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ORIGINAL ARTICLE

Evaluation of Anterior Ethmoidal Artery on Coronal CT Scan Paranasal Sinus

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ABSTRACT

Objective: To determine the frequency of different anatomical landmarks seen for identifying the course of anterior ethmoidal artery, in patients presenting at Fauji Foundation hospital, Rawalpindi for CT paranasal sinus.

Methodology: A total of 140 patients in this prospective cross-sectional study were included on coronal computed tomography of paranasal sinuses. The duration of the study was six months. All the examinations were done on Aquilion 64 slice Toshiba CT scan. Only the coronal image was used for study and analysis.

Results: Patients had an average age of 40.77±15.62. Supra orbital pneumatization was 52.14 percent. The anterior ethmoidal sulcus and foramen were visible in 96.43% and 98.57% of scans. No age group had age-related changes in anterior ethmoidal foramen or sulcus (p-values = 0.52 and 0.95). Age did not affect supraorbital pneumatization (p=0.70). Women (98.6%) had the Anterior Ethmoidal Sulcus more than men (94%), although the difference was not significant (p-value 0.19). Gendered supraorbital pneumatization was similar (p=0.73).

Conclusion: This study found that key anatomical landmarks for identifying the AEA—the anterior ethmoidal foramen, sulcus, and supraorbital pneumatization—are consistently present across age and gender groups, with no significant differences. These results confirm the reliability of these landmarks in guiding surgical approaches to the AEA.

Keywords: Anterior ethmoidal artery; CT scan paranasal sinus; Supraorbitary pneumatization

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1,2Conception; Literature research; manuscript design and drafting; 2,3Critical analysis and manuscript review; 3,4Data analysis; Manuscript Editing.	*Huma Khaliq* *Email: huma.khaliq@hotmail.com* ***Note: All the authors were working in same institute at the time of study***	*Received: March 11, 2025* *Accepted: December 20, 2022*

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Introduction

Frontal and ethmoidal sinus surgery uses the anterior ethmoidal artery (AEA) as a marker. By identifying this artery, the surgeon can avoid accidental injuries that can cause profuse epistaxis, intra-orbital bleeding, retro- orbital hematoma, blindness, cerebrospinal fluid leak, or intracranial bleeding, and artery coagulation in the event of epistaxis.[1] Due to its susceptibility to injury, the anterior ethmoidal artery (AEA) must be identified before surgery. Several anatomical markers help locate this artery. Landmarks include: Skull Base The anterior ethmoidal artery can be identified at three locations along the skull base: the anterior ethmoidal foramen on the medial orbital wall, the anterior ethmoidal canal within the anterior ethmoidal sinus or skull base, and the anterior ethmoidal sulcus along the lateral lamella of the cribriform plate.[2] The AEA-skull base distance is significant. Another reference point is the anterior nasal spine. AEA measurements relative to the anterior nasal spine demonstrate statistically significant differences, confirming its use in locating the artery. Anterior Axilla of the Middle Turbinate: This landmark is reliable for AEA location. Its high inter-rater reliability and low population variability made it a preferred surgical reference point. As with the middle turbinate axilla, the nasal axilla provides a valid anatomical reference for the AEA. Preoperative planning and intraoperative navigation benefit from its regular location.[3]

From the internal carotid artery, ophthalmic arteries enter the orbit through the optic foramen lateral to the optic nerve. It leaves the orbit by making a convex anterior loop and entering the anterior ethmoidal canal in the frontoethmoidal suture. It enters the olfactory fossa by lateral cribriform plate lamella by anterior ethmoidal sulcus after passing through ethmoidal air cells.[4,5]

Functional endoscopic sinus surgery improves sinus mucociliary drainage and removes diseased mucosa or bone that blocks sinus outflow pathways. This procedure risks cribriform plate lateral lamella and AEA damage.[6,7] Preoperative knowledge of skull base anatomy and landmarks and course of artery can prevent FESS complications like optic nerve damage, CS Fleak, meningitis, carotid vascular injury, nasolacrimal duct stenosis, epistaxis, intra orbital bleed, and retro orbital hematoma.[8] The precise determination of AEA and its trajectory is crucial in order to minimize the likelihood of difficulties occurring during surgical procedures, such as endoscopic sinus surgeries and skull base operations. Erroneous identification of the AEA can result in significant hemorrhaging, cerebral fluid leakage, or harm to neighbouring anatomical structures. Since the anatomical presentation of the AEA can vary, this work is crucial in elucidating the various anatomical landmarks shown on CT scans that help in determining the path of the artery. A comprehensive analysis of the occurrence rate of particular anatomical features, such as the anterior ethmoidal foramen, anterior ethmoidal sulcus, and supraorbital pneumatization, can enhance the preparation for surgery, reduce the occurrence of problems, and enhance the results for patients. The objective of this study was to determine the frequency of different anatomical landmarks used to identify the course of the AEA in patients who presented at Fauji Foundation hospital, Rawalpindi, for a CT scan of the paranasal sinuses. The study examined coronal CT features like the anterior ethmoidal foramen, sulcus, and supraorbital pneumatization. The anterior ethmoidal foramen was formed when the upper border of the ethmoid bone coincided with a comparable notch in the frontal bone. The anterior ethmoidal sulcus was a bony groove on the lateral wall of the olfactory fossa, whereas supraorbital pneumatization was the pneumatization of the orbital roof postero-laterally to the frontal recess.

Methodology

This cross-sectional study was conducted at the Radiology Department of Fauji Foundation hospital, Rawalpindi. The sample size, calculated using the WHO sample size calculator with a 95% confidence level, 5% absolute precision, and an anticipated population proportion of 10%, was approximately 140 patients. The study was carried out over a period of six months, employing a consecutive (non-probability) sampling technique. The study included patients aged 12 and above undergoing CT scans of the paranasal sinuses. Exclusion criteria were prior surgery or trauma to the sinuses or skull base, congenital facial anomalies, malignancies, osteofibrous lesions, and sinus diseases causing opacification of the frontal recess or anterior ethmoidal cells. CT scans were recommended to patients by the ENT department for further evaluation. Each and every examination was performed with the assistance of a 64-slice CT scanner, and only coronal pictures were utilized for the purposes of investigation and analysis. With perpendicular sections aligned to the hard palate, these images were captured in the ventral decubitus posture. The range of the perpendicular sections goes from the anterior border of the frontal sinuses to the anterior border of the clivus.

SPSS version 26 was used for data analysis. For quantitative variables such as age, the mean ± SD was computed. For qualitative variables such as gender, anterior ethmoidal foramen, anterior ethmoidal sulcus, anterior ethmoidal canal, and supraorbital pneumatization, frequency and percentages were determined. Stratification was performed based on age and gender to observe their effects on the outcome. A Chi-square test was applied after stratification, and a p-value of less than 0.05 was considered statistically significant.

Ethical approval was taken from the IREB of Fauji Foundation Hospital, Rawalpindi Hospital (Ref no. 738/RC/FFH/RWP) dated 26 July 2024.

Results

A total of 140 patients undergoing CT scans of the paranasal sinuses were included in this study. The average age was 40.77±15.62 years (Table 1). The cohort comprised 67 males (47.86%) and 73 females (52.14%). The bar chart illustrates the age distribution of patients who participated in the study. The largest group, consisting of 35 patients (25.0%), was in the 31–40 age range, indicating that most participants were middle-aged. This was followed by the 41–50 age group, with 28 patients (20.0%), and the 21–30 age group, with 26 patients (18.6%). The number of patients decreased in both younger and older age groups, with 15 patients (10.7%) aged 20 or younger, and 14 patients (10.0%) over the age of 60. The 51–60 age group had 22 patients (15.7%). Overall, the chart demonstrates a higher concentration of patients in the middle-age categories, with fewer in the extremes of the age range. Supraorbital pneumatization was present in 52.14% of cases, the anterior ethmoidal sulcus in 96.43%, and the anterior ethmoidal foramen in 98.57%. The distribution of these landmarks by age and gender is detailed in Tables 3 and 4. There was no statistically significant difference in the frequency of anatomical landmarks between different age groups or between males and females.

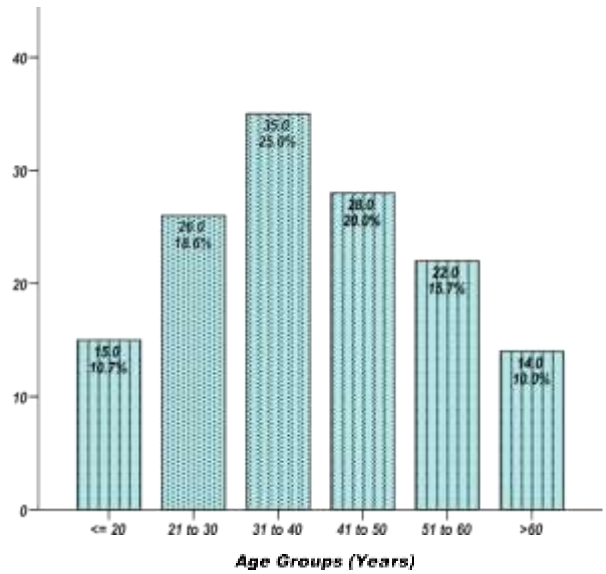

Figure 1: Age Distribution of the Patients (N=140)

The age distribution of 140 patients shows a mean age of 40.77 years with a standard deviation of 15.62, indicating significant variability. The 95% confidence interval (38.16–43.38 years) suggests the true mean age likely falls within this range. The median age is 38, showing a slight skew toward older ages. The interquartile range of 21 years confirms a broad distribution, with ages ranging from 14 to 80 years. This indicates a diverse patient group, with the majority in their late 30s to early 40s. The data shows that the presence of anatomical landmarks used for identifying the AEA does not significantly vary with age. For the Anterior Ethmoidal Foramen, Anterior Ethmoidal Sulcus, and Supraorbital Pneumatization, p-values are 0.52, 0.95, and 0.70, respectively, indicating no significant differences across age groups.

There are no significant gender differences in the presence of anatomical landmarks for identifying the AEA, with p-values of 0.95, 0.19, and 0.73 for the Anterior Ethmoidal Foramen, Sulcus, and Supraorbital Pneumatization, respectively.

Table I: Frequency of Different Anatomical Landmarks for Identifying the Course of AEA (n=140)			
Anatomical Landmark	**Frequency (Yes)**	**Percentage (Yes)**	**Percentage (No)**
Anterior Ethmoidal Foramen	138	98.57%	1.43%
Anterior Ethmoidal Sulcus	135	96.43%	3.57%
Supraorbital Pneumatization	73	52.14%	47.86%

Table II: Frequencies of different anatomical landmarks seen for identifying the course of AEA according to age groups (n=140)					
Different Anatomical Landmarks	**Age Groups (Years)**				**P-Value**
	≤ 30 n=41	**31-40 n=35**	**41-50 n=28**	**>50 n=36**	
Anterior Ethmoidal Foramen					
Yes	40(97.6%)	35(100%)	27(96.4%)	36(100%)	
No	1(2.4%)	0(0%)	1(3.6%)	0(0%)	0.52
Anterior Ethmoidal Sulcus					
Yes	39(95.1%)	34(97.1%)	27(96.4%)	35(97.2%)	0.95
No	2(4.9%)	1(2.9%)	1(3.6%)	1(2.8%)	
Supraorbitary Pneumatization					0.70
Yes	20(48.8%)	21(60%)	13(46.4%)	19(52.8%)	
No	21(51.2%)	14(40%)	15(53.6%)	17(47.2%)	

Table III: Frequency of different anatomical landmarks seen for identifying the course of AEA according to gender (n=140)			
Concern and fears	**Male n=67**	**Female n=73**	**P-Value**
Anterior Ethmoidal Foramen			
Yes	66(98.5%)	72(98.6%)	0.95
No	1(1.5%)	1(1.4%)	
Anterior Ethmoidal Sulcus			
Yes	63(94%)	72(98.6%)	0.19
No	4(6%)	1(1.4%)	
Supraorbitary Pneumatization			
Yes	36(53.7%)	37(50.7%)	0.73
No	31(46.3%)	36(49.3%)	

Discussion

The AEA has been the subject of a great number of anatomical investigations that have been published; the majority of these researches make use of endoscopic measures that are associated with endonasal anatomical markers. High-resolution CT scans are essential before functional endoscopic sinus surgery to identify the AEA. Endoscopic reference points, such as the axilla of the middle turbinate and ground lamella, help locate the artery during surgery. Cadaver dissections further enhance anatomical understanding, improving surgical accuracy and safety.[9]

In a systematic review and meta-analysis, authors compiled data from 38 studies to examine appearance and route of the AEA. Results indicated that in 56.91% of cases, the AEA was either embedded within or at the level of the skull base, often producing a bony protrusion. The mean diameter of the AEA was 0.94 mm in the intraorbital area and 0.76 mm in the intracranial area. The artery most commonly passed between the second and third lamellae, with a prevalence of 65.82%. These findings highlight the significant variability in the AEA's course and position, emphasizing the risk of iatrogenic injury during sinus and skull base surgeries. Surgeons must be aware of these variations to ensure intraoperative safety and prevent complications.[10]

Males have longer distanced to the ANS and AXN than females, although statistically significant differences have not been found by laterality. The research shows no statistically significant differences in SB and AXCM distances by sex or laterality.[11,12,13] Beraldin et al. reported that 44% of patients demonstrated a clear separation between the anterior ethmoidal artery (AEA) and the skull base, while a lateral displacement greater than 1 mm was identified in 30% of cases.[14] The AEA channel was observed to be located underneath the ethmoidal ceiling in cases of supra orbital pneumatization during anatomical dissections of 30 partial skulls by Simmen et al.[11]

From August 2024 to January 2025, in a Prospective study 145 direct coronal CT images of the paranasal sinuses identified AEA landmarks and their connection to supraorbital pneumatization. The anterior ethmoidal foramen was present in 98% of scans, the AEA canal in 33% (mainly complete), and supraorbital pneumatization in 28%. A substantial association was established between supraorbital cells and AEA canal visibility. CT scans consistently show the anterior ethmoidal foramen, giving it a solid landmark for surgeons. The decreased visibility of the AEA canal (33%), and its link with supraorbital pneumatization, suggest that supraorbital cells can help locate the canal. These findings improve surgical planning for frontal and ethmoid sinus surgeries, improving accuracy and safety.[15]

In another study on anatomical landmarks for accurately locating the AEA, identified four reliable landmarks—SB, ANS, AXCM, and AXN—with AXCM being the most dependable. The findings are valuable for procedures involving the frontal sinus, anterior ethmoidal sinus, and SB (e.g., FESS), helping improve AEA localization and avoid iatrogenic injury.[16] Still few studies have concluded differently as discussed. In a retrospective study analyzed 99 NCCT scans of the nose and paranasal sinuses to measure the distance between the AEA and the skull base and frontal sinus, as well as the number and types of intervening air cells. The AEA foramen was visualized bilaterally in all patients. The average distance from the skull base to the AEA was 1.66 mm, and from the AEA to the frontal sinus was 7.51 mm. Supra bulbar cells were the most common intervening cells. The distance between the AEA and the frontal sinus varied based on the number of intervening cells. While understanding AEA anatomy is crucial for endoscopic surgery, it may not consistently serve as a reliable landmark for the frontal sinus in FESS.[17] A thorough analysis of the anatomical changes in the AEA was presented in this study using coronal CT imaging. During diagnostic evaluations and surgical procedures, clinicians, particularly otolaryngologists and radiologists, can use this information to more accurately predict the path of the artery and its connection to relevant structures which will increase the accuracy of surgical planning, especially in endoscopic procedures with limited sight, and boost patient safety by minimizing the chances of unintended injury to the artery. Furthermore, the results can enhance the education of medical practitioners by providing a benchmark for analyzing CT scans in patients receiving assessments of the paranasal sinus. Moreover, the data could assist in improving radiological procedures, therefore assuring the consistent and precise evaluation of important structures such as the AEA.

Conclusion

Statistical analysis revealed no significant differences in the presence of these anatomical landmarks across different age groups or between genders, with p-values of 0.52, 0.95, and 0.70 for age and 0.95, 0.19, and 0.73 for gender, respectively. This suggests that the AEA's anatomical landmarks are consistently present across diverse patient demographics.

These findings provide valuable insight for clinicians and surgeons, confirming that these landmarks are reliable for identifying the AEA during surgical planning, regardless of the patient's age or gender.

Limitations: The study's sample size, while sufficient for general analysis, *may* not capture rarer anatomical variations. Additionally, the cross-sectional design limits the ability to assess longitudinal changes in anatomical landmarks.

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