The utilization of paranasal sinus coronal tomography scans as a predictor for the anterior ethmoidal artery course.

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Abstract

Background. This study aims to identify radiological features on paranasal sinus coronal tomography images that can guide the surgeon to localize and determine the course of the anterior ethmoidal artery (AEA). These features include the visualization of anterior ethmoidal foramen (AEF) and anterior ethmoidal sulcus (AES) as well as the supraorbital pneumatization (SOP).

Methods. This retrospective study includes 182 of the paranasal sinuses coronal tomography (CT) for patients who attended the clinic from January 2019 to August 2019 in King Abdullah University Hospital. We excluded the following images from our study: patients younger than twelve years old, patients with a sinus surgery record or trauma, patients with sinus malignancies, congenital anomalies of the face, images with fibro-osseous lesions that impaired the visualization of ethmoid roof, and images with opacified frontal recess region and/or the ethmoidal cells.

Results. Both AEF and AES are prominent features on the coronal CT scan that are used to localize the AEA canal and predict its course in the ethmoid labyrinth. It was found that both radiological landmarks are presented in 100% and 93.4 % of our cases; respectively. Moreover, the presence of SOP is significant with the existence of AEA canal on coronal CT scan images.

Conclusion. The preoperative evaluation of a coronal CT scan to localize the AEA can be precisely determined by visualization of both the AEF and AES. On the other hand, the presence of SOP is considered a significant sign on the CT scan where AEA can be identified.

Background

The anterior ethmoidal artery (AEA) is one of the supreme cornerstones in the nasal cavity that we should keep it in mind during endoscopic sinus surgery; it is one of the branches of the ophthalmic artery, which emerge from the internal carotid artery. AEA passes through three different anatomical spaces: the orbit, the nasal cavity, and the anterior cranial fossa. It leaves orbit through the anterior ethmoidal foramen (AEF) toward the ethmoid labyrinth where it's usually covered within an osseous passage called anterior ethmoidal canal [1]. Once the AEA reaches the lateral lamella of the cribriform plate specifically at radiological and anatomical landmark mark called the anterior ethmoidal sulcus (AES), here it passes through it to the olfactory fossa. The insertion region is considered the weakest among the whole anterior skull base and prone to injury during endoscopic sinus surgery causing cerebrospinal fluid (CSF) leak [2]. The AEA supplies the frontal sinus, the anterior ethmoidal cells as well as anterior one-third of nasal septum and the sidewall of the nasal cavity. Moreover; within the olfactory fossa, it grants the meningeal vessels to the dura mater [3].

Due to varying variable relations between the AEA and the ethmoid roof during its path through the nasal cavity from the medial orbital wall towards the olfactory fossa, the artery is at risk during surgical procedures [4, 5]. Accordingly, identifying its course allows the surgeon during endoscopic procedures to avoid unwanted damage to it which may leads to intraorbital bleeding if the AEA retracted back to orbit

due to injury at the lateral side of the artery (proximal to the AEF) or can produce cerebrospinal fluid leak if the damages occurs at the medial aspect of the artery [6, 7].

A computed tomography (CT) scan is a premium imaging technique used to assess the sinonasal cavities. It is used to review both the anatomy as well as to assess and evaluate sinonasal problems [8]. CT scan principally the coronal sections is deemed as a guide for evaluating the anatomy of nasal cavity and paranasal sinuses that vary between persons even between both sides for the same individual; this may give the surgeon a hint about possible complications during sinus surgery [9, 10]. Gotwald et al found that both AEF and AFS were good radiological key points on coronal CT scan for identifying the orientation and position of the AEA within the ethmoid labyrinth [11]. Moreover, in an endoscopic study that was done by Simmen et al, they concluded that in addition to variable positions of AEA that can be found in endoscopic exam, in the presence of an SOP the artery existed underneath the level of skull base [12].

The goal of the present investigation study is to recognize the principle milestones of the AEA canal on both sides of nasal cavity depending on coronal paranasal sinus CT scan, also to link between the existence of SOP and the ability to visualize the AEA canal.

Methods

This Retrospective study was done for patients who attended the clinic in king Abdullah university hospital Irbid, Jordan in the period from January 2019 to August 2019. We considered 182 of the paranasal sinuses CT among those patients who fulfill the inclusion criteria for our research.

This study aims to recognize the principle milestones of the AEA on the medial and lateral wall of the nasal cavity. Moreover, to link between the existence of SOP and the ability to visualize the AEA canal on coronal CT scan. To achieve the previous goals, we designed our paper to have the following exclusion criteria:

- Patients younger than twelve years old
- Patients with sinus surgery record or trauma
- Structural abnormalities of the head.
- Patients with sinus or nasal cavity.
- Images with fibro-osseous lesions that impaired the visualization of the ethmoid roof.
- Images with opacified frontal recess region and/or the ethmoidal cells

A coronal CT scan was done using a 16 slice CT SCANNER with 3 mm slice thickness. The patient was in prone posture and the Images of the paranasal sinus cavity were taken started anteriorly from the frontal and nasal bone and extended posteriorly to clivus and nasopharynx.

Depending on the following anatomical landmarks for AEA, a single observer interpreted all exams to link between the existences of SOP and the ability to visualize the AEA canal on coronal CT scan; these points include:

- AEF (bony indentation on the lamina papyracea of the orbit) (**Figure 1**)
- AES (bony indentation on the lateral wall of the olfactory fossa) (**Figure 2**).
- SOP (cell formed by superolateral pneumatization of the orbital plate of the frontal bone [13]) (**Figure 3**).
- AEA canal and its passage in the roof of the nasal cavity (**Figure 4**).

Study approval was received from the ethics committee for scientific research (IRB) at our hospital. Only patients who signed informed consent were included in the study.

Data were recorded in a Microsoft Excel (Redmond, WA, USA) spreadsheet and analyzed by SPSS program version 16.0, Statistical significance was assessed using a two-tailed Fisher's exact test (statistical significance was considered for $p < 0.05$).

Results

The study included 182 patients; they were 96 males (52.7%) and 86 (47.3%) females, ages ranged from 15 to 75 years with a mean age of 35 years. Supraorbital pneumatization was seen bilateral in 23.7% of CT scans; however, it was seen in 29.1% in all exams (**Table 1**). On the other hand, the AEA canal was seen bilateral in 27 % of CT scans and 36.8% in all exams. (**Table 2**). Both AEF and AES anterior were found in 100% and 93.4% in all CT scans.

In our study, the relationship between the existences of SOP on coronal CT scan of the paranasal sinus and the ability to visualize the AEA canal was statistically significant (**Table 3**) with a P-value of 0.0001

Discussion

Recognize the position and course of AEA through focused reading of CT scan of the patients is very crucial before surgery, As Wong et al. described that the area of the AEA is fundamental and important for surgeon due to their worries regarding the possible complications (such as bleeding, CSF leak and, retro-bulbar hematoma) that can occur if there is injury to the AEA or its surrounding area [7]. Moreover, many authors mentioned that AEA is a good anatomical landmark to locate the frontal recess, which aids in both frontal and ethmoid sinus surgery as well as for the localization the skull base in endonasal surgery [1, 2, 4].

Nowadays, CT can serve as an anatomic map for the surgeon and it is mandatory for the assessment of the nasal cavity and the paranasal sinuses regarding its anatomy as well as its pathology [14]. CT scan is broadly prescribed by surgeon prior to do sinus surgery as it overcomes the other radiological studies by the ability to define the bony structures of the nasal cavity and sinuses, so almost all surgeon asked this

type of image (coronal CT scan of paranasal sinuses) in order to evaluate the complex anatomy of the nasal cavity including the precise identification the site and course of the AEA in order to diminish the possible dangerous complications that they can face during operations.

Gotwald et al. evaluated 40 coronal plane CT exams and noticed that the AEF and the AES were found respectively in 95% and 84% of exams [11]. Noori et al. evaluated 145 coronal scans and noticed that AEF and AFS were noticed in 100% and 98% respectively [15]. Moreover, McDonald et al. studied 50 CT exams in the coronal plane and notices the AEF bilaterally in 95% of exams [16]. In our study, we found that AEF and AES were dependable landmarks on coronal CT scans to locate the AEA since they were noticed in 100% and 93.4% respectively.

In this study we have noticed the AEA canal in 36.8% of cases which was almost similar to Noori et al study where they found it in 33% of cases [15]. Moreover, Basak et al in his study observed the artery in 43% of exams [9]. On the other hand, Gotwald et al. who just rely on the structural cornerstones of the artery in paranasal sinus CT scans without directly visualizing the AEA, canal reported the possible orientation of AEA in 79% of their CT exams [11].

Also, in our study, the SOP was seen in 29.1% of cases, this rate is somewhat greater than that of Chung et al. and Noori et al that they reported visualization of supraorbital pneumatization in 26%, 28% respectively [15, 17]. Moreover, in a study by Cho et al, the incidence of SOP in a Korean population was 2.6%, while the incidence in a Western population was 64.4% [18]. In this study there was a strong correlation ship between the existence of SOP on paranasal coronal CT scans and visualization of the AEA canal. In other words, The AEA canal was seen in all exams in which SOP was present. These findings are consistent with Zhang et al who found that the AEA was always located posterior to the SOP. However, they reported only a 5.4% incidence of SOP in their study [19].

It was concluded that AEF (indentation existing on the lamina papyracea) and AES (indentation existing on the sidewall of the olfactory fossae) were prominent features on CT scan to detect the AEA canal and it was found in 100% and 93.4% of cases respectively. Furthermore, there was a statistically significant association between the existence of SOP on coronal paranasal sinus CT scans and the ability to visualize the AEA canal. In other words, the AEA canal was seen in all exams in which SOP was present on coronal CT scans of the paranasal sinus.

Conclusion

It was concluded that AEF (indentation existing on the lamina papyracea) and AES (indentation existing on the sidewall of the olfactory fossae) were a prominent features on CT scan to detect the AEA canal and it was found in 100% and 93.4% of cases respectively. Moreover, there was a statistically significant association between the existence of SOP on coronal paranasal sinus CT scans and the ability to visualize the AEA canal. In other words, the AEA canal was seen in all exams in which SOP was present on coronal CT scans of the paranasal sinus.

Declarations

Ethics statement

Institutional approval was obtained from the Institutional Review Board at King Abdullah University Hospital. This study was conducted in accordance with the Declaration of Helsinki. The consent was waived due to the retrospective nature of the study.

Competing Interests

There are no conflicts of interest to declare.

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Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author.

Acknowledgment

None

Abbreviations

Anterior ethmoidal artery (AEA), Anterior ethmoidal foramen (AEF), Anterior ethmoidal sulcus (AES), Supraorbital pneumatization (SOP), Coronal Tomography (CT)

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Tables

Table 1. Distribution of supraorbital pneumatization according to the side it was found.

Visualization of supraorbital pneumatization			
Absent	129	70.9%	70.9%
Present bilateral	43	23.7%	29.1%
On left side alone	4	2.2%	
On right side alone	6	3.2	
	182	100%	100%

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Table 2. Distribution of Anterior ethmoidal artery canal according to the side it was found.

Visualization of the AEA canal			
Absent	115	63.2%	63.2%
Present bilateral	49	27%	36.8%
On left side alone	7	3.8%	
On right side alone	11	6%	
	182	100%	100%

Abbreviations: AEA: Anterior ethmoidal artery

Table 3. The relation between the visualization of the anterior ethmoidal artery canal and supraorbital pneumatization in CT scans.

AEA CANAL	SOP		TOTAT
	Abscent	Present	
Absent	115	0	115
Present	14	53	67
Total	129	53	182

Abbreviations: AEA: Anterior ethmoidal artery, SOP: Supraorbital pneumatization

Figures

Figure 1

A, Coronal computed tomographic (CT) scan illustrating the right anterior ethmoidal foramen - bony notch (arrow) on the medial wall of the right orbit.

Figure 2

A, Coronal computed tomographic (CT) scan illustrating the right anterior ethmoidal sulcus - bony sulcus (tip of arrows) on the right lateral wall of the olfactory fossae.

Figure 3

A, Coronal computed tomographic (CT) scan illustrating the left supraorbital pneumatization.

Figure 4

A, Coronal computed tomographic (CT) scan illustrating the right anterior ethmoidal canal.