonasal process. Ectodermal invagination in centre of each nasal placode occurs forming an oval nasal pit in 6th week. There occurs elevation of the nasal pit rims to form lateral and medial nasal processes. In sixth and seventh weeks, both maxillary processes expand medially, first fusing with lateral nasal process followed by medial nasal process causing separation of nasal pits from primitive mouth.[8]

Intermaxillary process develops as a result of medial nasal processes joining with each other. It forms bridge of nose as well as philtrum. Growth of intermaxillary process occurs in posterior direction to form nasal septum. Nasal alae are formed by enlargement lateral nasal processes. Lateral nasal processes grow posteriorly to form lateral wall of nose which has multiple elevations - the turbinates.[8]

The maxillary process join with lateral nasal processes leading to formation of naso-optic groove. The floor of the nose develops during eighth and ninth week of gestation. Palatine shelves develop from medial part of the maxillary processes which fuse in midline and anteriorly with primary palate to form a secondary palate. It undergoes fusion with septum resulting in formation of two nasal passages which open into pharynx through definitive choanae. Medial growth and subsequent central fusion of mandibular processes forms the lower lip and jaw.[8]

In a newborn, the ratio of volume of the cranium to that of the facial skeleton is 7:1. The facial skeleton increases in volume more rapidly than the cranium during the growing period due to growth of sinuses and teeth.[8]

DEVELOPMENT AND GROWTH OF THE PARANASAL SINUSES:

DEVELOPMENT OF MAXILLARY SINUS:

Maxillary sinus develops earliest among all the sinuses, beginning in third gestational month. The infundibulum of ethmoid develops lateral to uncinate process. This is followed by growth of a channel towards precursor of maxillary bone, which occurs inferiorly and laterally by 3rd month of gestation. Thus, the primordial maxillary sinus is formed. The maxillary sinus gradually widens with progressive resorption of the surrounding nasal capsule extending into the developing maxilla by 5th month of gestation. Multi-directional expansion of the sinus occurs, occurring maximally in anterior– posterior direction, resulting in an elongated ovoid shaped sinus. Rapid increase in size takes place till 7 years of age, followed by gradual enlargement to adult size by 17-18 years of age.[9]

DEVELOPMENT OF ETHMOID SINUS:

During the gestational age of 9 to 10 weeks, a series of folds called ethmoturbinals appear in the lateral nasal wall, each separated by its corresponding groove. Crests are formed during fusion of these folds and each crest has an ascending and descending portion.[9]

A cartilaginous bulge is formed in the middle meatus by 12th week of gestation. This bulge is the primordial bulla. It is the origin of the anterior ethmoidal air cells which develop from the fifth month. By the 7th month, the developing sinus is filled by evaginating nasal epithelium. The cells of the posterior ethmoid sinus begin to develop during 16 to 20 weeks of foetal life from the infundibulum of the ethmoids. At birth, the ethmoidal air cells are small and underdeveloped, with interlinking connective tissue bands.[9]

DEVELOPMENT OF SPHENOID SINUS:

Sphenoid sinuses are the most posteriorly located sinuses, are cuboidal shaped and located within the sphenoid bone. Its boundaries are ethmoidal air cells anteriorly, clivus posteriorly and inter-sinus septum medially. The sphenoid ostium is located anteriorly, draining into the spheno-ethmoidal recess in the superior meatus.[9]

The sphenoid sinuses begin to develop in 3rd month of intrauterine life as an infolding of the nasal mucosa into the posterior portion of the cartilaginous nasal capsules, to form a pouch like primitive sinus. In the fifth month, the sphenoidal conchae are formed by ossification the anterolateral walls. There is progressive expansion of the sinus postero-inferiorly which fuses with the sphenoid bone at three years of age. Pterygoid canal forms the lower limit of the sinus by six to seven years of age and hypophyseal fossa forms the posterior limit of the sinus by eight years of age. Lateral growth occurs towards anterior clinoid process by eight to twelve years of age and then onwards to optic strut. The sinus expands in the medial direction leading to thinning of the inter-sinus septum. After extension of the sinus into the pre-sphenoidal plate, pneumatization proceeds inferiorly and postero-laterally.[9]

With reference to the sella turcica, three pneumatization patterns have been described, the most common being the sellar, followed by the pre-sellar and the least common being the conchal type. The sinuses can also pneumatize into the pterygoid root laterally forming a lateral sphenoid recess and causing exposure of the neurovascular structures surrounding the sinus.[9]

DEVELOPMENT OF FRONTAL SINUS:

Frontal sinuses (FS) start developing after all other sinuses have begun, starting in the 4th month of gestation. It develops from a protrusion in the antero-

superior part of the middle meatus which also grows upwards and medially giving rise to ethmoidal cells and frontal recess. Mainly the FS arises from rudimentary cell nests within the frontal recess. In some cases, it may also originate from the suprabullar recess, anterior ethmoidal air cells or the infundibulum. It causes the formation of variable connections between the sinus and the nasal cavity and a complex drainage system. The FS begins to pneumatize in horizontal plate of the frontal bone in the first 2 years of life reaching the level of the nasion by 3 years of life by advancing superior to anterior ethmoidal air cells and reaches level of the roof of orbit by 4-7 years of age. Gradual pneumatization occurs and the FS is seen in most scans by 8 years of age. During adolescence, there occurs significant pneumatization of the FS which is completed by 18 years of age.[9]

ANTERIOR ETHMOIDAL ARTERY (AEA):

The ethmoidal arteries begin their course from ophthalmic artery which in turn arises from the internal carotid artery, coursing into the orbit through the optic foramen, laterally to the optic nerve. Ophthalmic artery then traverses the orbital cavity in a lateral to medial direction, superior to optic nerve.[10]

ANATOMICAL COURSE OF THE ANTERIOR ETHMOIDAL ARTERY:

AEA begins its course from ophthalmic artery in the anterior third of the orbit. After its exit, it travels anteriorly looping below superior oblique (SO) muscle, and returns about 5mm posteriorly into the anterior ethmoidal canal (AEC). Coronal cuts of CT scan shows AEA being visualised as a pyramid-shaped indentation in the medial orbital wall, indicating site of exit of the artery between SO and medial rectus (MR) muscles. It is a reliable anatomical landmark in CT-PNS.[10]

The artery then enters the AEC. The AEC is located between the FS and supraorbital ethmoid cell (SOEC); however, if the FS is rudimentary, the AEC lies within the anteriormost and adjacent posterior ethmoidal air cell. AEC travels in a horizontal plane in the anteromedial direction, opening into the ethmoid fovea intracranially. It then travels anteriorly below the dura within a bony sulcus which is about 9mm long. The artery then travels through the cribro-ethmoid foramen towards the anterior nasal cavity, usually antero-superior to the axilla of the middle turbinate to supply the nasal cavity. The artery supplies the anterior ethmoidal air cells and the FS. It gives rise to meningeal vessels in olfactory fossae, and supplies the anterior third of septum and lateral wall of the nose.[11]

CLINICAL IMPORTANCE OF THE ANTERIOR ETHMOIDAL ARTERY:

The AEA serves as a keystone for surgeries of base of skull and frontal recess. It can be easily damaged if not identified during FESS. Hence anatomical knowledge of the landmarks of the AEA is important and it should identified during surgery.[11]

The AEA can be divided into 3 segments: intra-orbital, intra-ethmoidal, and endocranial segments. AEA is most prone to injury in the ethmoidal segment.[2] If injured at the lateral end, it can retract into orbit causing a retro-orbital hematoma. Optic nerve compression can occur causing loss of vision. Conversely, an injury at the medial end at the site of entry of artery into lateral lamella of cribriform plate can cause CSF rhinorrhea and formation of post-surgical encephaloceles.[12]

RADIOLOGICAL ANATOMY OF THE ANTERIOR ETHMOIDAL ARTERY:

Anatomical landmarks used for identifying anterior ethmoidal artery in CT-PNS are: the bony notch on the medial orbital wall- the anterior ethmoidal foramen

(AEF), and the bony sulcus on the lateral wall of the olfactory fossa- the anterior ethmoidal sulcus (AES).[13]

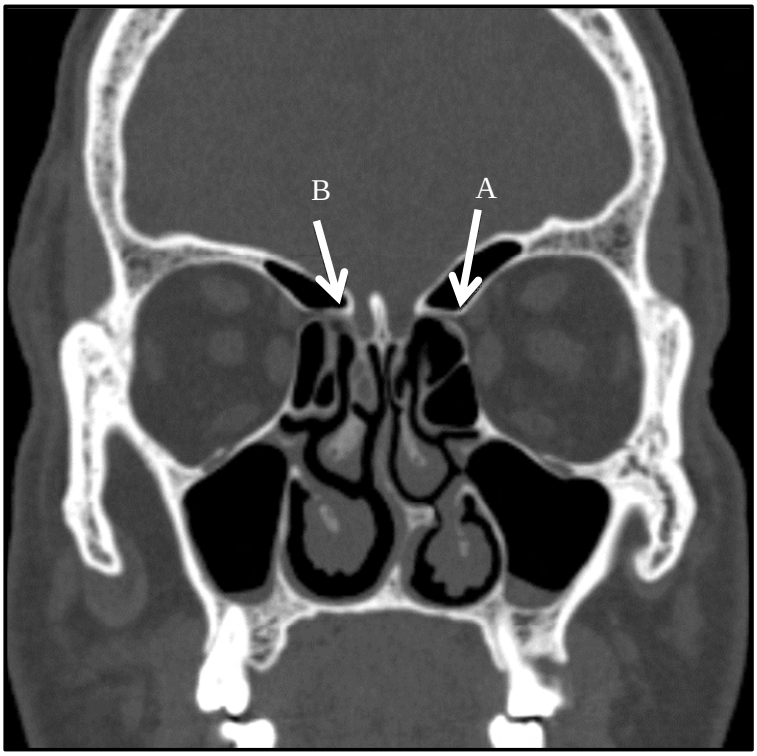


FIGURE 1: Anterior ethmoidal arteries visualised in coronal section. Anterior ethmoidal foramen is visualised on medial wall of orbit (A) and anterior ethmoidal sulcus is visualised on lateral wall of olfactory fossa (B).

AEA runs from AEF to AES in a bony canal known as the AEC. The bony part of the canal may be dehiscent, exposing the artery and raising the chances of its damage during endoscopic nasal surgery.

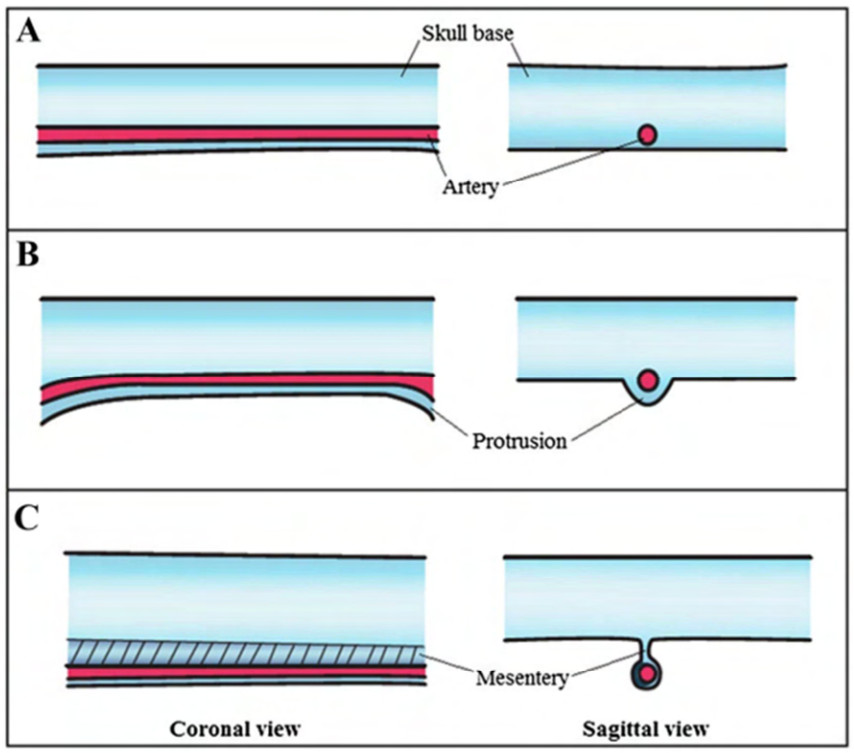
The AEA travels in between SO and MR muscles. Therefore, AEF is found medial and inferior to the SO muscle.[13] (FIGURE 1)

RELATION OF THE ANTERIOR ETHMOIDAL ARTERY TO THE SKULL BASE:

Depending on the distance of the AEA from SB and the length of AEC, it is classified as skull base, short mesentery and long mesentery. (TABLE 1, FIGURE 2,3,4,5)

TYPE	AEA CANAL TO SKULL BASE DISTANCE	LENGTH OF CANAL FROM AEF TO AES
SKULL BASE:	<2.5mm	-
SHORT MESENTERY:	2.5 – 5mm	<10mm
LONG MESENTERY:	>5mm	>10mm

TABLE 1: Classification of anterior ethmoidal artery in relation to skull base and canal length.



The variable position of anterior ethmoidal artery at skull base in coronal view and corresponding sagittal view. **a** The anterior ethmoidal artery is within skull base. **b** The anterior ethmoidal artery courses at the level of skull base producing bony protrusion. **c** The anterior ethmoidal artery courses freely in ethmoid sinus within a bony anterior ethmoidal canal and is connected to skull base by a thin bony mesentery

FIGURE 2: Variations of position of anterior ethmoidal artery at skull base and mesentery.[12]

In studies done by Lannoy-Penisson et al. and Ko et al. variations of anatomical course of AEA relative to skull base (SB) have been categorised into 3 grades. AEA is denoted Grade 1 when it is found to be included in SB, Grade 2 when it courses just below the SB and Grade 3 is when the AEA travels at a distance below the SB. Presence of a Grade 3 AEA warrants more caution during endo-nasal surgery.[12]

FIGURE 3: Bilateral anterior ethmoidal arteries in skull base position (shown with arrows)

FIGURE 4: Right anterior ethmoidal artery in short mesentery position. (shown with arrows)

FIGURE 5: Bilateral anterior ethmoidal arteries in long mesentery position. (shown with arrows)

RELATION OF ANTERIOR ETHMOIDAL ARTERY WITH SUPRAORBITAL PNEUMATISATION

When supraorbital pneumatisation is present, the AEA runs posterior to the supraorbital ethmoidal cell (SOEC).

A positive association exists between the distance at which AEA runs away from SB with presence of supraorbital pneumatisation. When supraorbital pneumatisation is present, AEA travels below SB at a greater distance away from SB as compared to when it is absent. Thus, AEA is at a higher risk of injury in cases when supraorbital pneumatisation is present.[14] (FIGURE 6)

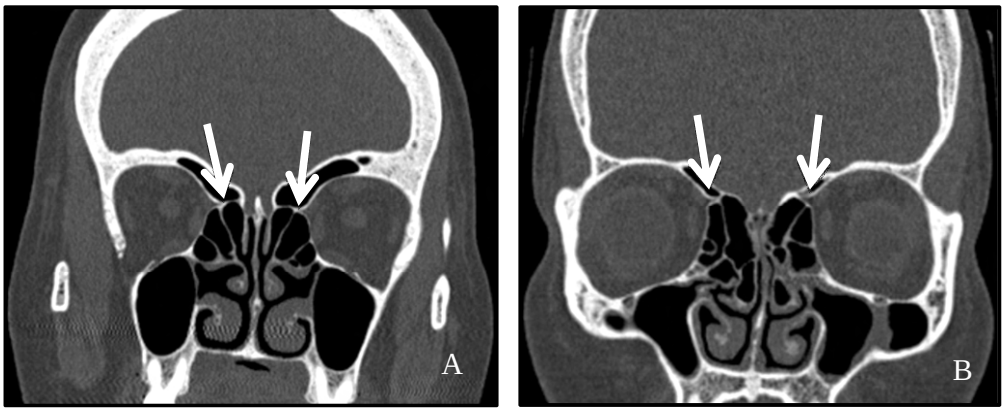


FIGURE 6: In image A, supraorbital pneumatisation is present. Anterior ethmoidal arteries are running in mesentery position. In image B, supraorbital pneumatisation is absent, anterior ethmoidal arteries are running close to skull base.

RELATION OF ANTERIOR ETHMOIDAL ARTERY WITH FRONTAL SINUS DEVELOPMENT:

Gumus and Yildirim defined hyper-pneumatized or well developed frontal sinuses as sinuses which have undergone pneumatisation along the orbital plate and the squamous part of frontal bone. Hypo-pneumatized or rudimentary sinuses are sinuses not exceeding 6mm in anteroposterior diameters with failure of pneumatisation till the squamous part of frontal bone. It is found that as the degree of pneumatisation of the frontal sinuses increases, the AEA runs at a larger distance from the SB. In cases where the frontal sinus development is rudimentary, the AEA runs within the SB.[2]

POSTERIOR ETHMOIDAL ARTERY(PEA):

The PEA arises from ophthalmic artery and supplies superior part of septum of nose and lateral nasal wall, ethmoid sinus and sphenoid sinus. It travels in a bony canal at a close distance away from optic nerve. Ligation of PEA helps achieve haemostasis during uncontrolled epistaxis and helps minimize blood loss in surgery of SB meningiomas.[15]

ANATOMICAL COURSE OF THE POSTERIOR ETHMOIDAL ARTERY:

PEA arises from ophthalmic artery in the posterior third of the orbit, passes through the orbital canal and emerges at the intersection of posterior ethmoid sinuses and sphenoid roof.[15]

PEA shows variations at its site of origin. It can arise from 3rd part of ophthalmic artery (5%), or even from 2nd part of ophthalmic artery (5%). In some cases, it can originate from AEA or from middle meningeal arteries as well.[15]

After emerging from orbital canal, it travels upwards and backwards, between superior rectus and SO muscles, passing through the medial orbital wall to finally enter the posterior ethmoidal canal (PEC). The PEA enters into its canal located at an angle with SB ranging from 0° and 18°. The PEA is closely related to optic nerve: the distance between the two ranges from 4 to 16mm.[15]

It terminates in the posterior part of lateral wall of nose. In the septum, branches of PEA along with AEA, superior labial artery and naso-palatine arteries form the Kisselbach area. It also irrigates the sphenoid sinus and dura mater overlying the ethmoid sinus.[15]

RADIOLOGICAL ANATOMY OF POSTERIOR ETHMOIDAL ARTERY:

PEA traverses the ethmoid roof, above and in front of sphenoid sinus. The PEC is noted running above SO muscle. These landmarks help to locate and identify the PEA in CT-PNS.[11] (FIGURE 7)

FIGURE 7: The posterior ethmoidal artery is noted running in its bony canal in the SB, superior to superior oblique muscle (shown by arrow).

The PEA runs in its bony canal mostly within the SB. It may also run in the mesentery position. Depending on the position and the distance of the PEC from SB in mesentery position, it can be classified as short mesentery and long mesentery. In a majority of patients, the PEA run in SB, however it may be found in mesentery position in some patients, which makes it prone for injury during FESS surgery. (TABLE 2, FIGURE 8,9) [1]

TYPE	POSTERIOR ETHMOIDAL ARTERY TO SKULL BASE DISTANCE
SHORT MESENTERY:	<1mm
LONG MESENTERY:	>1mm

TABLE 2: Classification of the posterior ethmoidal artery in relation to skull base

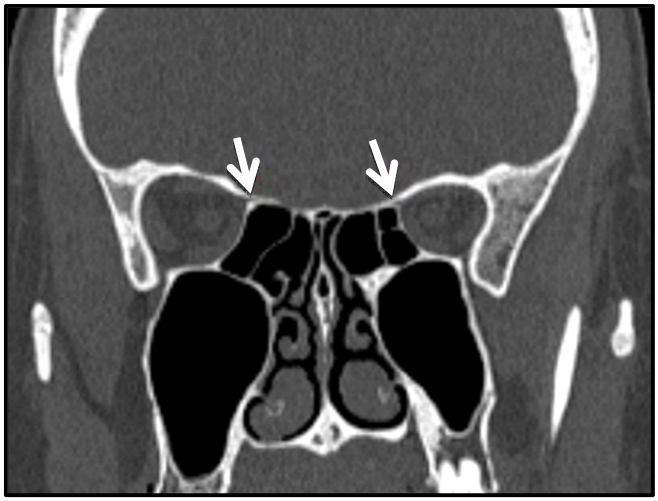


FIGURE 8: Bilateral posterior ethmoidal arteries in skull base position (shown by arrows)

FIGURE 9: Bilateral posterior ethmoidal arteries in mesentery position. (shown with arrows)

MIDDLE ETHMOIDAL ARTERY (MEA):

The AEA and PEA have been extensively studied and are useful landmarks in endonasal surgeries of the anterior skull base. In some studies, vessels located neither behind the PEA nor in front of the AEA were found, hence were labelled as "middle" ethmoidal arteries. The MEA has a variable location in the nasal cavity between AEA and PEA, and it enters the nose through an independent bony foramen.[16]

A cadaver study found MEA to be present in 31.8%–33% of nasal cavities examined. It irrigates the nasal septum and the ethmoidal air cells. It has been found that there is a higher incidence of presence of unilateral MEA than presence of middle ethmoidal arteries on both sides.[4]

Wang et al in his paper titled "Endoscopic anatomy of the middle ethmoidal artery" described the appearance of MEA on nasal endoscopy which is summarised below:[17]

1. The MEA traverses the ethmoidal fovea within the middle ethmoidal canal, forming a ridge on skull base.
2. The thickness of the bony canal of MEA is more than that of AEA, making its identification difficult.
3. MEA traverses in a horizontal plane from orbit to SB.
4. MEA appears shorter and thinner in size than AEA.
5. It is most commonly located midway between AEA and PEA and occasionally is even closer to PEA.

"The average distance between AEA to MEA is 8.1 ± 1.52mm and MEA to PEA is 5.5 ± 1.29mm." The MEA is seen most commonly hidden within a bony canal in the SB, and less commonly seen with a mesentery. (FIGURE 10,11) [18]

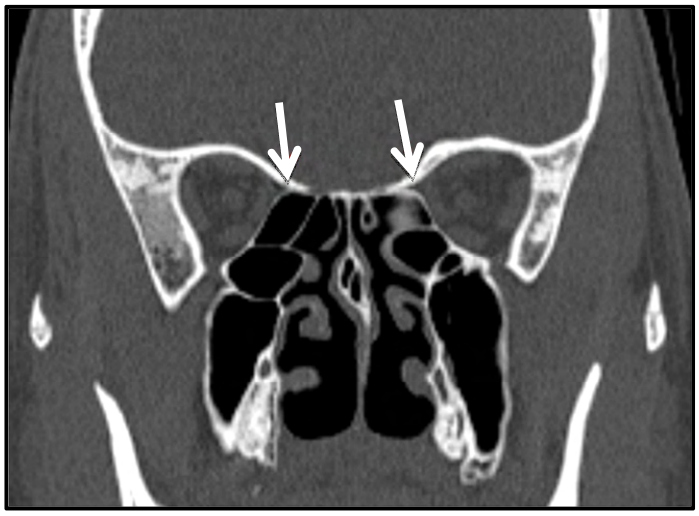


FIGURE 10: Coronal section of CT PNS showing presence of bilateral middle ethmoidal arteries in skull base position. (shown by arrows)

FIGURE 11: Coronal section of CT PNS showing left middle ethmoidal artery in mesentery position. (shown by arrows)

CLINICAL SIGNIFICANCE OF MIDDLE ETHMOIDAL ARTERY:

Identification and anatomical knowledge of MEA is important in endonasal and orbital surgeries for control of bleeding, as damage to the vessels can cause retraction of the artery and uncontrollable bleeding. In uncontrolled epistaxis, it is important to identify and ligate all ethmoidal arteries. Anterior skull base lesions are now commonly managed by endoscopic endonasal surgery. The ethmoidal arteries supplying the meninges in the region of anterior skull base may be larger in size in cases with tumours arising in this region. For achieving good haemostasis, it important to identify the presence of MEA and ligate all the ethmoidal arteries.[17]

FUNCTIONAL ENDOSCOPIC SINUS SURGERY (FESS):

The aims of the surgery are to normalise aeration of the sinuses, enlarge sinus ostia for better drainage and improve mucociliary clearance. It was devised by Stammberger wherein the surgery is performed stepwise from anterior to posterior direction, systematically entering every paranasal sinus and clearing the disease.[18]

The indications of FESS are:

- Chronic sinusitis
- Nasal polyps
- Fungal sinusitis
- Sinonasal tumours
- As a part of endonasal approach to approach to orbit and optic canal
- As a part of anterior skull base surgery

In FESS, the ethmoidal arteries can be visualised after complete exposure of the fovea ethmoidalis. The steps to visualise the ethmoidal arteries are described

henceforth. After uncinectomy, the cells along the drainage pathway of the frontal sinus are removed till the frontal beak. Frontal sinusotomy is performed followed by excision of the bulla ethmoidalis. This exposes the fovea ethmoidalis and the AEA can be visualised within. The ground lamella is removed and the posterior ethmoidal air cells are cleared. Resection of the superior turbinate ground lamella is done to visualise the spheno-ethmoidal recess. Between the posterior ethmoidal air cells and the spheno-ethmoidal recess, runs the PEA. The MEA is identified as an accessory foramen between the anterior and posterior ethmoidal foramina.[19]

MATERIALS AND METHODS

Source of Data:

Patients undergoing Computed Tomography of the Paranasal Sinuses at the Department of Radiology, KLE'S Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi.

Study Design:

Cross Sectional Study (Observational Study)

Study Period:

1 year

Sample Size:

Sample Size:60

Sample Size Formula:

The minimum sample size formula based on prevalence rate is

$$n = \frac{z_\alpha^2 P(1-P)}{d^2}$$

where P is the prevalence rate of presence of anterior ethmoidal artery in skull base and d is the percentage likely difference in the prevalence.

z_α is linked with the level of significance. For 5% level of the significance $z_\alpha = 1.96$.

Ref: Amarnath SB, Suresh Kumar P. Study of variants of anterior ethmoidal artery on computed tomography of paranasal sinuses. International Journal of Otorhinolaryngology and Head and Neck Surgery. 2018 Dec 25;5(1):19. [2]

With P = 50.75% and d = 25% of P = 12.69%, the sample size is 60.

Sampling technique:

Patients presenting to the Department of Otorhinolaryngology & Head and Neck Surgery with complaints of nose block, headache, frequent colds, who are planned for DNE/FESS/Septoplasty are selected for the study.

After taking informed consent from the patient, their details and a thorough clinical history will be obtained for compliance with inclusion and exclusion criteria.

Inclusion Criteria:

1) Age above 18 years at the time the imaging was done.

2) Well-formed paranasal sinuses.

3) No history of previous sinus surgery/trauma/injury.

Exclusion Criteria:

1) Patients aged below 18 years.

2) A history of surgery or trauma in the paranasal sinuses or the skull base.

3) Congenital anomalies of the face.

4) Underdeveloped paranasal sinuses.

5) Paranasal sinus malignancies, bony or fibrotic lesions.

Study protocol:

Patients presenting to the Department of Otorhinolaryngology & Head and Neck Surgery with complaints of nose block, headache, frequent colds, who are planned for DNE/FESS/Septoplasty are selected for the study.

After taking informed consent from the patient, their details and a thorough clinical history will be obtained for compliance with inclusion and exclusion criteria.

All patients will be clinically examined including general physical examination and careful examination of the ear, nose and throat.

The patient will then undergo Computed Tomography Scan of the Paranasal Sinuses in the Department of Radiology at KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre.

Data collection procedure:

- The RadiAnt DICOM viewer will be used to view CT scans and evaluate CT images. The scan is studied in axial view for the presence of AEA, MEA and PEA, which is confirmed in sagittal and coronal view.

- Once identified, the distances between the arteries and the skull base were measured on a coronal plane. The presentation of the arteries whether in a bony canal, a short mesentery or long mesentery is documented.

- AEA is evaluated in all scans with respect to the important anatomical landmarks like medial orbital wall, superior oblique muscle, suprabullar cells, suprabullar recess, and anterior ethmoid recess.

- PEA is evaluated in all scans with respect to landmarks such as medial orbital wall, superior oblique muscle, and optic eminence of sphenoid bone.

- MEA is evaluated in all scans with respect to its distance from skull base, its distance from AEA and PEA.

- Anatomy of the arteries are studied, its relations with the various landmarks are assessed and compared with the results of other studies.

- Scans are studied in coronal, axial and sagittal views and analysis is done to determine which view is best for identification and study of each ethmoidal artery.

Data processing and analysis/statistical analysis:

Since the study is an observational study the plan of analysis will be as follows.

For the continuous quantitative variables, mean and standard deviation will be calculated. For the purpose of comparison, if the data is divided into two groups with respect to certain qualitative characteristic, the continuous variables will be compared using suitable tools of statistics like student's unpaired 't' test. The pre and post treatment measures will be compared using student's paired 't' test.

Discrete variables will be represented by median.

The categorical data will be expressed in terms of rates, ratios and percentages. The association between the outcome, clinical and demographic characteristics will be tested using Chi-square test, test of proportion or Fisher's exact test.

For discrete variables nonparametric tests will be used.

Apart from the above suitable tools like ANOVA, correlation, regression etc., will be used according to the need.

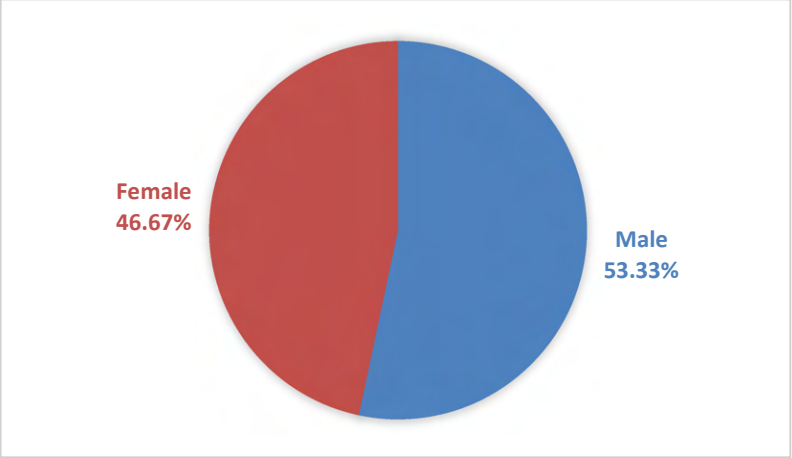
Suitable graphs will be used to depict the comparison.

For all the tests the value of p less than 5% (0.05) will be considered significant.

RESULTS

CT-PNS scans of 60 patients were studied in the Department of Otorhinolaryngology and Head & Neck Surgery of KAHER's Jawaharlal Nehru Medical College from October 2022 to September 2023. All recorded observations are described under following headings.

Gender distribution



GRAPH 1: Gender distribution of the sample

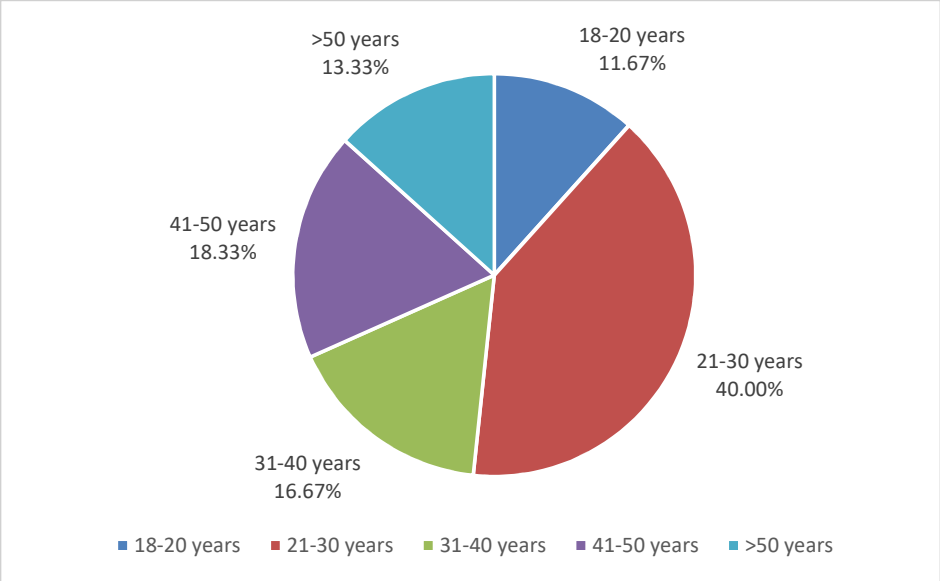
Gender	Number	Percentage (%)
Female	28	46.67
Male	32	53.33
Total	60	100.00

TABLE 3: Gender distribution of the sample

A total of 60 scans were studied. There were 32 males (53.33%), and 28 females (46.67 %) (GRAPH 1, TABLE 3).

Age distribution of sample:

The patients were aged from 18– 72 years, with a mean age of 34.45 years, with youngest being 18 years of age and oldest being 72 years of age.



GRAPH 2: Age distribution of the sample

Age group (in years)	Number	Percentage (%)
18-20	7	11.67
21-30	24	40.00
31-40	10	16.67
41-50	11	18.33
>50	8	13.33
Total	60	100.00
Mean (in years)	34.45	
SD (in years)	14.30	

TABLE 4: Age distribution of the sample

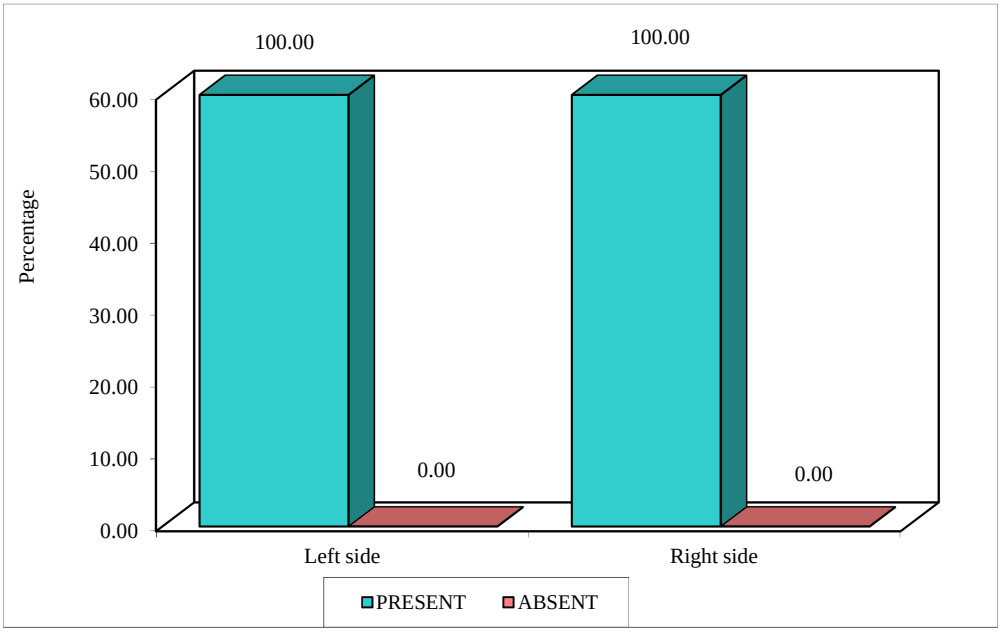
In this study population, the mean age was 34.45 years.

Among the study population, 7 cases were aged less than 20 years (11.67%), 24 cases between 21 to 30 years (40%), 10 cases were aged between 31 to 40 years (16.67%), 11 cases were aged between 41 to 50 years (18.33%), and 08 cases were above 50 years (13.33%). (GRAPH 2, TABLE 4)

On plotting the age distribution of samples there was a maximum concentration of the samples between the ages of 21-30 years followed by 41-50 years.

ANTERIOR ETHMOIDAL ARTERY (AEA):

Incidence of AEA in left and right nasal cavity is shown below:



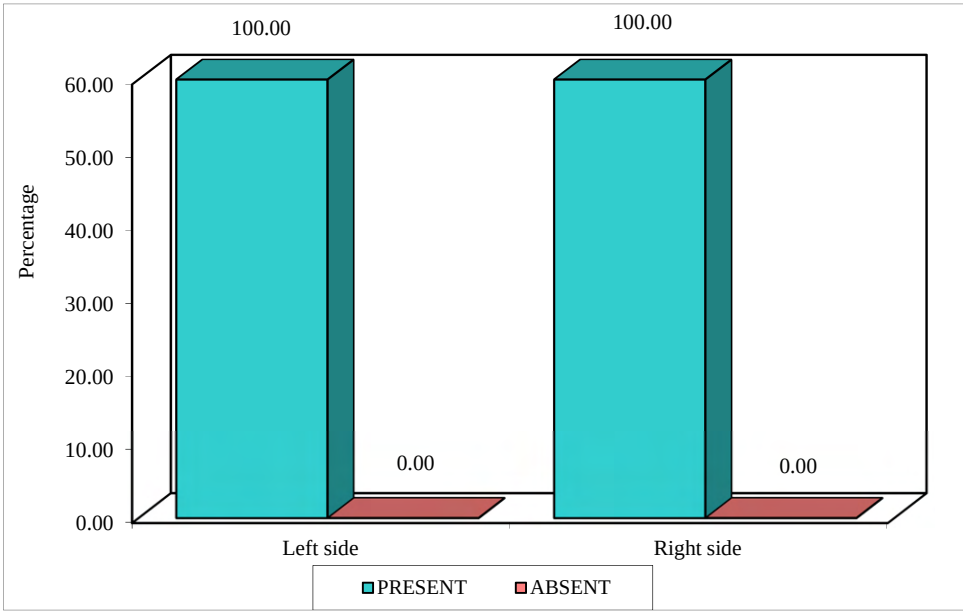
GRAPH 3: Comparison of presence of AEA in left and right nasal cavity

	PRESENT	ABSENT	TOTAL
LEFT	60/60 (100%)	0/60 (0%)	60/60 (100%)
RIGHT	60/60 (100%)	0/60 (0%)	60/60 (100%)
TOTAL	120/120 (100%)	0/120 (0%)	120/120 (100%)

TABLE 5: Comparison of presence of AEA in left and right nasal cavity

AEA were present in 100% of the computed tomography scans. (GRAPH 3, TABLE 5).

Distribution of presence of bony notch in medial wall of orbit (AEF) in left and right nasal cavity is shown below:



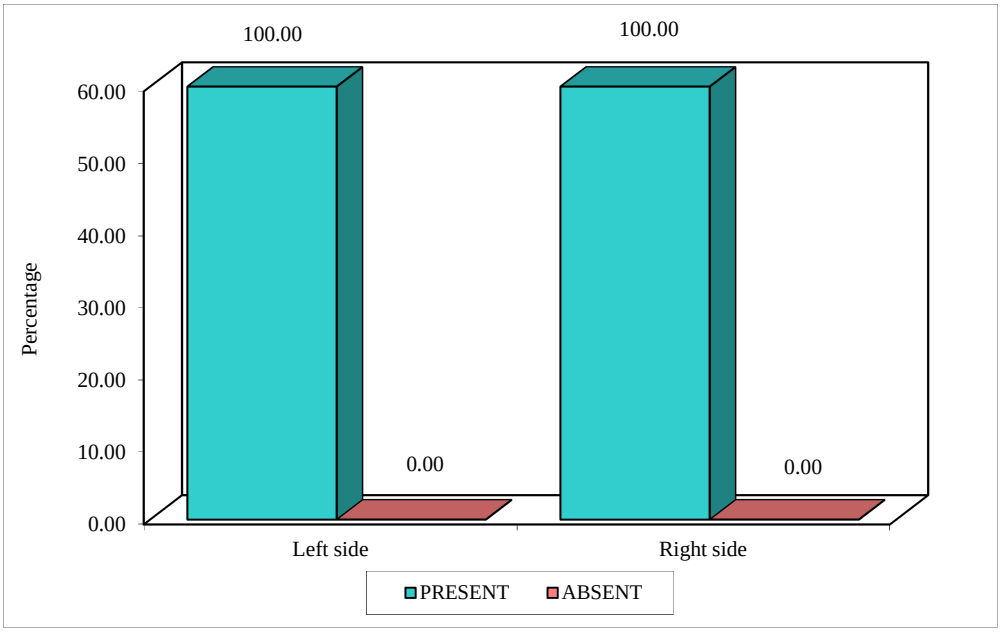
GRAPH 4: Comparison of presence of bony notch in medial wall of orbit (AEF) in left and right nasal cavity

	LEFT	RIGHT	TOTAL
PRESENT	60/60 (100%)	60/60 (100%)	120/120 (100%)
ABSENT	0/60 (0%)	0/60 (0%)	0/120 (0%)
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)

TABLE 6: Comparison of presence of bony notch in medial wall of orbit (AEF) in left and right nasal cavity

Anterior ethmoidal foramen (AEF) was found on both sides in all the scans studied. (GRAPH 4, TABLE 6)

The distribution of bony notch in lateral wall of olfactory fossa (AES) in left and right nasal cavity is shown below:



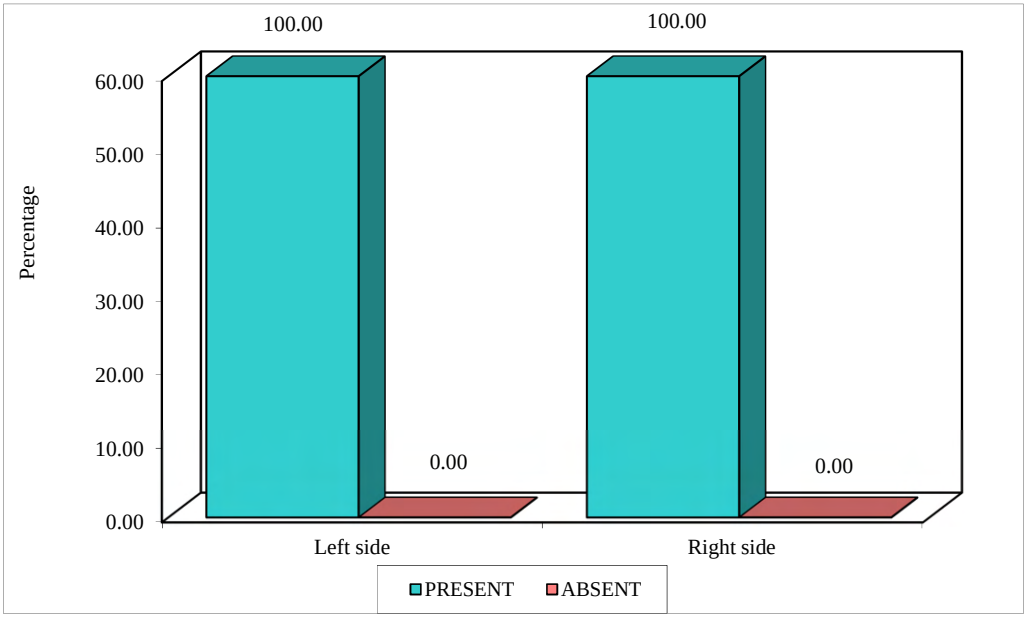
GRAPH 5: Comparison of presence of bony notch in lateral wall of olfactory fossa (AES) in left and right nasal cavity

	LEFT	RIGHT	TOTAL
PRESENT	60/60 (100%)	60/60 (100%)	120/120 (100%)
ABSENT	0/60 (0%)	0/60 (0%)	0/120 (0%)
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)

TABLE 7: Comparison of presence of bony notch in lateral wall of olfactory fossa (AES) in left and right nasal cavity

The bony notch in lateral wall of nasal cavity which corresponds to anterior ethmoidal sulcus (AES) was found on both sides in all the scans studied. (GRAPH 5, TABLE 7)

The anatomical relation of the AEC was studied with respect to SO muscle in left and right nasal cavity are shown below:



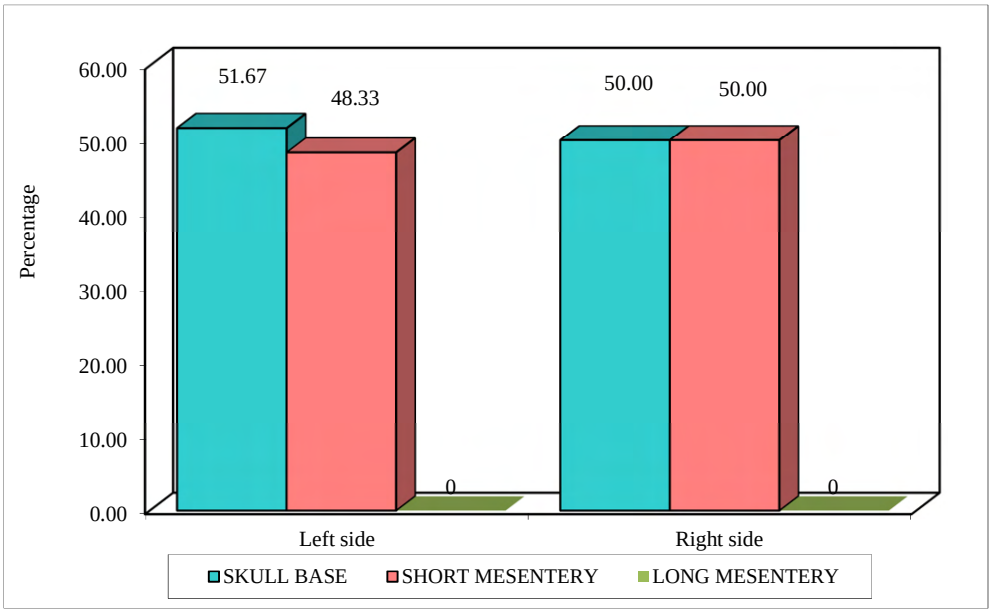
GRAPH 6: Comparison of presence of AEC on lower edge of superior oblique muscle in left and right nasal cavity

AEC PRESENT ON LOWER EDGE OF SUPERIOR OBLIQUE MUSCLE	LEFT	RIGHT	TOTAL
PRESENT	60/60 (100%)	60/60 (100%)	120/120 (100%)
ABSENT	0/60 (0%)	0/60 (0%)	0/120 (0%)
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)

TABLE 8: Comparison of presence of AEC on lower edge of superior oblique muscle in left and right nasal cavity

The AEC was found at lower edge of SO muscle in both sides in all the scans studied. (GRAPH 6, TABLE 8)

The distribution of position of AEA with skull base in left and right nasal cavity is shown below:



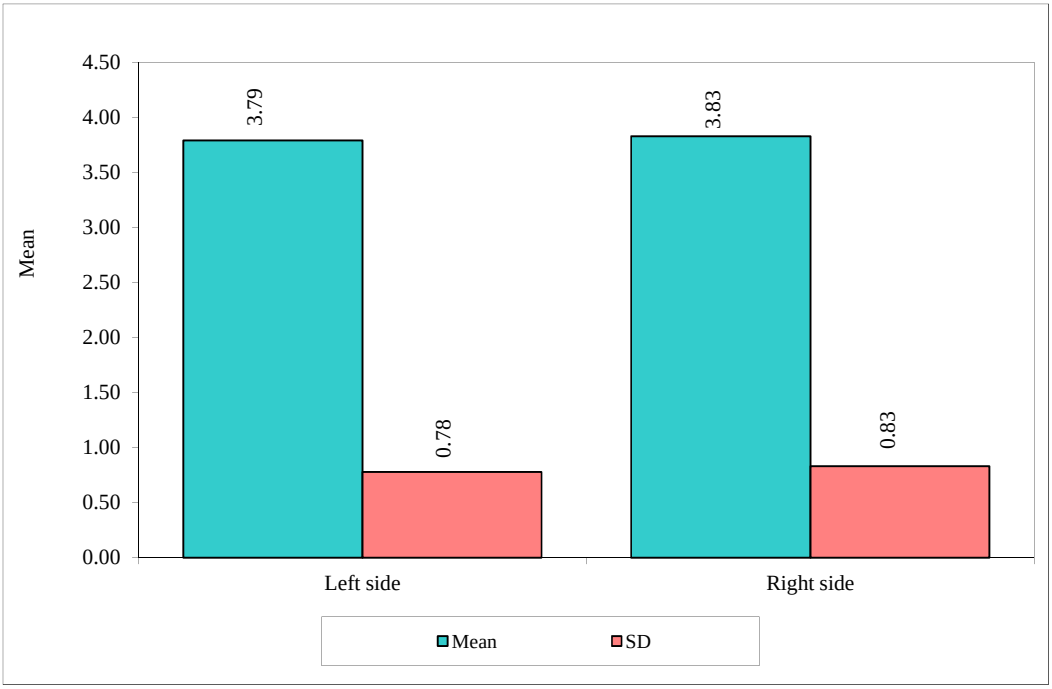
GRAPH 7: Comparison of type of AEA between left side and right side

	LEFT	RIGHT	TOTAL	Mc Nemar
SKULL BASE	31/60 (51.67%)	30/60 (50%)	61/120 (50.83%)	P= 1.000
SHORT MESENTERY	29/60 (48.33%)	30/60 (50%)	59/120 (49.17%)	
LONG MESENTERY	0/60 (0%)	0/60 (0%)	0/60 (0%)	
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)	

TABLE 9: Comparison of type of AEA between left side and right side

Of total number of AEA examined, 50.83% ran in the skull base, 49.17% had short mesentery and 0% had long mesentery. (GRAPH 7, TABLE 9)

In cases where the arteries were in mesentery position, the distance of the artery from the SB and the distance of the AEF to AES was studied.

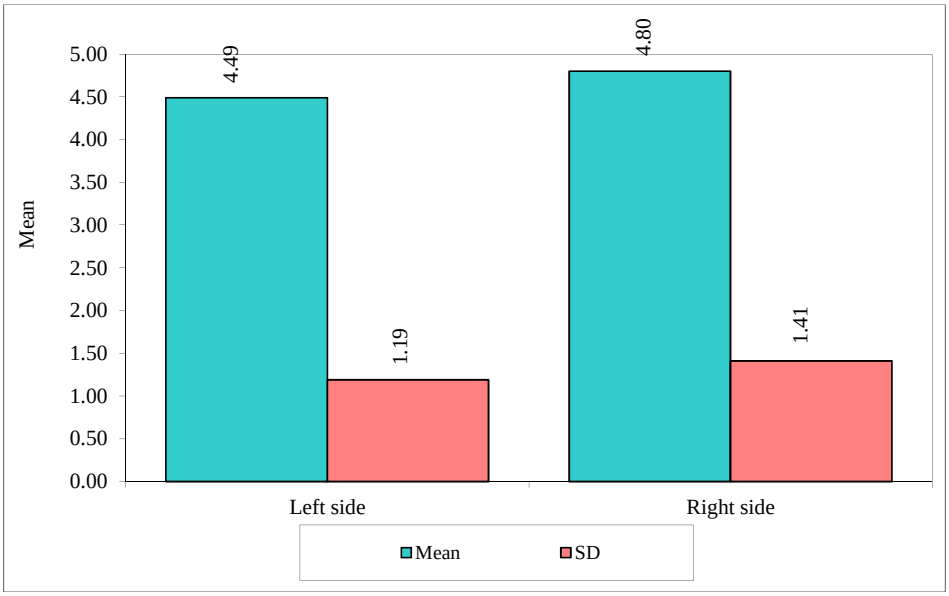


GRAPH 8: Comparison of mean distance of AEC from SB on left and right side

SIDE	MEAN DISTANCE (IN MM)	STANDARD DEVIATION (IN MM)	T VALUE	P VALUE
LEFT	3.79	0.78	-0.6683	0.5066
RIGHT	3.83	0.83		

TABLE 10: Comparison of mean distance of AEC from SB on left and right side (by dependent 't' test)

The mean distance of AEC from SB is 3.79mm on left and 3.83mm on right side. Average distance of AEC from SB across both sides was found to be 3.81mm, ranging from 2.64mm to 4.98mm. The p value was calculated to be 0.5066 indicating no significant difference in the average distance of AEC to SB between left and right sides. (GRAPH 8, TABLE 10)



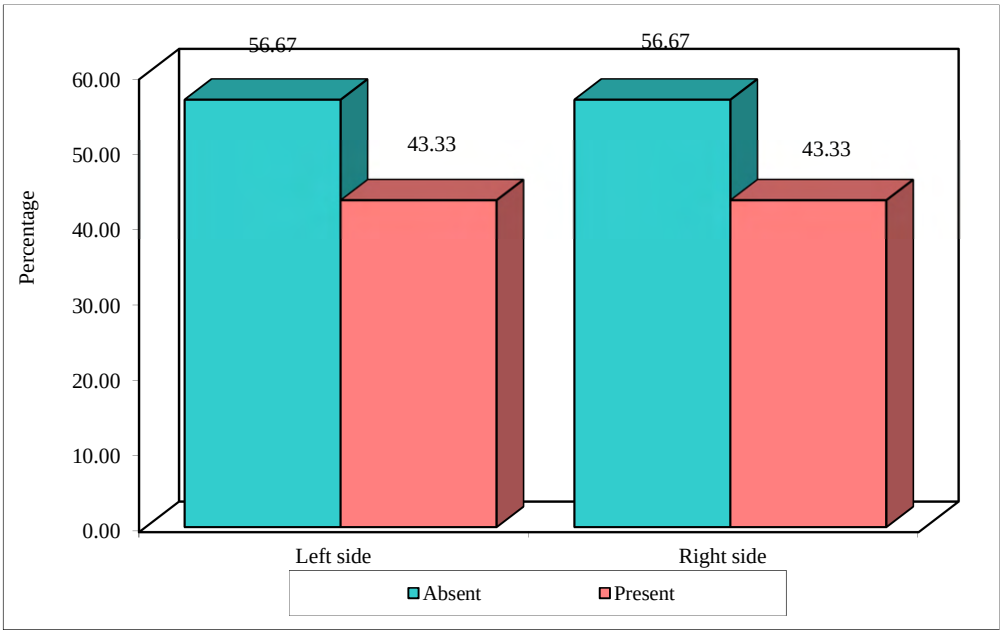
GRAPH 9: Comparison of mean length of AEC from AEF to AES on left and right side

SIDE	MEAN DISTANCE (IN MM)	STANDARD DEVIATION	Z VALUE	P VALUE
LEFT	4.49	1.19	1.6382	0.1014
RIGHT	4.80	1.41		

TABLE 11: Comparison of mean length of AEC from AEF to AES on left and right side by Wilcoxon matched pairs test

In mesentery position, average distance of AEF to AES was 4.49mm on left and 4.80mm on right side. Average distance of AEF to AES on both sides was found to be 4.62mm. The range of distance was found to be from 2.02mm to 7.71mm. The p value was calculated to be 0.1014 indicating no significant difference in mean length of AEC from AEF to AES across both sides. (GRAPH 9, TABLE 11)

Relationship of AEA with supraorbital pneumatisation:



GRAPH 10: Comparison of presence of supraorbital pneumatisation on left and right side

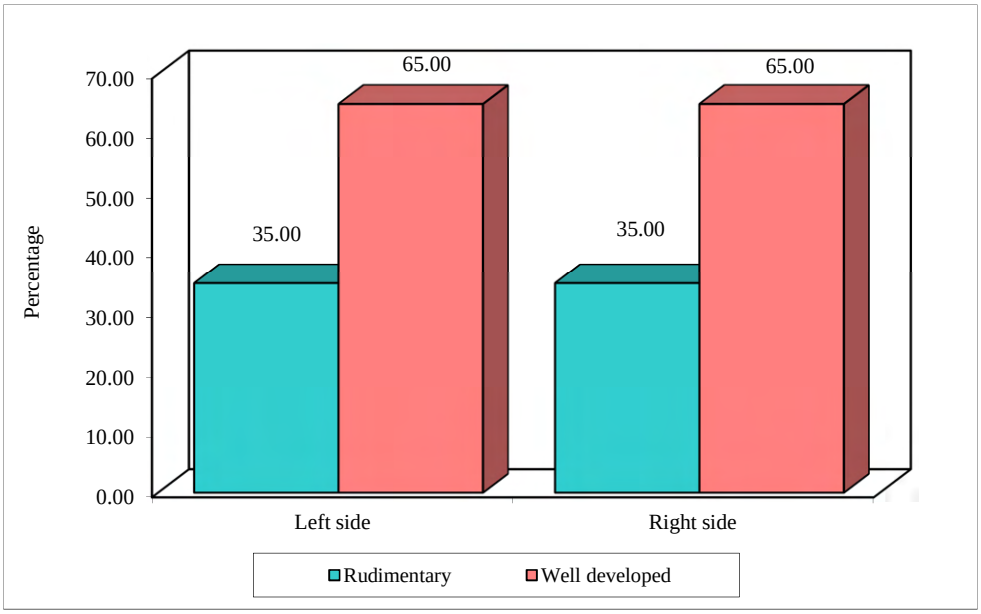
PRESENT	52/120	43.33%
ABSENT	68/120	56.67%

TABLE 12: Comparison of presence of supraorbital pneumatisation on left and right side

Supraorbital pneumatisation was present in 43.33% of the nasal cavities that were examined. (GRAPH 10, TABLE 12)

In cases where supraorbital pneumatisation was present, anatomical position of AEA with SOEC was studied. It was found to be identifiable on posterior wall of the supraorbital ethmoidal air cell in all cases where supraorbital pneumatisation was present.

Relationship of anatomy of AEA with development of the FS:



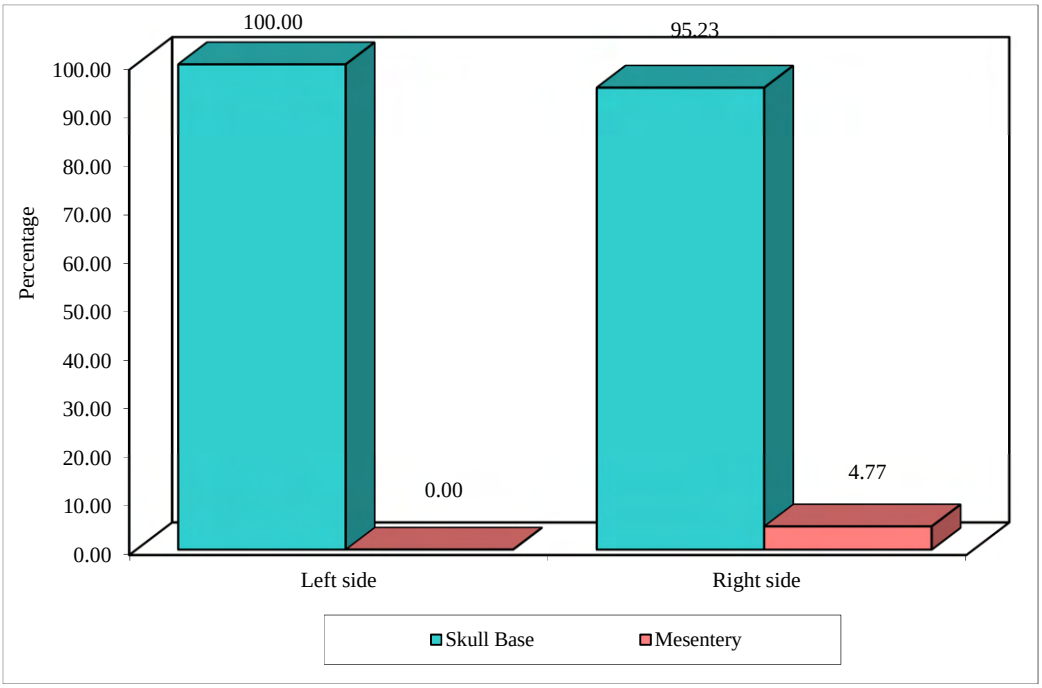
GRAPH 11: Comparison of development of FS on left and right side

	RUDIMENTARY	WELL DEVELOPED
LEFT	21/60 (35%)	39/60 (65%)
RIGHT	21/60 (35%)	39/60 (65%)
TOTAL	42/120 (35%)	78/120 (65%)

TABLE 13: Comparison of development of FS on left and right side

The FS was well developed in 65% of all sides examined. The development was rudimentary in 35% of all sides examined. (GRAPH 11, TABLE 13)

In cases where the FS development was rudimentary, the relation of the AEA with the SB was studied.



GRAPH 12: Comparison of position of AEA with SB when FS is rudimentary on left and right side

	SKULL BASE	MESENTERY
LEFT	21/21 (100%)	0/21 (0%)
RIGHT	20/21 (95.23%)	1/21 (4.77%)
TOTAL	41/42 (97.62%)	1/42 (2.38%)

TABLE 14: Comparison of position of AEA with SB when FS is rudimentary on left and right side

In cases where the FS development was rudimentary, the AEA was found run in SB in 97.62% of the cases. (GRAPH 12, TABLE 14)

AEA was best visualized in:

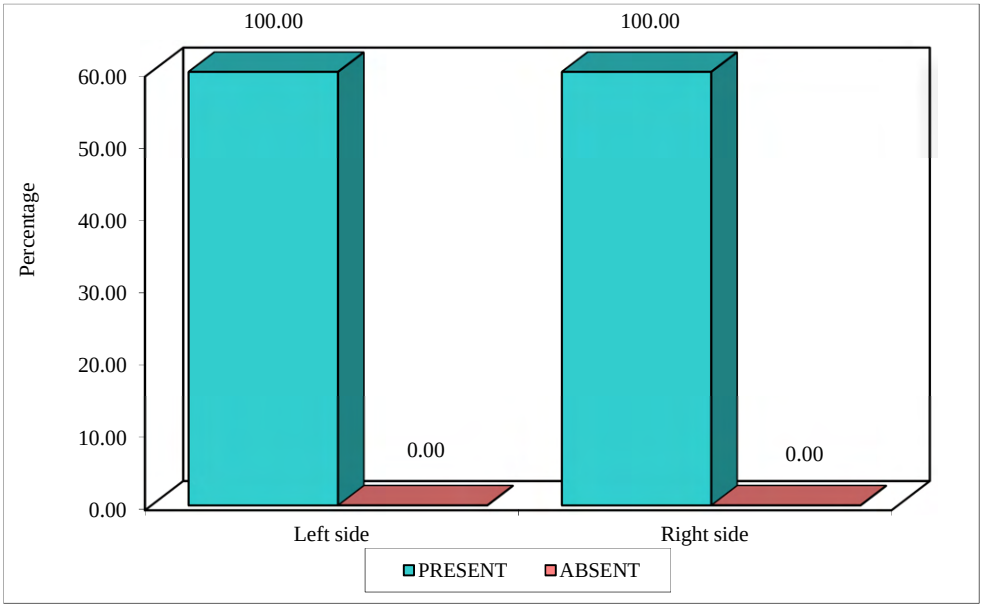
SECTION	
CORONAL	120/120 (100%)
AXIAL	0/120 (0%)
SAGGITAL	0/120 (0%)

TABLE 15: Section of the CT scan in which AEA was best visualized

The AEA was best visualized in coronal section in all the scans. (TABLE 15)

POSTERIOR ETHMOIDAL ARTERY (PEA):

The distribution of presence of PEA in the left and right nasal cavity is shown below:



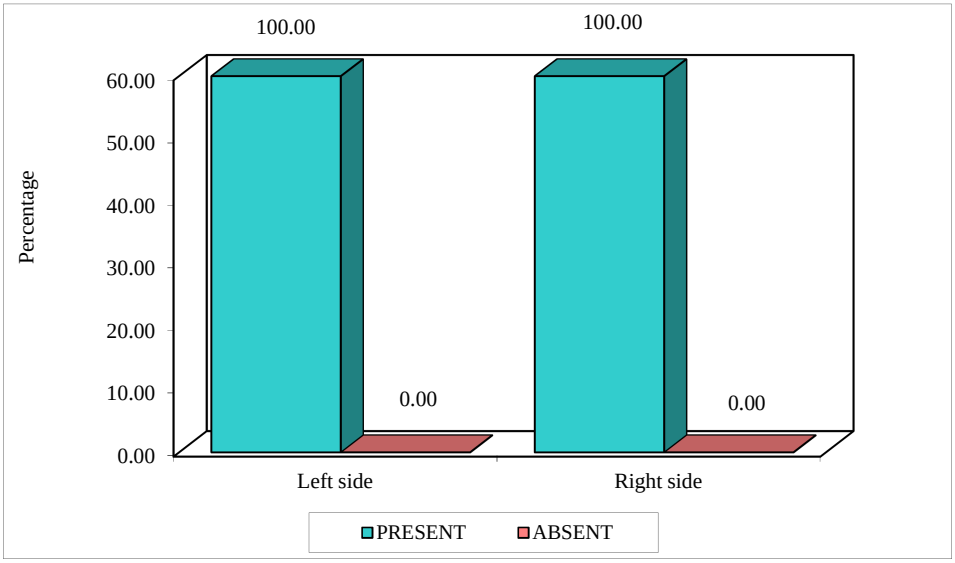
GRAPH 13: Comparison of presence of PEA in left and right nasal cavity

	PRESENT	ABSENT	TOTAL
LEFT	60/60 (100%)	0/60 (0%)	60/60 (100%)
RIGHT	60/60 (100%)	0/60 (0%)	60/60 (100%)
TOTAL	120	0	120

TABLE 16: Comparison of presence of PEA in left and right nasal cavity

PEA were present in 100% of the computed tomography scans. (GRAPH 13, TABLE 16)

The anatomical relation of the PEC was studied with respect to SO muscle in left and right nasal cavity are shown below:



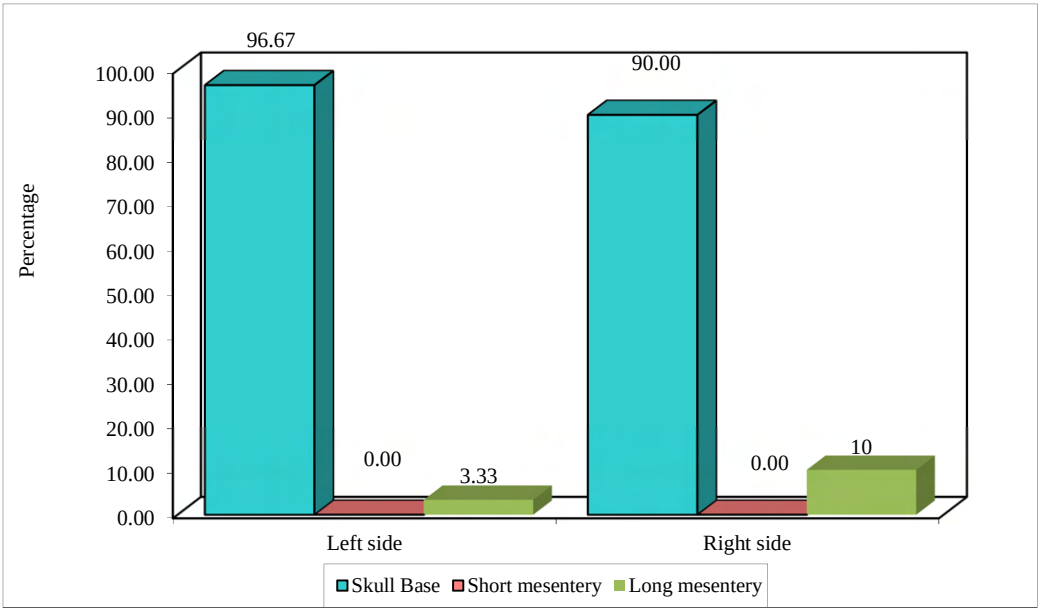
GRAPH 14: Comparison of presence of PEC superior to superior oblique muscle in left and right nasal cavity

PEC PRESENT SUPERIOR TO SUPERIOR OBLIQUE MUSCLE	LEFT	RIGHT	TOTAL
PRESENT	60/60 (100%)	60/60 (100%)	120/120 (100%)
ABSENT	0/60 (0%)	0/60 (0%)	0/120 (0%)
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)

TABLE 17: Comparison of presence of PEC superior to SO muscle in left and right nasal cavity

The PEC was found to be above SO muscle in all sides in all scans studied. (GRAPH 14, TABLE 17)

The distribution of the position of PEA in relation to SSB in left and right nasal cavity is shown below:



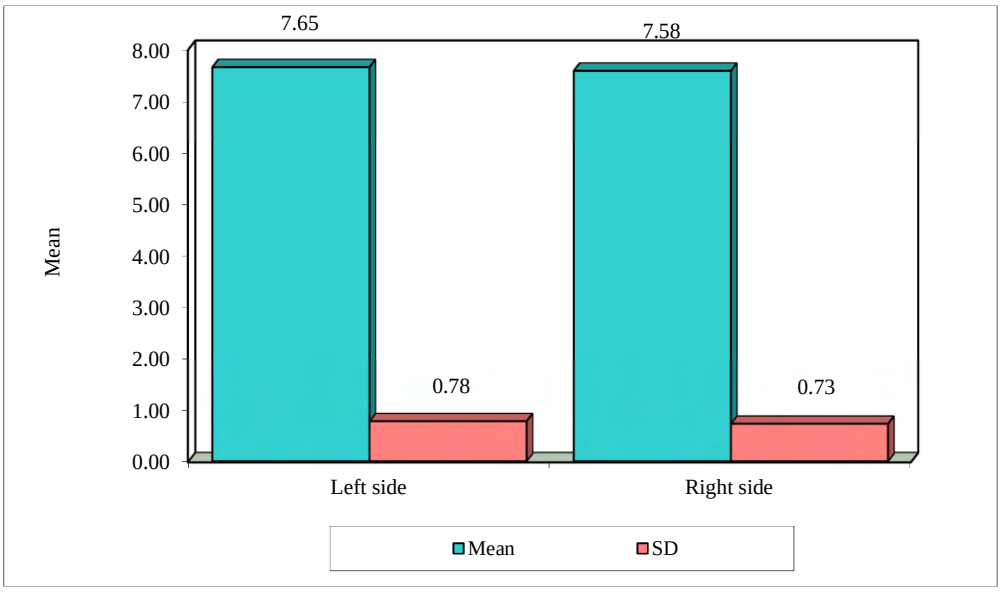
GRAPH 15: Comparison of the position of PEA in relation to SB in left and right side.

	LEFT	RIGHT	TOTAL
SKULL BASE	58/60 (98.67%)	54/60 (90%)	112/120 (93.33%)
SHORT MESENTERY	0/60 (0%)	0/60 (0%)	0/120 (0%)
LONG MESENTERY	02/60 (3.33%)	06/60 (10%)	8/120 (6.67%)
TOTAL	60/60 (100%)	60/60 (100%)	120/120 (100%)

TABLE 18: Comparison of the position of PEA in relation to SB in left and right side.

Of all PEA examined in this study, 93.33% were found to run in the SB, and 6.67% had a long mesentery. (GRAPH 15, TABLE 18)

The distance of the PEA from the optic canal was studied.



GRAPH 16: Comparison of mean distance of PEA from the optic canal on left and right side

SIDE	MEAN DISTANCE (IN MM)	STANDARD DEVIATION	Z VALUE	P VALUE
LEFT	7.65	0.78	0.9719	0.3311
RIGHT	7.58	0.73		

TABLE 19: Comparison of mean distance of PEA from the optic canal on left and right side by Wilcoxon matched pairs test

The average distance of PEA from the optic canal was 7.65mm on left and 7.58mm on right side. The average distance of PEA from the optic canal on both sides was 7.62mm. The range of distance was found to be from 6mm to 9.8mm. The p value was calculated to be 0.3311; there is no significant difference in mean distance of PEA from optic canal between left and right sides. (GRAPH 16, TABLE 19)

PEA was best visualized in:

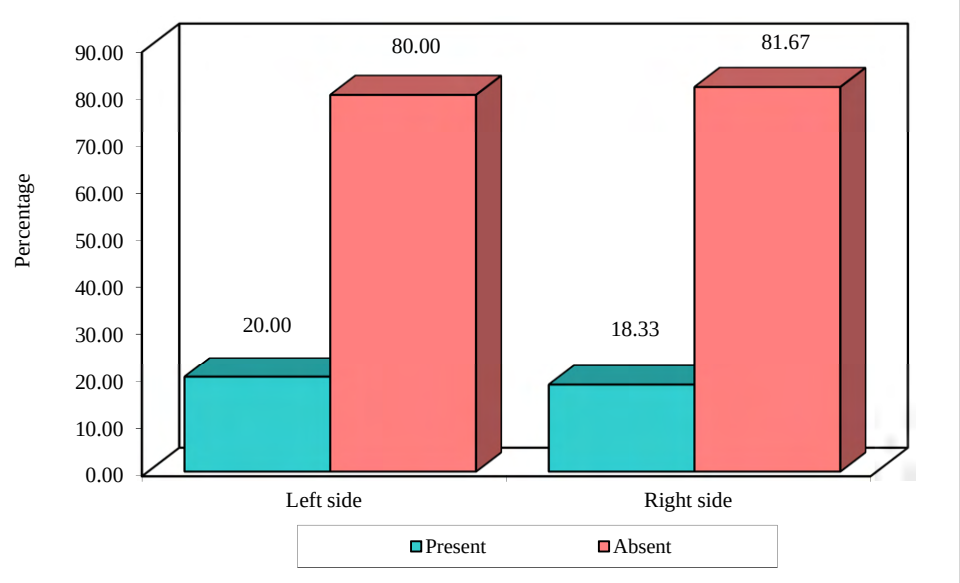
SECTION	
CORONAL	120/120 (100%)
AXIAL	0/120 (0%)
SAGGITAL	0/120 (0%)

TABLE 20: Section of the CT scan in which PEA was best visualized

The PEA was best visualized in coronal section in all the scans. (TABLE 20)

MIDDLE ETHMOIDAL ARTERY (MEA):

The distribution of presence of MEA in the left and right nasal cavity is shown below:



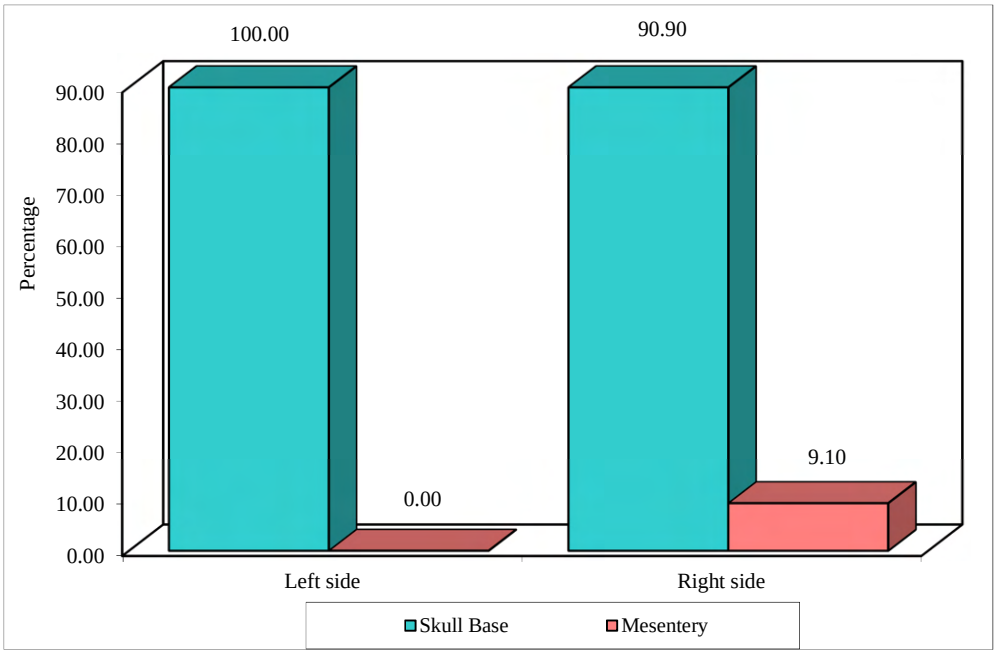
GRAPH 17: Comparison of presence of MEA between left side and right side

	PRESENT	ABSENT
LEFT	12/60 (20%)	48/60 (80%)
RIGHT	11/60 (18.33%)	49/60 (81.67%)
TOTAL	23/120 (19.16%)	97/120 (80.83%)

TABLE 21: Comparison of presence of MEA between left side and right side

MEA were present in 19.16% of the sides assessed in all the CT-PNS scans studied. (GRAPH 17, TABLE 21)

The distribution of position of MEA with skull base in left and right nasal cavity is shown below:



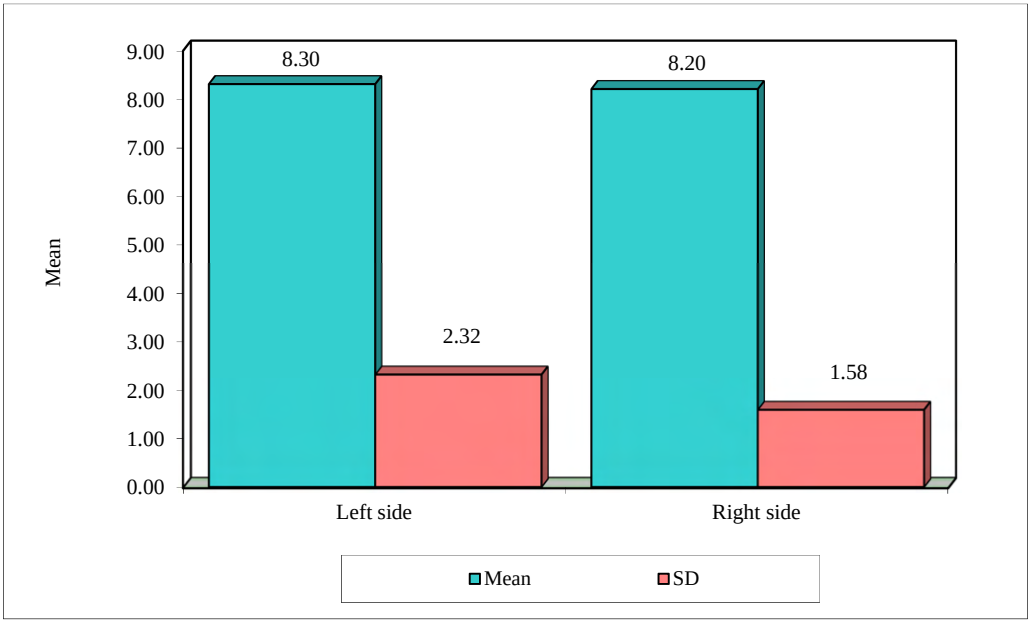
GRAPH 18: Comparison of position of MEA between left side and right side

	LEFT	RIGHT	TOTAL
SKULL BASE	12/12 (100%)	10/11 (90.9%)	22/23 (95.65%)
MESENTERY	0/12 (0%)	1/11 (9.1%)	1/23 (4.35%)
TOTAL	12/12	11/11	23/23 (100%)

TABLE 22: Comparison of position of MEA between left side and right side

Of all MEA examined, 95.65% ran in the SB, 4.35% ran in a mesentery. (GRAPH 18, TABLE 22)

The distance of the MEA from AEA in left and right nasal cavity is shown below:



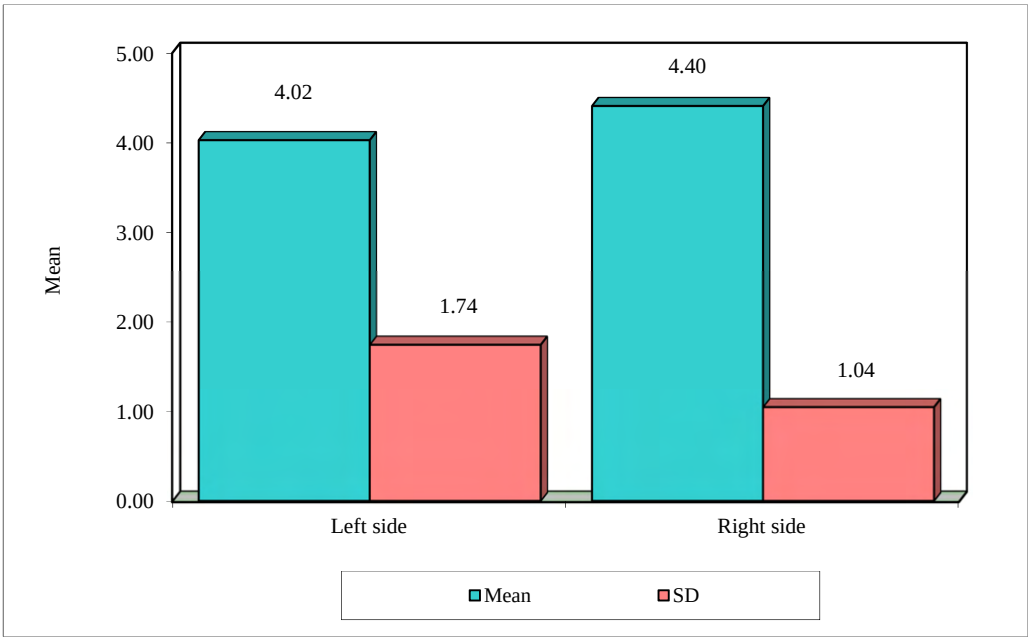
GRAPH 19: Comparison of mean distance of the MEA from the AEA

SIDE	MEAN DISTANCE (IN MM)	STANDARD DEVIATION	T VALUE	P VALUE
LEFT	8.30	2.32	0.2743	0.7900
RIGHT	8.20	1.58		

TABLE 23: Comparison of mean distance of the MEA from the AEA by dependent 't' test

The average distance of MEA from AEA is 8.30mm on left and 8.20mm on right side. Average distance of MEA from AEA is 8.27mm on the both sides. The range of distance was found to be from 4.5mm to 12mm. The p value was calculated to be 0.7900 which indicates that there is no significant difference in the average distance of MEA from AEA on both sides. (GRAPH 19, TABLE 23)

The distance of the MEA from PEA in left and right nasal cavity is shown below:



GRAPH 20: Comparison of distance of MEA from PEA on left and right side

SIDE	MEAN DISTANCE (IN MM)	STANDARD DEVIATION	T VALUE	P VALUE
LEFT	4.02	1.74	-0.9678	0.3584
RIGHT	4.40	1.04		

TABLE 24: Comparison of distance of MEA from PEA on left and right side by dependent 't' test

The average distance of MEA from PEA is 4.02mm on left side and 4.40mm on right side. Average distance of MEA from PEA is 4.2mm on both sides. The range of distance was found to be from 3mm to 9mm. The p value was calculated to be 0.3584 which indicates that there is no significant difference in average distance of MEA from PEA on both sides. (GRAPH 20, TABLE 24)

MEA was best visualized in:

SECTION	
CORONAL	23/23 (100%)
AXIAL	0/23 (0%)
SAGGITAL	0/23 (0%)

TABLE 25: Section of the CT scan in which MEA was best visualized

The MEA was best visualized in coronal section in all the scans.

DISCUSSION

The ethmoidal arteries which branch from ophthalmic arteries, are critical vessels supplying the septum, lateral wall of nose and ethmoid air cells. They are important anatomical landmarks in endonasal surgeries and surgeries of the skull base (SB). There are three ethmoidal arteries: anterior, middle and posterior ethmoidal artery.[1] Its variable location makes prone to injury during endonasal surgery.[4] CT-PNS helps to accurately visualise both bone and tissue in nose in detail, which is useful to identify the landmarks to identify the ethmoidal arteries, assess their distance from SB and critical structures such as optic nerve. Anatomical knowledge of the ethmoidal arteries and its variations through radiological imaging can help the surgeon identify the arteries during surgery to prevent its injury and complications.[6,7]

This study examined CT-PNS scans of 60 patients. The study population had 28 males and 32 females. The study population was divided in to 5 age groups i.e. age ranging from 18-20 years, 21 -30 years, 31-40 years, 41-50 years, and more than 50 years. The age group of 21-30 years had the most samples. The sample population had a mean age of 34.4 years.

In the present study, each scan was assessed for the presence of anterior, middle and posterior ethmoidal arteries (AEA,MEA and PEA), the various anatomical landmarks which help in identifying the arteries were studied and the distance of arteries from each of these landmarks was assessed. Additionally, the arteries were localised in axial, sagittal and coronal sections of the CT scan to determine which cut is most useful for identification of each artery.

In our study, the AEA was found bilaterally in all the 60 scans studied. The artery travelling in a canal was located medial to superior oblique (SO) muscle in all scans. All scans showed the presence of AEF and AES. Hence it can be concluded that the bony notch on medial orbital wall, the bony notch on lateral wall of nose and SO muscles are keystones in identifying AEA within the AEC in CT scans. Amarnath et al in his study found that AEA was found in all scans bilaterally, and AES was found in 94.5% of the sides studied.[1] Gottwald et al in 2003, identified key points to find the AEA in CT-PNS and compared incidence of these landmarks in scans with 3mm and 4mm cuts. It was found that the AEF was seen as an indentation on the medial orbital wall in 95% scans with 3mm thick slices and in 88% of scans with 4mm thick slices. The AES was identified on the nasal septum in 84% of scans with 3mm thick slices and in 78% of scans with 4mm thick slices. The AEC was identified inferior to SO muscle in 95% of scans with 3mm thick slices and in 83% scans with 4mm thick slices. Our study used coronal cuts reconstructed from axial cuts in thickness of 0.6mm which is why the incidence of the landmarks is higher in our study when compared with Gottwald et al.[11] Amarnath et al in his study found that AEA was found in all scans bilaterally, and AES in 94.5% of all sides studied.[1] Anwar et al in their paper published in 2020, with a study series of CT scans of 150 patients, the AEA was present in all sides studied, the AEF was found in 97.7% of the sides and the AES in 76% of the sides.[21] McDonald et al in 2007, in a study of 50 CT scans found that the AEF was visualised bilaterally in 95% of the scans and at least in one side in the remaining 5% of the scans. They mentioned that the AEA was visualised less easily, at a mere 33% of the cases.[22] Garcia et al in his radiological study of 20 cadaver heads, located AEA in 95% of the orbits studied.[10] Ferrari et al in his study of endoscopic and radiological examination of 14 cadaveric heads found the AEA to be

present in all the sides studied.[19] Similar results were seen in the studies done by Kho et al[1] in 2018, Felding et al[20] in 2017 and Simmen et al[23] in 2006.

Based on the distance of AEC from the SB and the length of the AEC as measured from AEF to AES, the AEA can be classified as running in SB, short mesentery position and long mesentery position. The surgeon has to be careful during nasal surgery when the AEA is in mesentery position as it is more prone to injury leading to complications. In our study, the AEA was found to be in SB position in 50.83% of the sides studied and in 49.17% of the sides studied, the artery was found to run in short mesentery position. No arteries were found to run in long mesentery position in this study. In the scans where the AEA travels in mesentery position, average distance of the artery from the SB was 3.81mm (3.79mm on left and 3.83mm on right). Mean length of AEC in mesentery position was found to be 4.62mm (4.49mm on left and 4.80mm on right). Statistical analysis showed no significant difference in average values on left and right sides. Amarnath et al in his study in 2019 found that in a series of 100 CT-PNS scans, found that AEA was found to run in SB in 50.75% of the sides studied, in short mesentery in 39.25% of the sides studied and the least (10%) in long mesentery position.[2] Cankal et al in 2004 concluded that AEA ran in mesentery in 84% of cases and within SB in 16% of cases. The length AEC ranged from 4-12mm with a mean of 8.2mm.[3] Anwar et al in his study of 150 CT scans found that the AEA ran in SB in 64% of the cases, had a short mesentery in 33% of the sides and in the remaining 3% it ran in long mesentery position. The average length of AEC in nasal cavity was 6.7mm with a range of 4.2-10.6mm.[21] A paper done by McDonald et al in 2007, showed AEA to be in SB in 72% of cases and in mesentery in the rest.[22] Ferrari et al in his study of 14 cadaveric heads and its radiological examination, found the AEA to run caudal to SB in 60.7% of the sides

studied.[19] In the study done by Kho et al in 2018, the AEA was found to be in long mesentery in majority of the cases (57.4%), followed by short mesentery (22.4%) and the least in SB.[1] Simmen et al in their study in 2006, found the AEA to be in running near to the SB in 18 out of 34 scans studied and in the remaining scans, the artery was seen well below SB running at a mean distance of 3.5mm from SB.[23] Randhawa et al in 2023, in a sample population of 200 scans, AEA was most commonly located in the SB, while the long mesentery position was the least common.[25] In a study of CT scans of 901 patients, Guarnizo et al in 2020, found the AEA to be in the SB in 76.8% of the cases and located below SB in the remaining 23.1% of the cases.[26]

The supraorbital ethmoidal cell (SOEC) is a keystone for localising AEA, which is always located posterior to the SOEC. Additionally, when there is a well pneumatised SOEC, the AEA courses at a longer distance from the SB, i.e. in mesentery position. In our study, in 43.33% of sides examined, SOEC could be reliably identified. In the scans where SOEC was present, AEA was located posterior to it in all the sides studied. Amarnath et al in his study in 2019, found that in 100 scans, SOEC was found in 44.75% of the sides studied, in which AEA was located posterior to it in all sides and was in a mesentery position in 98.8% of the sides.[2] In a study done by Anwar et al in 2019, there was a positive correlation with increase in distance between SB and AEA and increase in distance between AEA and FS with presence of supraorbital pneumatisation.[21] Ferrari et al in his study in 2017 noted a significant positive correlation between the AEA travelling more caudal to SB with presence of supraorbital ethmoidal air cell.[19] Simmen et al in 2006 in their study noted that in radiological examination of 34 cadavers, noted that in 16 scans where well pneumatised supraorbital ethmoid cells were present, anterior ethmoidal arteries were found in low lying position, 3.7mm from the SB, while in remaining 18 scans where

no SOEC was found, the anterior ethmoidal arteries were found to run closer to the SB.[23] Similarly Li et al in their study in 2019 studied the relation between supraorbital ethmoidal air cell and AEA and found that there was an increase in incidence of AEA travelling in mesentery position with the presence of supraorbital ethmoidal air cell and also the artery travelled at a greater distance caudal to the SB when the SOEC was present than in cases where SOEC was absent, which places the AEA at a higher risk for injury during endonasal surgery.[24] Sağlam et al, in their article published in 2023, studied the association between anatomical course of AEA and presence of SOEC and found an increased frequency of Grade III AEA in cases with well pneumatised SOEC. [28] Erem et al in their study published in 2014, analysed the correlation of ethmoids and the position of AEA and found that distance between the frontonasal junction and AEA increases with increase in ethmoidal pneumatisation.[27]

In cases where the FS is rudimentary, the AEA is almost always found to be in SB. In our study, the FS was found to be rudimentary in 35% of the sides. In the scans where FS was rudimentary, the AEA was found to be in SB in 97.62% of the sides studied and in mesentery in the rest. Amarnath et al in their publication in 2019, it was found that in all the scans where the development of FS was rudimentary, the AEA was always found to travel in the SB.[2]

Among all the cuts in the CT-PNS scans, the AEA was most easily visualised in the coronal cuts of the CT scan. Amarnath et al concluded in their study, that coronal sections were ideal in pre-operative assessment of anatomy of AEA.[2] Kho et al in their study in 2018, found the AEA easily identifiable on axial view.[1] Cankal et al in 2004, was able to identify 2/3rd of the AEA in coronal section and reconstructed

sagittal sections as well.[3] Souza et al in 2009 employed only coronal sections for studying the anatomy of AEA.[13]

In our study, PEA was found bilaterally in all the 60 scans studied. the artery travelling in a canal was located superior to SO muscle in all the scans. In a study done by Yamamoto et al, in 2018, the PEA was found in all sides of the 100 scans studied.[4] Kho et al in her study of 54 CT scans found the PEA to be present in 86% of all sides examined.[1] In a study done by Gottwald et al in 2003, comparison of rate of detect of PEA was done using CT scans of 3mm and 4mm thick slices. It was found that PEC was found by means of a posterior indentation in medial orbital wall in 66% scans with 3mm thick slices and in 65% scans with 4mm thick slices. PEC is superomedial to SO muscle in 63% scans with 3mm thick slices and in 55% of the scans with 4mm thick slices.[11] Ferrari et al in his study done in 2017 found the PEA to be present in all the sides examined.[19] Felding et al in his study of radiological examination of 25 cadaver heads, detected the presence of PEA in 2/3rd of the orbits studied.[20] Garcia et al in 2011, found PEA to be present in 35% of the total orbits studied in his radiological study of 20 cadaver heads.[10]

Based on the distance of PEC from the SB, the PEA can be classified as running in SB, short mesentery position and long mesentery position. In our study, the PEA was found to run in SB in 93.33% of all the sides studied and in the remaining 6.67%, it was found to run in long mesentery position. Cankal et al in his study done in 2004, found the PEA to run in a separate canal in 8% of the sides it was detected in, while it ran in SB in the remaining sides.[3] In the study done by Ferrari et al, the PEA was found to travel caudal to SB (that is, in mesentery position) in 18% of the sides studied.[19] In her article in 2018, Kho et al on studying CT scans of 54 subjects, found

that PEA travelled in the SB in 87% of the cases, followed by short mesentery and the least in long mesentery.[1] Yamamoto et al in 2018 found that in a study of 100 CT scans, the PEA travelled away from the SB at a distance ranging from 0 to 6mm (mean: 1.2mm), and it was found in a long mesentery position in 12% of the sides examined.[4]

The average distance of the PEA from the optic canal was measured and found to be 7.65mm on left side and 7.58mm on right. The average distance was 7.62mm in all sides. There was no significant difference between the mean difference on the left and right side. Garcia et al in his study done in 2011, found the mean distance between PEA and the optic canal to be 7.26mm +/- 1.33mm.[10] In her study done in 2018, Kho et al found the mean distance between PEA and optic canal to be 8.5mm, ranging from 1 to 19mm.[1] Cankal et al in their study in 2004, found the PEC to be at a distance of 4-16mm from the optic foramen (mean: 6.7mm).[3] In 2017, Felding et al, found posterior ethmoidal foramen and optic canal to be 6mm apart.[20]

The PEA was found to be easily identifiable in coronal cuts in CT-PNS. Kho et al in a paper in 2018, found the PEA easily identifiable on axial view.[1]

The MEA was found in 19.16% (23/120) of the total sides studied in this study. Kho et al in a study done in 2018, studied the computerised tomography scans of 54 patients of Asian origin, and found MEA in 30% of the scans assessed.[1] Mason et al in his paper published in 2015, studied the radiological anatomy of MEA in 50 CT scans and found that MEA was found in 19 of the 50 scans studied.[16] Yamamoto et al in his study done in 2018, found that on analysis of 100 CT scans, MEA could be found in 21% of the total sides examined.[4] In a study done by Ferrari et al in 2017, where the anatomy of the ethmoidal arteries was studied by endoscopic examination

of 14 cadaver heads and their CT scans, the MEA 28.6% (8/28) of the sides examined by radiological examination.[19] Wang et al in his study in 2013, studied the incidence and anatomy of MEA by endoscopic examination of 22 cadaver heads, and found the MEA to be present in 31% (14/44) of the sides studied.[17] The low sensitivity of CBCT in identifying MEA is due to poor image contrast between the SB and the artery, the tiny calibre of the bony canal, and non-availability of contrast.

The MEA ran in SB in 95.65% sides it was present (22/23), and in 4.35% of the sides (1/23), it was found to run in mesentery position. Kho et al found the MEA to run in a bony canal in SB in 50% of the cases, short mesentery in 38% of the cases and long mesentery in the remainder of the cases.[1] Ferrari et al in his study found the MEA to run in mesentery position in 25% of the sides studied.[19] MEA was found to run 1.2mm away from SB as per a study done by Yamamoto et al.[4]

MEA was found to run 8.3mm away from AEA on left side and 8.2mm away from AEA on right, with no significant difference on left and right sides. Kho et al calculated mean distance between MEA and AEA to be 8.1mm (range from 4.1 to 11.2mm).[1] Mason et al calculated the average distance to be 10.8mm on right and 11.77mm on left side in his study.[16]

MEA was found to run 4.02mm away from PEA on left side and 4.40mm away from PEA on right side, with no significant difference on the left and right sides. Kho et al calculated the mean distance between MEA and PEA to be 5.5mm (range from 3.3 to 8.8mm).[1] Mason et al calculated the average distance to be 11.2mm on right and 11.4mm on left side in his study.[16]

The MEA was best visualised in coronal cuts in all the CT-PNS scans studied. Mason et al in his study in 2015, found that coronal cuts were the most ideal for detecting middle ethmoidal foramina.[16] Kho et al in their study in 2018, found the MEA easily identifiable on axial view.[1]

CONCLUSION

Ethmoidal arteries begin their course from ophthalmic artery, which is a branch of internal carotid artery. The arteries travel from orbit, through ethmoidal air cell system into the nasal septum proper. They supply the nasal septum, lateral wall of the nose and ethmoidal air cells.

Anterior ethmoidal artery and posterior ethmoidal artery was found in all patients. There exists a third accessory artery, also known as the middle ethmoidal artery, which exists into up to 1/5th of all patients. The study concluded that the anterior ethmoidal sulcus, anterior ethmoidal foramen, superior oblique muscle and supraorbital ethmoidal air cell were reliable landmarks in identifying anterior ethmoidal artery. Pneumatisation of frontal sinus affects the position of anterior ethmoidal artery wherein anterior ethmoidal artery was found to almost always run in skull base when development of frontal sinus was rudimentary. The superior oblique muscle was a reliable landmark in identifying the posterior ethmoidal artery. The middle ethmoidal artery arose as an accessory foramen between the anterior and posterior ethmoidal arteries. Unlike the anterior ethmoidal artery which had an almost equal incidence of being found in skull base and mesentery positions, the middle and posterior ethmoidal arteries were found to run in the skull base in majority of the cases, thereby making it less prone to injury during endonasal surgery. In our study, coronal cuts were found to be ideal to identify and study the anatomy of all the ethmoidal arteries.

All ethmoidal arteries are prone to traumatic injury during endonasal surgeries and endoscopic skull base surgeries. Anatomy of these arteries can be assessed by radiological imaging which helps in preventing damage to these vessels, and also if damaged, to localise the vessels to control bleeding and reduce risk of complications.

SUMMARY

The study titled **"A STUDY OF VARIATION OF ETHMOIDAL ARTERIES IN NASAL CAVITY USING COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES – A ONE YEAR OBSERVATIONAL STUDY"** was conducted in the Department of Otorhinolaryngology and Head and Neck Surgery of KLE'S Jawaharlal Nehru Medical College and KLE'S Dr. Prabhakar Kore Hospital and MRC, Belagavi from October 2022 to September 2023. The study included 60 patients who underwent CT-PNS for various indications. The CT scans were collected and the anatomy of the ethmoidal arteries and its variations were studied in RadiAnt DICOM Viewer.

In our study, there was a male predilection in the cases with 32 males (53.33%) and 28 females (46.67%). The mean age of the patients enrolled in our study was 34.45 years, with the youngest patient being 18 years old and the oldest being 72 years old.

The anterior ethmoidal artery (AEA) was identified in all sides examined. The landmarks which helped to localise the AEA were the anterior ethmoidal foramen (AEF) and the anterior ethmoidal sulcus (AES). AEF and AES were identified in all the sides examined in the study. The AEA travelled in an anterior ethmoidal canal (AEC) which was present inferior to superior oblique (SO) muscle in all sides examined. According to distance of AEA from SB and length of the AEC from AEF to AES, AEA was classified as travelling within the SB, short mesentery position or long mesentery position. In mesentery position, the artery travels away from the SB, which makes it trauma prone in endonasal surgery. AEA was found in SB in 61

(50.83%) of the sides studied and in short mesentery position in 59 (49.17%) of the sides studied. In mesentery position, the mean distance of AEC from SB is 3.79mm on left and 3.83mm on right side. Mean AEC to SB distance across both sides was found to be 3.81mm. In mesentery position, mean distance of AEF to AES was 4.45mm on left and 4.78mm on right side. Average distance of AEF to AES on both sides was found to be 4.62mm. Supraorbital pneumatization was present in 52 (43.33%) sides studied. The AEA was located posterior to the supraorbital ethmoidal air cell in all the sides where supraorbital pneumatization was present. The FS was well developed in 65% of the sides studied and rudimentary in the rest. In the cases where the FS development was rudimentary, the AEA travelled in SB in 97.62% of the sides studied and in mesentery position in the remaining sides. The AEA was most easily identified in coronal cuts of CT-PNS.

Posterior ethmoidal artery (PEA) was identified in all sides examined. The PEA travelled in a posterior ethmoidal canal (PEC) located above SO muscle in all sides examined in the study. Based on the distance of the PEA from the SB, the PEA was classified as travelling within the SB, short mesentery position or long mesentery position. The PEA was found in SB in 112 (93.33%) of the sides studied and in long mesentery position in 8 (6.67%) of the sides studied. The mean distance of PEA from the optic canal was 7.65mm on left and 7.58mm on right side. The mean distance of PEA from the optic canal on both sides was 7.62mm. The PEA was best visualised in coronal cuts of CT-PNS.

Middle ethmoidal artery (MEA) was seen in 23 (19.16%) sides. Based on the distance of the MEA from the SB, the MEA was classified as travelling within the SB or mesentery position. The MEA was found in SB in 22 (95.65%) of

the sides studied and in mesentery position in 1 (4.35%) of the sides studied. The distance of MEA from AEA and PEA was studied. Average MEA to AEA distance was 8.30mm on left and 8.20mm on right side with a mean of 8.27mm on both sides. The mean distance of MEA from PEA was 4.02mm on left and 4.40mm on right side with a mean of 4.2mm on both sides. The MEA was best visualised in coronal cuts of the CT-PNS.

CT-PNS helps in pre-operative planning and detailed examination of areas of nasal cavity that are difficult to visualise endoscopically and are prone to injury. The operating surgeon must be familiar with the anatomy of the ethmoidal arteries and its variations which can be assessed easily in the CT scan preoperatively. This helps the surgeon to be aware of arterial location and its relation with critical structures so as to prevent damage to the arteries during the endonasal surgery and prevents occurrence of complications.

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ANNEXURES

ANNEXURE – I

INFORMED CONSENT FORM

"A STUDY OF VARIATION OF ETHMOIDAL ARTERIES IN NASAL CAVITY USING COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES – A ONE YEAR OBSERVATIONAL STUDY"

Name of Student/Principal Investigator: REG NO: BE0121003

Name of Guide/Co Investigators: _____

Objective:

- To study the Anatomical course of the Ethmoidal arteries and its variations.
- To assess which sections in Computed Tomography Scan of Paranasal Sinuses is ideal for identification and study of the course of the ethmoidal arteries.

Introduction:

The ethmoidal arteries which arise from the ophthalmic arteries, are important anatomical landmarks in endonasal surgeries to critical structures such as the optic nerve and skull base. Knowledge of the individualized course of the ethmoid arteries within the ethmoid sinuses is essential to ensure a safe surgical procedure.

There is a shortage of literature on the computed tomographic imaging of the ethmoidal arteries; in particular, their precise location and frequency of their variations in cross sectional images. While adequate studies have been done on the anatomy of anterior ethmoidal artery and posterior ethmoidal artery, the middle ethmoidal artery has not been well studied.

The need to correlate radiological features, which can assist surgeons while planning for endonasal surgeries and to reduce perioperative complications needs to be addressed.

Explanation of procedure:

If you agree to participate in this study, the relevant data will be collected as per the proforma and the final diagnosis will be confirmed. After getting inducted in the study, you will be evaluated on clinical examination. Following this the patient will then have to undergo CT scan examination and the scan will be studied.

Withdrawal from participation in the study:

Participation in this study is voluntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will/will not have nor get any benefits by participating in this study. The data gathered will help the population at large.

Possible risks from participating in the study: There are no risks involved in participating in this study.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. Your identity will never be revealed. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Financial incentives: You will not receive any payment for participating in this study.

Authorization for publication of aggregated data: Results obtained after processing of the aggregated data will be published for scientific purposes and or presented to scientific groups. However, your identity will never be revealed.

Questions:

If you have any question or complaints with regard to your right as study participant you may contact Dr Harsha Hegde, Chairperson, Ethical committee of JNMC, 0831-2473777 Extension 4052.

Legal rights: By signing this consent form, we are not waving any of your legal rights.

CONSENT STATEMENT

I am making a voluntary decision to participate in the study "**A STUDY OF VARIATION OF ETHMOIDAL ARTERIES IN NASAL CAVITY USING COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES – A ONE YEAR OBSERVATIONAL STUDY**". My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

Signature of the investigator:

ANNEXURE – II

PROFORMA

STUDY OF VARIATION OF ETHMOIDAL ARTERIES IN NASAL CAVITY USING COMPUTED TOMOGRAPHY SCAN OF PARANASAL SINUSES – A ONE YEAR OBSERVATIONAL STUDY

Date: Date of assessment:

Name: Address:

Age: Date of discharge:

OP/IP No.:

Sex:

Occupation:

CHIEF COMPLAINTS:

HISTORY OF PRESENTING ILLNESS:

PAST HISTORY:

FAMILY HISTORY:

PERSONAL HISTORY:

GENERAL EXAMINATION:

Physical Examination

Pulse: Pallor

Blood pressure: Icterus

Respiratory Rate: Clubbing

Cyanosis

Lymphadenopathy

Oedema

ENT Examination

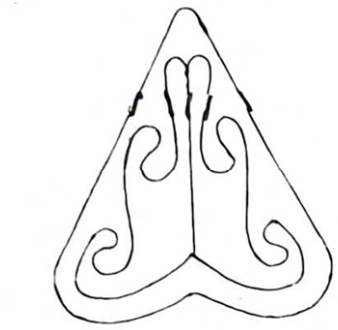
NOSE EXAMINATION

External appearance

Root
Bridge
Dorsum
Alae
Tip
Columella

Cold spatula test
Tip elevation test

Anterior Rhinoscopy

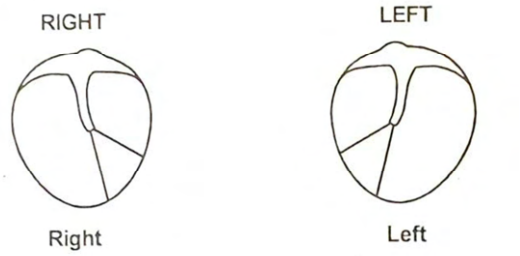


Posterior Rhinoscopy

Paranasal Sinus Examination	RIGHT	LEFT
Frontal Sinus:		
Ethmoid Sinus:		
Maxillary Sinus:		

EAR EXAMINATION: **RIGHT EAR** **LEFT EAR**

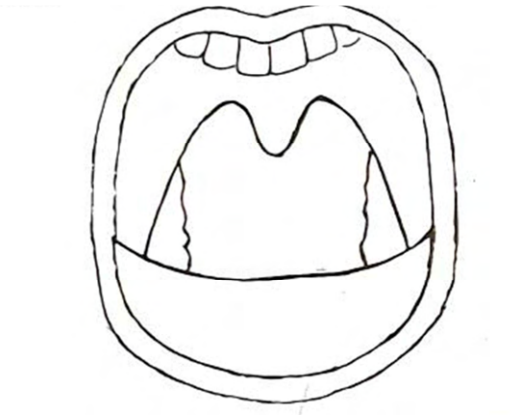
Pinna
Preauricular area
Post auricular area
External auditory canal
Tympanic membrane



TUNING FORK TEST: **RIGHT EAR** **LEFT EAR**

Rinne's test:
256Hz
512Hz
1024Hz
Weber's test:
Absolute Bone Conduction test:

ORAL CAVITY and OROPHARYNX:



NECK EXAMINATION:
DIAGNOSIS:

Findings on CT scan of Paranasal Sinuses:

- **ANTERIOR ETHMOIDAL ARTERY:**

1) Bony Notch on medial wall of orbit (corresponds to anterior ethmoidal foramen – AEF):

SIDE	PRESENT/ABSENT
LEFT	
RIGHT	

Bony Notch on lateral wall of olfactory fossa (corresponds to anterior ethmoidal sulcus – AES):

SIDE	PRESENT/ABSENT
LEFT	
RIGHT	

2) Is anterior ethmoidal canal present at lower edge of superior oblique muscle?

SIDE	
LEFT	
RIGHT	

3) Distance of Anterior ethmoidal canal (AEC) from skull base:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

Length from AEF to AES:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

TYPE	AEA CANAL TO SKULL BASE DISTANCE	LENGTH OF CANAL FROM AEF TO AES
SKULL BASE:	<2.5 mm	-
SHORT MESENTERY:	2.5 – 5 mm	<10 mm
LONG MESENTERY:	>5mm	>10 mm

Type of Anterior Ethmoidal Artery (skull base/short mesentery/long mesentery):

SIDE	SKULL BASE/SHORT MESENTERY/LONG MESENTERY
LEFT	
RIGHT	

4) If AEA is in mesentery position, is bony canal present?

Side:	Bony Canal present	Bony Canal absent
Right		
Left		

5) Supraorbital pneumatization present/absent:

SIDE	PRESENT/ABSENT
LEFT	
RIGHT	

If present, is anterior ethmoidal artery identifiable on posterior wall of supraorbital ethmoidal cell?

SIDE	
LEFT	
RIGHT	

6) Type of Frontal Sinus (Rudimentary/ Well Developed):

SIDE	FRONTAL SINUS RUDIMENTERY/ WELL DEVELOPED
LEFT	
RIGHT	

If rudimentary, AEA Position (skull base/mesentery):

SIDE	SKULL BASE/MESENTERY
LEFT	
RIGHT	

Anterior Ethmoidal Artery is best visualized in: Coronal/Sagittal/Axial view

- **POSTERIOR ETHMOIDAL ARTERY:**

1) Relation of Posterior Ethmoidal Artery Canal to superior edge of superior oblique muscle:

SIDE	
LEFT	
RIGHT	

2) Distance of Posterior Ethmoidal Canal from Skull Base:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

3) Distance of Posterior Ethmoidal Canal from optic canal:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

4) Type of Posterior Ethmoidal Artery (skull base/mesentery):

SIDE	SKULL BASE/ MESENTERY
LEFT	
RIGHT	

TYPE	POSTERIOR ETHMOIDAL ARTERY TO SKULL BASE DISTANCE
SHORT MESENTERY:	<1 mm
LONG MESENTERY:	>1mm

Posterior Ethmoidal Artery is best visualized in: Coronal/Sagittal/Axial view

❖ **MIDDLE ETHMOIDAL ARTERY:**

1) Is the Middle Ethmoidal Artery present/absent on CT scan

SIDE	ARTERY PRESENT/ABSENT
LEFT	
RIGHT	

2) Distance of Middle Ethmoidal Artery from Skull Base:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

3) Type of Middle Ethmoidal Artery (skull base/mesentery):

SIDE	SKULL BASE/ MESENTERY
LEFT	
RIGHT	

4) Distance of Middle Ethmoidal Artery from Anterior Ethmoidal Artery:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

5) Distance of Middle Ethmoidal Artery from Posterior Ethmoidal Artery:

SIDE	DISTANCE (IN MM)
LEFT	
RIGHT	

Middle Ethmoidal Artery is best visualized in: Coronal/Sagittal/Axial view

ANNEXURE – III

PHOTOS

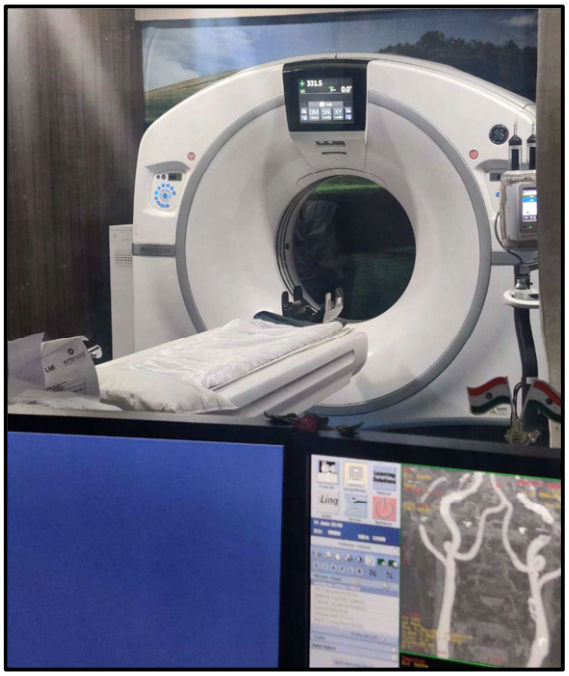


PHOTO 1: CT CONSOLE ROOM IN THE HOSPITAL

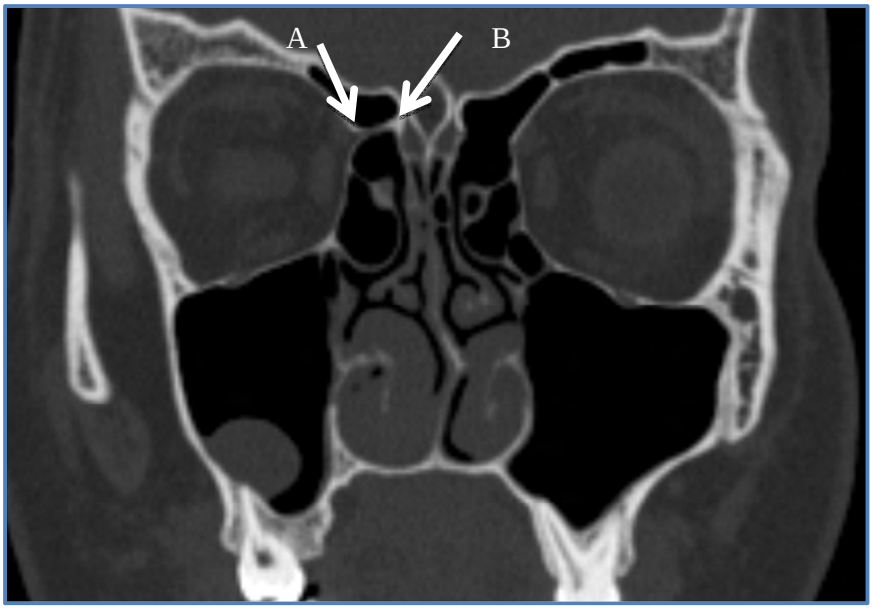


PHOTO 2: RIGHT ANTERIOR ETHMOIDAL ARTERY VISUALISED IN CORONAL SECTION. ANTERIOR ETHMOIDAL FORAMEN IS VISUALISED ON MEDIAL WALL OF ORBIT (A) AND ANTERIOR ETHMOIDAL SULCUS IS VISUALISED ON LATERAL WALL OF OLFACTORY FOSSA (B).

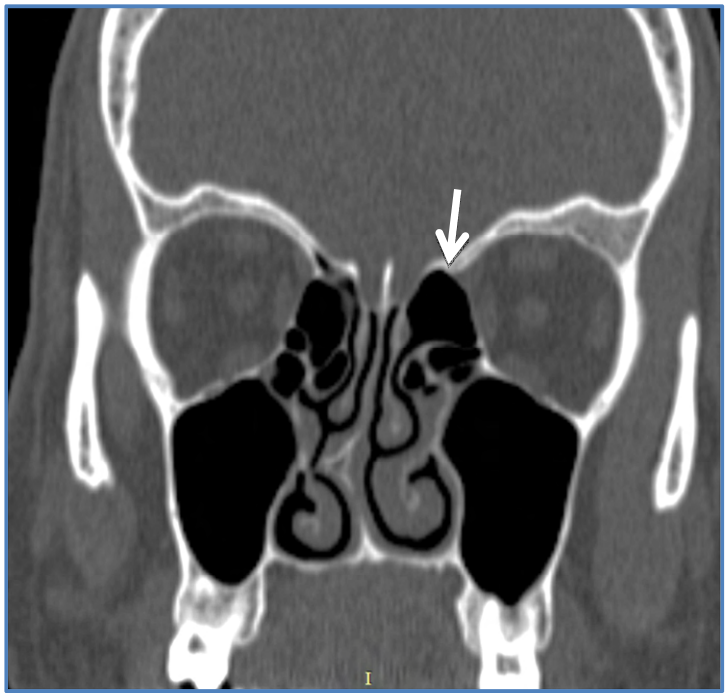


PHOTO 3: LEFT ANTERIOR ETHMOIDAL ARTERY IN SKULL BASE POSITION

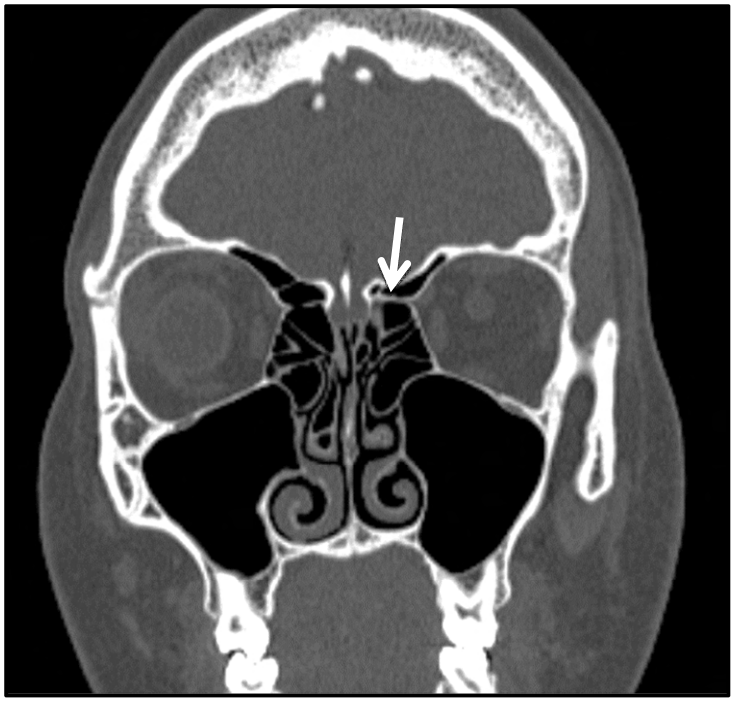


PHOTO 4: LEFT ANTERIOR ETHMOIDAL ARTERY IN MESENTERY POSITION

PHOTO 5: TAKING MEASUREMENTS OF DISTANCE OF AEF TO AES AND DISTANCE OF AEC TO SKULL BASE (BOTH ANTERIOR ETHMOIDAL ARTERIES ARE IN SHORT MESENTERY POSITION)

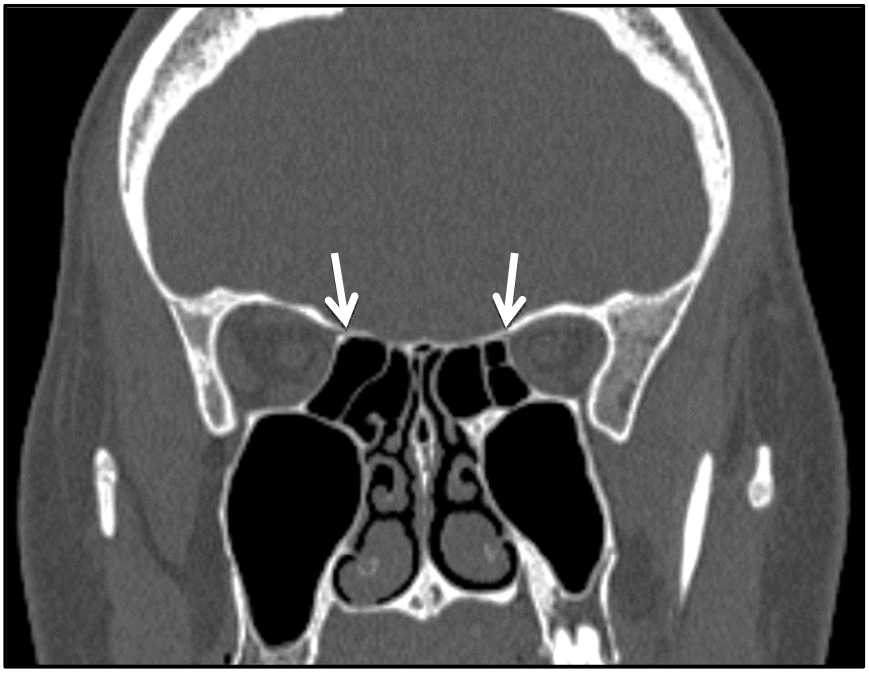


PHOTO 6: BILATERAL POSTERIOR ETHMOIDAL ARTERIES RUNNING IN SKULL BASE

PHOTO 7: LEFT POSTERIOR ETHMOIDAL ARTERY SEEN IN SKULL BASE POSITION AND RIGHT POSTERIOR ETHMOIDAL ARTERY SEEN IN LONG MESENTERY POSITION

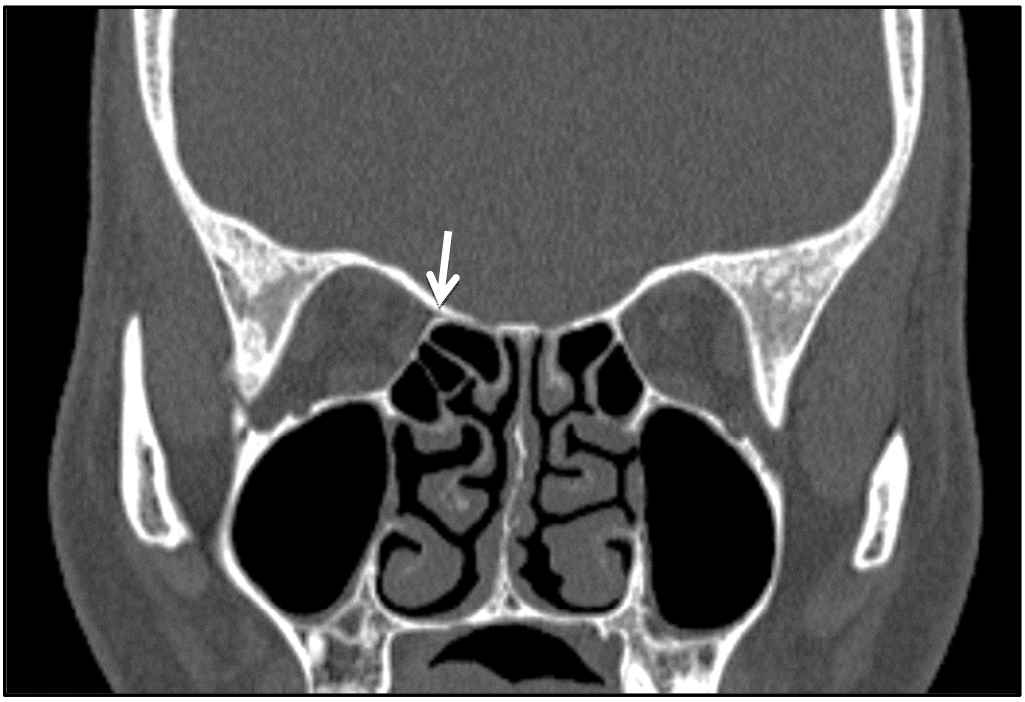


PHOTO 8: RIGHT MIDDLE ETHMOIDAL ARTERY SEEN RUNNING IN SKULL BASE

ANNEXURE – IV

KEY TO MASTER CHART:

AEF	Anterior ethmoidal foramen
AEC	Anterior ethmoidal canal
AES	Anterior ethmoidal sulcus
AEA	Anterior ethmoidal artery
MEA	Middle ethmoidal artery
PEA	Posterior ethmoidal artery

ANNEXURE – V KEY TO MASTER CHART:

SR NO.	AGE	SEX	IP NO	BONY NOTCH PRESENT ON MEDIAL WALL OF ORBIT (AEF)		BONY NOTCH PRESENT ON LATERAL WALL OF OLFACTORY FOSSA (AES)		AEC PRESENT ON LOWER EDGE OF SUPERIOR OBLIQUE MUSCLE		DISTANCE OF AEC TO SKULL BASE (IN MM)		DISTANCE BETWEEN AEF AND AEC (IN MM)		TYPE OF ANTERIOR ETHMOIDAL ARTERY		SUPRAORBITAL PNEUMATISATION PRESENT OR ABSENT		FRONTAL SINUS RUDIMENTARY OR WELL DEVELOPED		AEA BEST VISUALISED IN	RELATION OF PEC TO SUPERIOR OBLIQUE MUSCLE		DISTANCE OF PEC FROM SKULL BASE (IN MM)		DISTANCE OF PEC FROM OPTIC CANAL (IN MM)		TYPE OF PEA		PEA BEST VISUALISED IN	MEA PRESENT/ABSENT		DISTANCE OF MEA FROM SKULL BASE		DISTANCE OF MEA FROM PEA		DISTANCE OF MEA FROM AEA		MEA BEST VISUALISED IN
				L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R		L	R	L	R	L	R	L	R		L	R	L	R	L	R	L	R	
1	33	M	1159763	P	P	P	P	P	P	4.53	4.05	5.44	5.14	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	1.6	1.39	6	6.4	LONG MESENTERY	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-
2	32	M	6838562	P	P	P	P	P	P	3	2.86	5	4.74	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6.6	6	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
3	37	F	6880642	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6.6	6	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
4	25	F	1158420	P	P	P	P	P	P	3.27	3.01	3.93	3.8	SHORT MESENTERY	SHORT MESENTERY	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8	6	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
5	35	M	2322180	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	7	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
6	41	M	6015999	P	P	P	P	P	P	4.43	4.69	5.37	7.59	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
7	18	M	6869586	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8	7	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
8	26	F	6938450	P	P	P	P	P	P	3.78	4.66	-	5.72	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	4.98	8.5	8	SKULL BASE	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-
9	55	M	6914111	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
10	27	F	6920601	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.2	7.2	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
11	67	F	5183020	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
12	41	F	6935421	P	P	P	P	P	P	3.5	3.48	4.59	4.77	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
13	30	F	7046544	P	P	P	P	P	P	4.03	3.77	4.76	5.72	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
14	19	M	1190418	P	P	P	P	P	P	2.18	3.07	-	4.63	SKULL BASE	SHORT MESENTERY	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	7.5	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	3.5	3.5	7.5	7.5	CORONAL

15	40	F	1188168	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.5	7	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
16	27	M	1178352	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
17	23	F	2238378	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
18	50	M	2239357	P	P	P	P	P	P	4.98	4.54	6.89	5.51	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.4	7.8	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	5.4	5.4	10	11	CORONAL
19	20	M	1183352	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	6.5	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
20	22	F	6360221	P	P	P	P	P	P	2.67	4.69	5.68	5.76	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.4	8.4	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
21	24	F	1180236	P	P	P	P	P	P	2.91	2.85	3.6	2.02	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	7	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
22	44	M	1168192	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8.4	7.8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
23	25	F	6981909	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
24	22	F	6848303	P	P	P	P	P	P	1.96	1.45	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	9.6	9.8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
25	28	F	1170822	P	P	P	P	P	P	3.16	3.16	3.01	3.77	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
26	63	M	1181197	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8.4	7.2	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
27	32	M	1178477	P	P	P	P	P	P	3.36	2.42	3.36	-	SHORT MESENTERY	SKULL BASE	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6.6	7.2	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	3.6	3.6	7.5	7.5	CORONAL
28	48	F	6425826	P	P	P	P	P	P	2.41	2.14	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
29	18	M	6923258	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	9.6	8.4	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
30	54	F	1194480	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	6.8	7.2	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
31	19	M	3244999	P	P	P	P	P	P	4.86	4.84	6.4	6.92	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	2.35	8	7.5	SKULL BASE	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-
32	21	M	5079341	P	P	P	P	P	P	4.52	4.96	6.86	7.71	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	1.34	7.2	7.8	SKULL BASE	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-
33	21	M	7067053	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6.5	6.5	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	5	4	4.5	6.5	CORONAL
34	71	M	7088328	P	P	P	P	P	P	2.64	2.64	4.78	4.78	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
35	32	F	7224722	P	P	P	P	P	P	4.29	4.68	3.99	4.6	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	7	SKULL BASE	SKULL BASE	CORONAL	P	P	0	2.8	3.5	4	8.5	8	CORONAL
36	40	F	1198615	P	P	P	P	P	P	3.63	3.63	4.1	2.8	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.5	8	SKULL BASE	SKULL BASE	CORONAL	A	P	-	0	-	7	-	6.5	CORONAL
37	21	M	6926153	P	P	P	P	P	P	3.81	4.21	3.39	3.17	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8	8.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
38	52	F	6803765	P	P	P	P	P	P	3.23	2.95	2.64	3.56	SHORT MESENTERY	SHORT MESENTERY	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6.5	6.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-

39	26	F	6994533	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	2.5	0	7	7.5	LONG MESENTERY	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
40	24	M	1200740	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.4	8.4	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
41	46	M	1195024	P	P	P	P	P	P	4.36	4.37	3.51	4.19	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.4	8.4	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
42	32	F	7139589	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7	7	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
43	72	M	7116852	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.2	7.2	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
44	46	F	1206336	P	P	P	P	P	P	2.79	2.67	4.58	6.47	SHORT MESENTERY	SHORT MESENTERY	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.5	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
45	23	M	7104408	P	P	P	P	P	P	4.82	4.24	4	5.9	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
46	26	M	1008915	P	P	P	P	P	P	2.82	4.52	4.46	3.67	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	6	6	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
47	35	F	231974	P	P	P	P	P	P	3.37	2.9	3.6	4.34	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.2	7.2	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	4.8	5.4	9	9	CORONAL
48	22	F	63021793	P	P	P	P	P	P	1.7	2.68	-	3.33	SKULL BASE	SHORT MESENTERY	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.8	7.8	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	3	3	12	9.6	CORONAL
49	28	M	263446	P	P	P	P	P	P	1.26	1.56	-	-	SKULL BASE	SKULL BASE	A	A	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.8	8.4	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
50	26	F	5646620	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8.4	8.4	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	5.4	5.4	11	9.6	CORONAL
51	22	M	1201693	P	P	P	P	P	P	2.45	1.68	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8	8.5	SKULL BASE	SKULL BASE	CORONAL	P	A	0	-	7	-	6.5	-	CORONAL
52	49	M	7007764	P	P	P	P	P	P	2.27	2.41	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	7.2	7.8	SKULL BASE	SKULL BASE	CORONAL	P	A	0	-	9	-	8.4	-	CORONAL
53	24	F	6902125	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	6.5	7	SKULL BASE	SKULL BASE	CORONAL	A	P	-	0	-	5	-	8.5	CORONAL
54	48	M	3378082	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8	8	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
55	60	M	7222519	P	P	P	P	P	P	4.85	4.83	5.16	5.24	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7	7.5	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
56	20	M	7236465	P	P	P	P	P	P	4.85	4.38	5.15	5.69	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	7.2	7.2	SKULL BASE	SKULL BASE	CORONAL	A	A	-	-	-	-	-	-	-
57	18	M	1205581	P	P	P	P	P	P	0	0	-	-	SKULL BASE	SKULL BASE	A	A	RUDIMENTARY	RUDIMENTARY	CORONAL	MEDIAL	MEDIAL	0	0	8.4	8.4	SKULL BASE	SKULL BASE	CORONAL	P	A	0	-	7.2	-	11	-	CORONAL
58	45	F	7160326	P	P	P	P	P	P	4.79	4.79	5.12	4.69	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	1.96	8.4	7.6	SKULL BASE	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-
59	42	F	1205821	P	P	P	P	P	P	3.52	2.7	2.41	3.17	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	0	8.5	8.5	SKULL BASE	SKULL BASE	CORONAL	P	P	0	0	6	6	5.5	5.5	CORONAL
60	30	M	7136660	P	P	P	P	P	P	3.01	4.17	2.88	3.92	SHORT MESENTERY	SHORT MESENTERY	P	P	WELL DEVELOPED	WELL DEVELOPED	CORONAL	MEDIAL	MEDIAL	0	3.67	7.5	8	SKULL BASE	LONG MESENTERY	CORONAL	A	A	-	-	-	-	-	-	-