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A Computed Tomography-Aided Clinical Report on Anatomical Variations of the Paranasal Sinuses

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ABSTRACT

Purpose: *The purpose of this study was to defining the prevalence, size of incidence of different anatomical variations of the paranasal sinus (PNS) and nasal cavity among Sudanese patients and efficacy of CT scan in disease determination.* ***Introduction:*** *Disease of the PNS is a global public health problem, with the only treatment option available being endoscopic surgery. Previous studies have suggested that anatomical variations of the PNS are common in different populations; however, there is little information available to verify this. Hence, the objective of the present study was to determine the prevalence of different anatomical variations of the PNS and nasal cavity among Sudanese patients who were referred by ear, nose, and throat (ENT) surgeons for a computed tomography (CT)-aided study.* ***Methodology:*** *The total number of patients eligible for the study was 557; of these, 51 were excluded, 317 were in the study group, and 189 were controls. The CT images were carefully reviewed and discussed with the involvement of consultant radiologists, an anatomist, and an otolaryngologist.* ***Results:*** *Our results showed that there was extensive pneumatization of the frontal sinus (FS) in 37% of cases, a rudimentary FS in 11%, and absence of the FS in 12%. In addition, the Keros classification showed the FS to be normal in 55%, type I in 27%, type II in 10%, type III in 6%, and type IV in only 2% of patients. A large ethmoid bulla (EB) was found in 43% of patients, but the remaining 57% had a normal ethmoid sinus. Posterior ethmoid cells showed extensive pneumatization unilaterally in 5%, and bilaterally in 3% of patients; 92% were normal. Extensive pneumatization of the sphenoid was seen in 49% of patients, while the remaining 51% had a normal sphenoid. The sphenoid septum was attached bilaterally to the internal carotid artery in 6% and unilaterally in 21% of patients. A septate sphenoid sinus (more than one septum) was found in 33% of patients; the remaining 67% were normal. A bilateral hypoplastic maxillary sinus was seen in 23%, a unilateral hypoplastic maxillary sinus in 3%, extensive pneumatization in 17%, bilateral septation in 17%, unilateral septation in 19%, Haller cells in 33%, and normal anatomy in 67% of patients.* ***Conclusion:*** *A CT-aided study gives good results describing anatomical variations of the PNS in the Sudanese population and to the best of our knowledge, this is the first detailed clinical report on PNS in Sudan.*

Keywords: Sudanese population, paranasal sinuses, anatomic variation, computed tomography

INTRODUCTION

The paranasal sinuses (PNSs) are air-filled, mucosa-lined cavities that develop in the facial and cranial bones and communicate with the nasal airways. However, their function is not known, and has been the subject of much speculation. Some argue that they could be involved in decreasing the weight of the skull and others postulate that they may act as resonators for voice [1]. In lower animals, they are associated with a more acute sense of smell, and are largely lined by olfactory epithelium that has developed to increase the available surface area for smelling. However, in humans, olfaction is limited to a much smaller surface area, and the presence of the paranasal sinuses is probably a vestigial anachronism.

The PNSs are clinically categorized into the following four paired types:

1) The frontal pair in the frontal bone. The posterior wall is located adjacent to the anterior cranial fossa. They are usually asymmetrical and occasionally absent.

2) The maxillary pair in the maxilla. The superior wall forms the floor of the orbit and the medial wall is formed by the lateral wall of the nose. Inferiorly, the maxillary pair is related to the tooth-bearing area of the maxilla.

3) The numerous ethmoid cells in the superior and lateral walls of the nose and the medial walls of the orbits.

4) The sphenoid pair, located in the sphenoid bone where the sella turcica projects into this space [2].

Infection in the PNSs can cause headache because of obstruction to normal drainage as well as negative pressure created in the sinus. It has been reported that neoplasms growing in the sinuses also may cause obstruction for a prolonged period, and are therefore usually diagnosed at an advanced stage.

Types of anatomical variations in the PNS

Variable pneumatization of the frontal sinus: Pneumatization of the frontal sinuses is highly variable and asymmetric. Although extensive pneumatization of the frontal sinuses is very common, aplasia and hypoplasia can be seen in up to 5% of the population [3]. It is speculated that pneumatization may extend into the orbital plate of the frontal bone, resulting in development of the anterior ethmoids, and is associated with the absence of an ethmoid bulla [4]. Frontal cells are an additional reported variation of the frontal sinuses [5] demonstrated that these cells play a role in embryonic development of the sinuses, whereas Van Aleya, et al. [6] reported that these cells encroach into the frontal recess or frontal sinuses.

However, Delgaudio, et al. [7] classified these into the following four categories:

Type I: Single frontal recess cell above the agger nasi cells.

Type II: Tier of cells in the frontal recess above the agger nasi cells.

Type III: Single massive cell pneumatization cephalad to the frontal sinuses.

Type IV: Single isolated cell within the frontal sinus.

Variable pneumatization of the maxillary sinuses: Four types of recesses are reported in the maxillary sinuses, as follows. (i) Palatine recesses, which extend medially into the hard palate from the inferior aspect of the maxillary antra Lanzieri, et al. [8]. These recesses are bilateral and symmetric. (ii) Alveolar recesses, which are formed by extension of pneumatization into the superior alveolus and are seen more frequently in edentulous patients Bell, et al. [9]. They are close to the roots of the premolar and molar teeth. (iii) Infraorbital recesses are the result of pneumatization along the roof of the maxillary sinus and are medial to the groove for the infraorbital nerve. These extensions are usually confused with infraorbital ethmoid air cells, i.e., Haller cells. (iv) Zygomatic recesses are the result of extension of pneumatization of the maxillary sinus roof into the zygomatic bone.

Anatomical variation of the ethmoid sinuses: The most notable anatomical ethmoid variations include the agger nasi cells, which are mostly seen in the anterior ethmoid air cells, and are extramural (i.e., not within the ethmoid bone). Because of variations in anatomic descriptions, the prevalence of these cells also varies widely in nature. For the purpose of coronal CT imaging in this study, agger nasi cells are defined as those located anterior to the superior end of the nasolacrimal duct, because they may cause narrowing of the frontal recess and cause predisposition to ipsilateral frontal sinus disease. The large ethmoid bullae are another variation of the ethmoid sinus; these may compromise the osteomeatal complex at the level of the infundibulum, hiatus semilunaris, or middle meatus. A third anatomical variation is the presence of infraorbital ethmoid Haller cells, which extend along the medial aspect of the orbital floor; they may be present as discrete air cells or drain into the infundibulum or maxillary sinus. These infraorbital cells may cause narrowing of the ethmoid infundibulum, resulting in ipsilateral maxillary sinus disease (Figure 1).

The fourth and final variation is the fovea ethmoidalis. This asymmetric, low-lying ethmoid roof is a potential risk factor for intracranial injury during endoscopic surgery of the ethmoid air cells; focal dehiscence of the fovea ethmoidalis or cribriform plate may be posttraumatic or congenital [10].

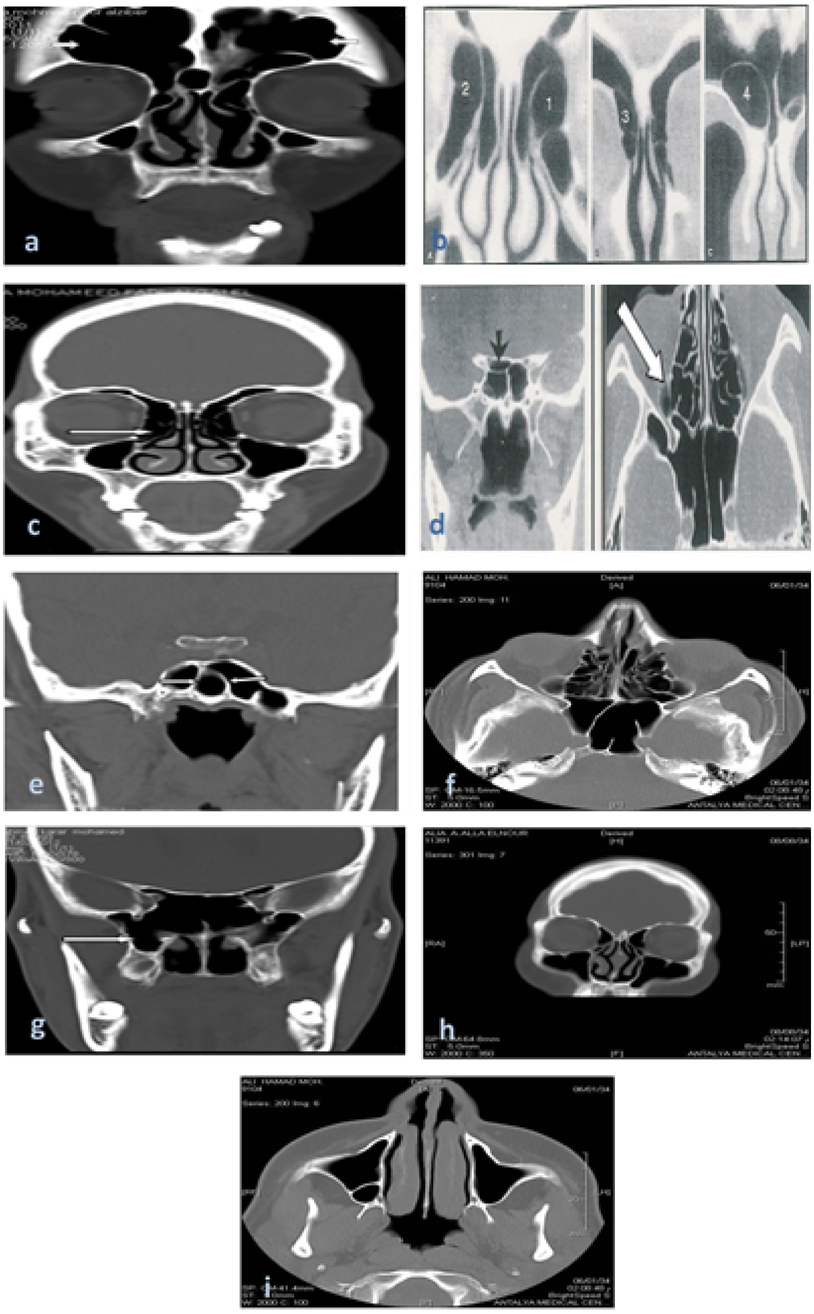

Figure 1. (a) Variable pneumatization of the Frontal sinuses as shown in coronal view. White arrow indicates the pneumatization (b) Showing the coronal views of four types of frontal cells (c) Figure showing the ethmoidal bulla is delineated (d) Black and white arrow indicates posterior ethmoidal cell shown in both coronal and axil section (e) White arrow indicates sphenoid pneumatization (f) showing sphenoid septum attached laterally to internal carotid artery (g) indicating the Septation of the sphenoidal sinus (h) image showing the anatomical variations of maxillary sinus (i) image showing the maxillary sinus in right unilateral direction

Anatomical variation of the sphenoidal sinuses: Sphenoid pneumatization is highly variable because the sphenoid sinuses can be hypoplastic or extensively pneumatized with aeration of multiple recesses. Lateral extension of pneumatization may occur into the lesser wing of the sphenoid above the optic nerve, or into the anterior clinoid processes inferior and lateral to the optic nerves. Pneumatization of the optic nerve may increase the risk of injury during endoscopic surgery in the region. Pneumatization into the greater wing may extend lateral to a line drawn between the pterygoid canal and foramen rotundum. These extensions excavate into the base of the pterygoid process and are referred to as pterygoid recesses. However, midline extensions may occur anteriorly into the nasal septum or posteriorly into the dorsum sellae. Another variation in the sphenoid sinus is septation. Vertical septations within the sphenoid may traverse the sinus obliquely and terminate posteriorly in the bony covering over the internal carotid artery, predisposing the vessel to injury [11]. Hence, an objective of the present study is to demonstrate the anatomical PNS variations that may occur in the Sudanese population. This study also intends to correlate sinus disease to anatomical variations of the PNS.

MATERIAL AND METHODS

Study design

This was a retrospective and descriptive hospital-based study that recruited 557 patients.

Study location

This study was conducted in the Department of Radiology of the Ear, Nose, and Throat (ENT) Hospital, and in the Antalia diagnostic Centre of Alzytona Hospital between January 1, 2012 and January 1, 2015.

Groups, inclusion, and exclusion criteria

The present study included 557 individuals. Of these, 368 were referred to the radiology department for a CT study of the PNS. We excluded 51 individuals for the following medical reasons: those who were diagnosed with nasal or sinus tumours and those who had a history of surgery of the nose or sinuses, as well as those who had congenital facial anomalies and dysmorphic syndromes. Finally, we included a total of 317 patients with PNS disease (Group B). The control group consisted of 189 randomly selected healthy individuals with no symptoms or signs of PNS (Group A).

CT scan equipment

We used a Siemens Sensation 64-slice multidetector CT scanner (Siemens AG, Germany); this is the preferred modality for PNS imaging because it provides a precise view of the anatomical structures. The PNS differ between patients, leading to anatomical variations in the general population. In this study, coronal reference views were used for data collection; in some cases, axial views were used for additional details. CT images were analyzed for the presence or absence of anatomical variations in the PNS and also for pathological conditions.

Statistical analysis

The collected data were analyzed using SPSS version 16 software (IBM Analytics, USA).

RESULTS

The results showed that there is a strong association between PNS anatomical variations and sinusitis in Sudanese patients.

Anatomical variation of the frontal sinus (FS) in the Sudanese population

Individuals belong to Group B were characterized by the pneumatization of the FS in about 28%, with a rudimentary FS in 10%, and the absence of FS in 11%. In addition, 51% showed no PNS anatomical variation. Our study also indicated that extensive pneumatization of FS had the highest incidence rate in group B, at about 37%, followed by a rudimentary FS in 11%, and absence of the FS in 12%. However, nearly 40% of group B showed no PNS anatomical variation (Table 1). The results indicated a strong correlation ($p<0.05$; chi-square between anatomical variation and PNS disease.

Table 1 Anatomical variations of the frontal sinus (FS) in group A and B

Sample	Anatomical variations of the frontal sinus				
	Normal FS	Extensive pneumatization	Rudimentary FS	Absent FS	Total
*Group A (No. of cases)	51% (96)	28% (53)	10% (19)	11% (21)	100% (189)
#Group B (No. of cases)	40% (127)	37% (117)	11% (35)	12% (38)	100% (317)
Cases/ control prevalence %			Chi – square		p-value
61.5/37.4%			640		p<0.05

*Group A=Healthy individual with no signs or symptoms of PNS
#Group B=Patients with PNS disease

Keros classification of the FS in the Sudanese population

Based on the Keros classification (13, 14), 64% of group A individuals were normal, Type I was seen in 19%, Type II in 9%, Type III in 6%, and Type IV in 2%; in contrast, 55% of individuals in group B were normal, Type I was seen in 27%, Type II in 10%, Type III in 6%, and Type IV in 2%, as shown in Table 2.

Table 2 Anatomical variations of the frontal sinus karos classification

Sample	Frontal sinus karos classification					
	Normal	Karos I	Karos II	Karos III	Karos IV	Total
*Group A (No. of cases)	64% (121)	19% (36)	9% (17)	6% (11)	2% (4)	100% (N=189)
#Group B (No. of cases)	55% (174)	27% (86)	10% (32)	6% (19)	2% (6)	100% (N=317)
Cases/control prevalence %				Chi – square		p-value
27.7 / 16.8%				147.474		0.05>p

*Group A=Healthy individual with no signs or symptoms of PNS
#Group B=Patients with PNS disease

Anatomical variation of the ethmoid sinuses in the Sudanese population

The ethmoid bulla (EB): In group B individuals, a large EB was present in about 43%, but 57% were normal. However, in group A, about 29% had a large EB, and 71% were normal (p<0.05). These results indicated a correlation between a large EB and ethmoiditis (Table 3).

Table 3 Anatomical variations of the size of ethmoid bulla

Sample	Size of Ethmoid bulla		
	Normal ethmoid bulla	Large ethmoid bulla	Total
*Group A (No. of cases)	(134) %71	29% (55)	100% (N=189)
#Group B (No. of cases)	57% (181)	43% (136)	100% (N=317)

*Group A=Healthy individual with no signs or symptoms of PNS
#Group B=Patients with PNS disease

Posterior ethmoid cells: In group A, unilateral cells were seen in about 2%, bilateral cells in 1%, and normal anatomy in 96% of patients. In group B, posterior ethmoid cells were extensively pneumatized unilaterally in 5%, bilaterally in 3%, and were normal in 92% of patients (Table 4).

Table 4 Anatomical variations of the posterior ethmoid cell Pneumatization

Sample	Posterior Ethmoid Cell Pneumatization			
	Normal	Unilateral	Bilateral	Grand Total
*Group A (No. of cases)	96% (181)	2% (5)	1% (3)	100% (N= 189)
#Group B (No. of cases)	92% (291)	5% (16)	3% (10)	100% (N= 317)

*Group A=Healthy individual with no signs or symptoms of PNS
#Group B=Patients with PNS disease

Anatomical variation of the sphenoid sinuses in the Sudanese population

Among individuals belong to Group A, 44% showed extensive pneumatization of the sphenoid sinuses, whereas 56% had normal sphenoids. However, in group B, extensive pneumatization of the sphenoids was found in 49% and 51% had normal sphenoids (Table 5).

Table 5 Anatomical variations of the Pneumatization of sphenoid sinus

Sample	Pneumatization of sphenoid sinus		
	Normal	Pneumatization of sphenoid sinus	Total
*Group A (No. of cases)	56% (106)	44% (83)	100% (N=189)
#Group B (No. of cases)	51% (162)	49% (155)	100% (N=317)
*Group A=Healthy individual with no signs or symptoms of PNS #Group B=Patients with PNS disease			

In addition, in group A, the sphenoid septum was attached bilaterally to the internal carotid artery in 16%, and unilaterally artery in 39% of patients. However, in group B, the sphenoid septum was attached bilaterally to the internal carotid artery in 6%, and unilaterally in 21% of patients (Table 6). In group A, a septate sphenoid sinus (more than one septum) was found in 41% of patients and 59% were normal. However, in group B, a septate sphenoid sinus was found in 33% of patients and about 67% were normal (Table 7).

Table 6 Anatomical variations of the sphenoid septum attached laterally internal carotid artery

Sample	Sphenoid Septum Attached Laterally internal carotid artery			
	Normal	Unilateral	Bilateral	Total
*Group A (No. of cases)	45% (85)	39% (74)	16% (30)	100% (N=189)
#Group B (No. of cases)	73% (231)	21% (67)	6% (19)	100% (N= 317)
*Group A=Healthy individual with no signs or symptoms of PNS #Group B=Patients with PNS disease				

Table 7 Anatomical variations of the septate sphenoid sinus

Sample	Septate sphenoid sinus (more than one septum)		
	Yes	No	Total
*Group A (No. of cases)	41% (77)	59% (112)	100% (N=189)
#Group B (No. of cases)	33% (10.4)	67% (12)	100% (N=317)
*Group A=Healthy individual with no signs or symptoms of PNS. #Group B=Patients with PNS disease.			

Table 8 Anatomical variation of maxillary sinus

Sample	Anatomical variation of maxillary sinus				
	Normal	Expensively	Bi Hypoplastic	UniHypoplastic	Total
*Group A	54%	17%	28%	2%	100%
#Group B	57%	17%	23%	3%	100%
Cases/ control prevalence %			Chi – square		p-value
61.5/37.4%			278.079		p<0.05
Conclusion			Very strong evidence		
*Group A=Healthy individual with no signs or symptoms of PNS. #Group B=Patients with PNS disease.					

Anatomical variation of the maxillary sinuses in the Sudanese populations

In group B, bilateral hypoplastic maxillary sinuses were observed in 23% of patients, and unilateral hypoplastic maxillary sinuses were found in only 3%, with extensive pneumatization in 17% (Table 8). Moreover, bilateral maxillary sinus septation was observed in 17% and unilateral septation in 19% of patients (Table 9). In group B, Haller cells were found in 33% of patients, while 67% had normal Haller cell anatomy. In group A, Haller cells were observed in only 15% of patients and 85% had normal Haller cell anatomy (Table 10).

Table 9 Anatomical variations of the maxillary sinus septa

Sample	Maxillary sinus septa			
	Normal	BiSeptate	UniSeptate	Total
*Group A (No. of cases)	74% (140)	12% (23)	14% (26)	100% (189)
#Group B (No. of cases)	64% (203)	17% (54)	19% (60)	100% (317)
*Group A=Healthy individual with no signs or symptoms of PNS. #Group B=Patients with PNS disease.				

Table 10 Anatomical variations of the Haller cells

Sample	Haller cells		
	Yes	**No**	**Total**
*Group A (No. of cases)	15% (28)	85% (161)	100% (189)
#Group B (No. of cases)	33% (105)	67% (212)	100% (317)
Cases/ control prevalence %		Chi – square	p-value
61.5/37.4%		113.834	p<0.05
Conclusion		Very strong evidence	

*Group A=Healthy individual with no signs or symptoms of PNS.
#Group B=Patients with PNS disease.

DISCUSSION

Anatomical variations of the PNS must be determined before performing any surgery in order to avoid the potential risks associated with functional endoscopic surgery (FESS) Abdullah, et al. [12]. Before proceeding with endoscopic surgery, the radiographic details of the osteomeatal complex as well as the anatomy of the other Para nasal sinus must be thoroughly verified.

In a previous study, Nitinavakarn, et al. [13] emphasized that CT of the PNS is usually required prior to any endoscopic sinus surgery because it demonstrates both the extent of disease and the anatomical variations that may predispose the patient to rhinosinusitis, as well as nearby vital structures so that iatrogenic injury can be avoided. Detailed knowledge of anatomical variations in the PNS region is critical for endoscopic sinus surgery as well for involvement by radiologists in the preoperative work-up. Prior knowledge of the anatomical variants and possible accompanying pathological influences are the key to the success of diagnostic and therapeutic management of PNS disease.

Haller cells are ethmoid air cells that project beyond the limits of the ethmoid labyrinth into the maxillary sinus. They are considered to be ethmoid cells that grow into the floor of the orbit and may narrow the adjacent ostium of the maxillary sinus, especially if they become infected [14] Furthermore, failure to diagnose this condition preoperatively can predispose the patient to orbital trauma and violation of the lamina papyracea during middle meatal antrostomy. The incidence of Haller cells in this study was 33%, [15] but reported the incidence as 15%, which was less than that reported previously by Palmer, et al. [16] (45.9%), Maru et al. [17] (36%), and Laine, et al. [18] (6.8%). Based on the above, it was clear that there is a strong association between maxillary sinusitis and anatomical variations of Haller cells ($p<0.05$).

The EB is the air cell directly above and posterior to the infundibulum and hiatus semilunaris. Although it is the largest ethmoid air cell, excessive size and pneumatization can impair sinus ventilation and drainage. An EB sometimes grows to a size that completely fills the sinus in the middle turbinate. An excessively large EB is a potential cause of sinus infection, especially if pus, polyps, or cysts are present. However, Danese, et al. [19] reported that this variation is difficult to assess and that it may be over diagnosed. The authors also reported that when compared to other variations, an enlarged EB had a lower correlation with sinus disease.

The present study reported a pneumatized EB in 43.2%, whereas Kang, et al. [20] found a large bulla unilaterally in 12.5%, and bilaterally in 7.4%. The presence of a large EB was strong evidence of maxillary sinusitis in our study ($p<0.05$). Preoperative evaluation of the anatomy of the sphenoid sinus by CT is a routine procedure and can direct surgical decision-making. Conchal pneumatization of the sphenoid sinus was seen in 2%, presellar pneumatization in 21%, sellar type in 54.7%, and postsellar pneumatization in 22.3% of patients. Lateral pneumatization of the greater wing of the sphenoid, leading to a capacious sinus, was reportedly seen in 83% of patients by Hamid, et al. [21], whereas the frequency of pneumatization of the sphenoid sinus was 49.5% in this study.

Asymmetric septation of the sphenoid sinuses (more than one septum) is very important, especially when it shows considerable deviation. As it advances, it marks the line of the internal carotid artery, which may protrude into the posterior ethmoidal cell [22]. However, the prevalence of septation in this study was about 33.5%; the frequency of presence of a unilateral sphenoid septum was 20.5%, and the septum was attached bilaterally to the internal carotid artery in 6.6%. If the removal of a sphenoid septum is required, it should be done cautiously after CT is performed in order to prevent possible complications in case of attachment to the internal carotid artery or the optic nerve.

The FSs are typically paired, asymmetric, and separated by a central intersinus septum, and have different degrees of pneumatization. Around 10% to 12% of normal adults may have a rudimentary FS or even a complete lack of frontal bone pneumatization on one side. Around 4% of the asymptomatic population has bilateral frontal sinus agenesis. In the present study, we found that extensive frontal sinus pneumatization occurred in 36.9%.

Agenesis of the paranasal sinuses is an uncommon clinical condition that appears mainly in the FS. Bilateral FS agenesis was seen in 11.7%, and unilateral agenesis was seen in only three individuals (11.1%) as reported by Pondé, et al. [23]. The prevalence of bilateral absence of the FS has been reported to be only 3-4%, but can be 10% in some populations [24]. However, this frequency was significantly higher in some populations, including Alaskan Eskimos (25% in males and 36% in females) and Canadian Eskimos (43% in males and 40% in females), as reported by Som, et al. [25]. The frequency of bilateral absence of the FS in this study was 11.7%, which is identical to that in Aydinlioğlu's report, but lower than that reported for most other ethnic populations [26].

Bulla frontalis is a group of variants basically indicating air cells located cranial to agger nasi cells, and extending towards the frontal sinus; they can be isolated and protruding (Type III) or not (Type I). In the present study, bulla frontalis was found in 31.5%. Frontal cells have been implicated as a cause of frontal recess obstruction. Follows 14.9% had Type I, 3.1% had Type II, 1.7% had Type III, and 2.1% had Type IV. The frontal cells in the present study, based on the Keros classification, showed the highest incidence for Type I (26.5%), followed by Type II (10.4%), Type III (5.7%) and Type IV (1.6%).

Extensive maxillary sinus pneumatization (EMSP) was defined when the largest horizontal and/or vertical dimension of the maxillary sinus was equal to or exceeded 90% of the corresponding diameter of the orbit. In a study by Meyer, et al. [27], the prevalence of EMSP was found to be 8% (7% bilateral and 1% unilateral). Extensive pneumatization was found in 17.3% of our cases, Maxillary sinus hypoplasia is an anomaly of the paranasal sinuses occasionally encountered by otolaryngologists. However, the literature lacks a system by which the various types of maxillary sinus hypoplasia can be classified using computerized topographic imaging. The overall prevalence of maxillary sinus hypoplasia was 10.4%. In the present study, we found that the incidence of a hypoplastic maxillary sinus was 26.5%, whereas twice this percentage was reported by Bassiouny, et al. [28].

Maxillary septa were found in 47%, and appropriate imaging prior to performing sinus surgery seems justified, since complications and the success rate of sinus floor elevation are clearly related to the presence of septa. Bilateral maxillary septa were seen in 22.7% of scans, whereas unilateral septa were seen in 13; the combined total percentage was 35.7%.

CONCLUSION

From the above results, we conclude that anatomical variations in patients have a great impact on the predisposition to inflammatory disease of the PNS, as these variations are largely found in patients with EB, Haller cells, variable pneumatization of the FS (hypo and hyper), frontal cells, and sphenoid sinuses with septation and pneumatization. Imaging of the PNS will aid in diagnosis in individual patients, and also provide a deeper understanding of the manifestations of the disease. In addition, CT topographical imaging of the PNS and anatomical variations enables endoscopic surgeons to be fully prepared for FESS, thus decreasing the risk of complications. This study may alert the endoscopic nasal surgeon to the importance of defining anatomical variations, and the significant impact of these variations on patient care, thereby reducing iatrogenic complications of morbidity and mortality.

Recommendations

The authors propose the following recommendations for the improvement of current treatment options available for PNS.

1) Collaboration between endoscopic nasal surgeons and radiologists is very important in proper diagnosis and interpretation of scans of the sinuses.

2) Establishment of a standard protocol for CT scanning of the nose, paranasal sinuses, and skull base, including window specifications, thickness of cuts, and views to increase the precision of detection of pathology and anatomical variations.

3) Regularly scheduled combined radiology and ENT academic meetings are recommended to bridge the gap between radiologists and ENT surgeons, and to provide exchange of knowledge and experience with the aim of improving medical services.

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