Presence of Agger Nasi cells and their relationship with frontal recess thickness: a retrospective study in a Brazilian population

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Abstract

Objective: The aim of this study was to carry out an epidemiological survey of the presence of Agger Nasi (AN) cells, using cone beam computed tomography (CBCT) images, in a Brazilian population in the region of Maringá - Paraná. Materials and Methods: The tomographic analyzes verified the thickness of the frontal beak (FB), anteroposterior length of the frontal isthmus, anteroposterior length of the FR and side-to-side, anteroposterior and vertical (cranio-caudal) diameter of the AN cells. Statistical analyzes were performed using the statistical program Jamovi (V2.5.5.0). For correlation analysis between the variables, the Spearman test was used. The study indicates the presence of AN cells in 100% of the individuals analyzed, being present bilaterally. Results: There was no significant correlation between FB and the AN cell. Significant positive correlations were found relating Right Agger Nasi Cell (ANC-R) and Left Agger Nasi Cell (ANC-L) with Front Recess (FR) and Frontal Sinus (FS). Conclusion: Anatomical knowledge on the part of professionals is of fundamental importance for a surgery to access the FS in a precise and uncomplicated way.

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Introduction

The osteomeatal complex is defined as a system whose function is to drain and ventilate the maxillary sinuses, frontal sinuses (FS) and anterior ethmoid cells. All those structures that surround the osteomeatal complex, such as cells, ostia, cracks, recesses or cavities, are susceptible to pathological processes.[1]

The frontal recess (FR) has been a highlight of interest of many professionals who work in the study and treatment of pathologies in the osteomeatal complex. According to the description of Stammberger, Jacob and Friedman,[1-3] the transition from the FS to the FR, in a tomographic image in sagittal reconstruction, has the shape of an "hourglass". The FS pavement undergoes an inferior narrowing towards the FS ostium (between the nasofrontal beak and the anterior skull base), which corresponds to the “hourglass” waist.[2] Just below the SF ostium, the FR appears, which widens inferiorly, taking the form of an inverted funnel.[4] The FR is composed of ethmoid cells, which surround it.[5] One of the structures present are the Agger Nasi (AN) cells that are formed when the lateral nasal wall of this cell is pneumatized.

The AN cell is located in the upper part of the first ethmoturbinate plate, which may appear as a tuberosity or a crest close to the middle nasal concha, as shown in the study by Stammnerger[1] Its pneumatization can occur at different levels, and it is possible that the cell reaches laterally to the lacrimal fossa, causing a narrowing in the FR, causing a change in its anatomy physiology. This process may occur due to its location, which borders five different bones of the skull: the lacrimal, the maxillary, the ethmoid, the frontal and the nasal.[1] The AN cell is an air chamber commonly found in anatomy studies, but its prevalence varies according to the study performed.

Due to the advent of endoscopic surgeries in the sinuses, computed tomography (CT) plays a fundamental role in the evaluation of contemporary anatomy, diagnosis and operative plan in surgeries in this region.[6] FR and FS surgery are always a challenge. It is postulated that a common cause for re-surgery is the incomplete removal of cells in this area. This often results in a blockage of the drainage pathway, with persistent inflammation and clinical symptoms. In addition, there are important anatomical structures close to the sinuses, such as the orbit, olfactory region and skull, which during surgical procedures, are at risk of being injured. Thus, an accurate and detailed knowledge of the anatomy is essential for any surgical procedure.[7]

One of the ways to obtain access to the FS through the endonasal route is through FR. However, this can become difficult due to the complex and variable anatomy of this region.[7,8] With CT performed preoperatively, this complexity has been reduced and the identification of anatomical variations in the FR has been facilitated. [6-9]

For these reasons, it is evident that the documentation of the FR morphology with its anatomical variations and their relationships with the FS morphology is fundamental for a surgery to access the SF with precision and without complications. Therefore, the objective of this study was to carry out an epidemiological survey regarding the presence of Agger Nasi cells, using cone beam computed tomography (CBCT) images, in a Brazilian population in the region of Maringá - Paraná.

Material & Methods

This retrospective and observational study was evaluated and approved by the Standing Committee on Ethics in Research Involving Human Beings of the State University of Maringá (UEM) (CAAE: 33176620.0.0000.0104) and was carried out in accordance with the recommendations of the STROBE initiative (Strengthening the Reporting of Observational Studies in Epidemiology).[10]

CBCT images of Brazilian patients of both sexes were used, who were referred to the Laboratory of Images in Clinical Research (LIPC), of the Health Technology Center (CTS) of the Research Support Center Complex (COMCAP), located at the Department of Dentistry at UEM. The CBCT exams were performed between January 2014 and December 2019 by the same specialist in dental radiology and imaging and they are all archived. 650 CBCT images were analyzed and 388 CT scans were selected. Of these, 266 were female and 122 were male. The study included CBCT scans performed for different purposes and dental specialties, of individuals over 18 years old, who completely contained the regions of interest and with the same image acquisition protocol. Images of individuals with congenital or acquired diseases, craniofacial deformities and with a history of trauma or surgery in the investigated region were excluded.

All images were initiated in the i-Cat Next Generation® equipment (Imaging Sciences International, Hatfield, PA, USA), operated at 120 kVp and 3-8 mA, with an isometric voxel of 0.300 mm and FOV (Field of view) de 17 X 23 cm. The images were protected with the scanner's own software (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA). Anatomical identification was supported by multiplanar reconstructions (MPRs) in all three planes and rendering of three-dimensional volumes. Images were evaluated in a quiet room with dimmed lighting.

All analyzes and measurements were performed by two independent radiologists (with more than 5 years of CBCT experience), blinded to gender details to minimize interpretation variation. The evaluators went through a calibration and training process. In this training, a theoretical discussion of all the criteria used in the evaluation was carried out. In this project, initial efforts focused on developing standardized configurations for the structures under study. Then, a practical training was also carried out, in which the examiners evaluated the same exams. After that, discrepancies between the results were tolerated, seeking consensus on the rules and criteria for evaluating the images. Finally, the medication itself was administered. To avoid eyestrain, only 10 images/day were evaluated. These same examiners performed the analyzes twice, with an interval of 15 days between estimates, and intra- and inter-examiner agreement was calculated using the Intraclass Correlation Coefficient (ICC).

In the tomographic analyzes, the following structures were verified and measured:

Greater side-to-side, anteroposterior and vertical (cranio-caudal) diameter of AN cells;

Larger diameter of the height, width and length of the FS;

Thickness of the nasofrontal beak;

Greater anteroposterior length of the frontal isthmus;

Greater anteroposterior length of the FR.

To facilitate this project, definitions were developed, based on traditional descriptions in contemporary anatomy literature, as shown in Table 1.

Table 1. Definition standard and criteria used in image visualization

Assessed structure	Definition
AN cells	• The AN is the most constant and anterior cell of the ethmoid bone.[3,4,11] • It is located below the nasofrontal beak and is identified in coronal reconstructions ahead of the anterior border of the vertical insertion of the middle turbinate.[11,12] • It relates frontally and inferiorly to the upper maxillary bone, and can be easily seen in parasagittal sections.[3,13] • It forms the anterior and inferior wall of the FR and its variable rate of pneumatization has an impact on the size of the FS ostium and the shape of the FR.[2,13–15] • When small, it is associated with a prominent nasofrontal beak which, when extending posteriorly, conditions a narrowing of the FS ostium. When larger, it is associated with a small nasofrontal beak and, consequently, with a wider FS ostium, but with the potential for monitoring the FR in its lower portion, by moving it posteriorly and laterally with the lacrimal fossa and the beginning of the FR lacrimal-nasal canal and supero-laterally with the bones of the nose.[3,13]

Table 1. Definition standard and criteria used in image visualization (cont.)

Assessed structure	Definition
FS	• FSs are usually paired, asymmetrical, separated by a central intersinus septum and with different rates of pneumatization.[16] • In adults, the average dimensions are 24.3 mm in height, 29 mm in width and 20.5 mm in depth. Approximately 10 to 12% of normal adults may have rudimentary FS or even a complete lack of pneumatization of the frontal bone on one side. Around 4% of the asymptomatic population may have bilateral FS agenesis.[16] • Gaafar et al., 2001 reported that the mean diameter of the FS ostium was 5.6 mm, ranging from 4 to 7 mm; • The frontal sinus drainage pathway is composed of three different regions and generally presents an “hourglass” configuration. The most superior part of the “hourglass” is represented by the FS itself, while the narrowest part corresponds to the ostium of this sinus. The lowest part of the “hourglass” is formed by the FR, a space dependent on the variable development of the anterior pneumatized cells.[1–3,16]
FR	• The FR is a complex space roughly shaped like an funnel or inverted cone with the apex at the FS ostium.[3,4] • It is bounded medially by the middle turbinate, laterally by the lamina papyracea, anteriorly by the frontal apophysis of the upper jaw and posteriorly by the ethmoidal bulla.[17] • This space can be pneumatized by various anterior ethmoid cells, including the AN cell, frontal cells, supraorbital ethmoidal cells, suprabullar cells, frontal bullous cells, interfrontal sinus septal cells, and recessus terminalis.[3,18] • In adults, the width, depth and limits of the FR are dependent on the anterior ethmoid cells and the embryonic pattern of neighboring bone lamellae.[4,18] • For the study of the anatomy of the RF, only the coronal images, CT standard, do not provide enough information for the reliable identification of the cells of the FR.[18] • The sagittal circumference provides an invaluable contribution to the assessment of RF.[13]
Nasofrontal beak	• The FB is the bone thickening of the midline, extension of the nasal process of the frontal bone. The FB is considered the anterior limit of the FS, the FS ostium and the FR. It is the posterior bone protrusion at the lowest part of the anterior table of the FS seen on parasagittal CT. Sagittal CT accurately identifies the dimensions of the FS and FR ostium and clearly shows the distance between the FB and the point where the posterior FS plate attaches to the anterior skull base.[19]
Frontal isthmus	• The anteroposterior length of the frontal isthmus is defined as the shortest length between the most prominent portion of the nasofrontal beak and the posterior table of the FS.[20] • High-resolution reconstructed parasagittal CT images clearly show the length between the nasofrontal beak and the junction of the posterior FS table with the anterior skull base.[2] • They show the AN cell size and the anteroposterior length of the frontal and RF isthmus, which is not detected on conventional paranasal sinus standard CT.[20]

Source: The authors (2023).

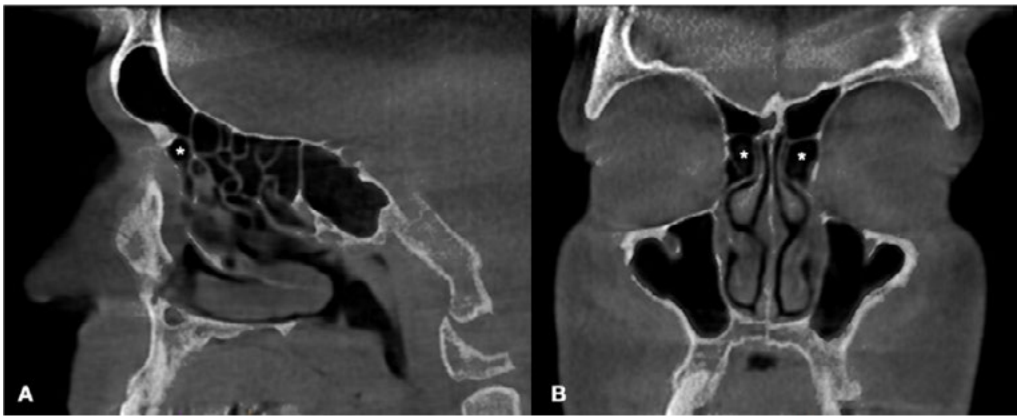

Figure 1. A) Left parasagittal section showing Agger Nasi (indicated by *); B) Coronal section showing bilateral Agger Nasi (indicated by *)

Figure 2. Coronal section shows Agger Nasi (*) above the upper end of the Nasolacrimal Duct

For the identification of the FR, we initially used sagittal reconstructions, in which identification is easier. In the software, we were able to visualize, at the same time, the axial, coronal and sagittal reconstructions on the same screen and, by moving the cursor marking of the program for measuring structures on the image in a certain type of section, the cursor automatically moved in the two other cuts simultaneously. Thus, we were able to identify and measure the dimensions of the structures under study more precisely. In the same way, we located the AN cell and measured it anteroposteriorly, side-to-side, and vertically (craniocaudal).

We considered the AN cells, the air cells located within the frontal process of the maxillary bone, in front of and/or above the anterior end of the middle turbinate.

FB thickness and anterior-posterior (AP) length of the frontal and FR isthmus were measured in the same parasagittal plane where the FB was most prominent. The AP length of the frontal isthmus was defined as the shortest length between the most prominent portion of the FB and the posterior board of the FS. The AP length of the FR was defined as the length between the most prominent portion of the FB and the superior insertion of the ethmoidal bulla lamella.

Statistical analysis

For statistical analysis, data were tabulated in a single spreadsheet and the statistical program Jamovi (V2.5.5.0) was used. First, a descriptive analysis of the collected data was carried out. Regarding the assumption of normality of the variables BF thickness, frontal isthmus length, FR, FS height, FS width, FS length, lateral diameter of AN cells, anteroposterior diameter of AN cells and vertical diameter of cells of AN, the Shapiro-Wilk test was used. For correlation analysis between the variables, the Spearman test was used. Inter-examiner agreement was verified using the CCI. For all analyses, a confidence interval of 95% and a significance level of 5% ($p < 0.05$) were considered.

Results

Through the ICC, it was observed that the inter-examiner and intra-examiner agreement was satisfied, noting that the coefficients varied from 0.89 to 0.98,[21] indicating excellent reliability and reproducibility.

Among the 388 patients evaluated, 68.38% (n=266) were female and 31.62% (n=122) were male. The mean age of the sample was 37.51 (standard deviation ±14.58); Maximum age 86 and minimum age 18. Right (CAN-D) and left (CAN-E) AN cells were present simultaneously in all evaluated patients, regardless of gender. According to the findings, AN cells in males were found in 122 cases, and in females in 266 cases.

Table 01 demonstrates the correlation between the FS volume and the CAN-D and CAN-E volume, so that the greater the volume of the FS, the greater the volume of the CAN-D (p=0.002) and CAN-E (p <0.001). It is still possible to observe a moderate to strong correlation between the volume of CAN-D and CAN-E (p<0.001).

Table 2. Correlation between FS volume and CAN-D and CAN-E volume

		FS Volume	CAN-D Volume	CAN-E Volume
FS Volume	Rho de Spearman	-		
	p-valor	-		
CAN-D Volume	Rho de Spearman	0.158**	-	
	p-valor	0.002	-	
CAN-E Volume	Rho de Spearman	0.201***	0.663***	-
	p-valor	<.001	<0.001	-

Nota. * p < .05, ** p < .01, *** p < .001

Table 02 demonstrates the correlation between the mean FB thickness, the FS volume and the volume of the CAN-D and CAN-E, showing that the mean FB thickness does not present a significant correlation with any of the other variables. There is a moderate positive correlation between FS volume and CAN-D volume. A weak positive correlation was also found between FS volume and CAN-E volume. Positive correlations show a directly proportional relationship between the analyzed structures.

Table 3. Correlation between FB, FS and CAN-D and CAN-E volume

		Average thickness FB (frontal beak)	FS Volume	CAN-D Volume	CAN-E Volume
Average thickness FB (frontal beak)	Rho de Spearman	-			
	p-valor	-			
FS Volume	Rho de Spearman	0.241***	-		
	p-valor	> .001	-		
CAN-D Volume	Rho de Spearman	0.112*	0.158*		
	p-valor	0.027	0.002		
CAN-E Volume	Rho de Spearman	0.092	0.201***	0.663***	-
	p-valor	0.070	<0.001	<0.001	-

Nota. * p < .05, ** p < .01, *** p < .001

Table 03 demonstrates the correlations between FR length, FS volume and CAN-D and CAN-E volume. The FR length presents positive but weak correlations with the CAN-D volume (p=0.014) and the CAN-E volume (p=0.002). CAN-D volume is positively correlated with FR length, while CAN-E volume is even more strongly correlated with FR length. However, the FS did not show significant correlations with any of the variables.

Table 4. Correlation between FR length, FS volume and CAN-D and CAN-E volume.

		FR length	FS Volume	CAN-D Volume	CAN-E Volume
FR length	Rho de Spearman	-	0.260***	0.124*	0.153**
	p-valor	-	<.001	0.014	0.002
FS Volume	Rho de Spearman		-		
	p-valor		-		
CAN-D Volume	Rho de Spearman		0.158**	-	
	p-valor		0.002	-	
CAN-E Volume	Rho de Spearman		0.201***	0.663***	-
	p-valor		<.001	<.001	-

Nota. * p < .05, ** p < .01, *** p < .001

Discussion

The nasofrontal communication is a mucosa-lined canal, rather than a true ductal structure, which connects the FS with the FR of the middle nasal meatus and through which ventilation and drainage occur. The course, width, and depth of this pathway in the adult are determined by the pattern of embryological pneumatization of anterior ethmoid air cells and the development of surrounding bony plates. Generally, the direct development of the FS from the embryological FR is associated with minimal pneumatization of the anterior ethmoid cells and wider and less tortuous communication with the middle nasal meatus,[2] but the anteroposterior dimension of the FR can be narrowed by pneumatization of the AN cell. In almost 100% of the ethmoid sinuses, there is some degree of pneumatization of the AN cells; However, the volume and pattern of development of such cells varies substantially.[2] Thus, in order to use the most appropriate approach in cases of removal of FR and FS lesions, a thorough understanding of the anatomical relationship between AN and FR and FS cells is essential.

Some anatomical variations, such as the presence of the AN cell, can induce obstruction in the drainage pathways of the maxillary and frontal sinuses. Anatomical variations of the paranasal sinuses must be evaluated to prevent serious and fatal complications secondary to sinus surgery. In addition, the identification of anatomical and morphological relationships is essential for the surgeon when approaching the skull base to avoid the risk of iatrogenic injuries in these thinner and more vulnerable structures.[22]

Determining and describing the precise anatomy, anatomical variations and pathology depends mainly on advanced imaging methods, as well as on the professional's experience and skills.[23] Many imaging modalities including radiographs, CT and CBCT are used for the evaluation of the detailed anatomy, pathology and variations of the paranasal sinuses. Although CT is established as the gold standard for diagnostic imaging of the paranasal sinuses, CBCT has advantages in terms of lower radiation dose, isotropic voxels, smaller metallic artifacts and lower cost than CT.[18,24–26]

In this study, CBCT was used to assess these structures, although there is no uniform methodology for such an analysis. In addition, the type of slice (axial, coronal or sagittal) and the thickness of the slices are different in each study, making data comparison very variable. Although Landsberg et al., 2011 reported that the identification of the AN cell is quite difficult, even with the use of sagittal reconstruction, this reconstruction was used to complement the analysis of axial and coronal sections, since it contributed to the identification of the FR, the FB and the AN Cell, as several authors report in the literature.

An important data of this analysis was the presence or not of the AN cell. In the present study, the AN cell was found in 100% of the evaluated patients, being present bilaterally. It is noteworthy that these data are presented in different ways in the literature, sometimes considering the presence of AN cell in the individual, sometimes considering the presence of AN cell on each side of the individual (right or left). In this study, we chose to use the prevalence in relation to the individual. Thus, the data found corroborate the studies by Jones, Pérez-Pinãs and Angélico Jr & Rapoport,[27,28] and the AN cell was found in 95% or more of the analyzed patients.

Another important data analyzed was the size of the BF, which varies according to the pneumatization of the AN cell and the frontal ethmoidal cells in the “beak”. A large AN cell and pneumatization of the frontal ethmoid cells often reduces the size of the beak, whereas the absence of these cells would produce a thick beak.[12] In our study, this correlation was not found, in which the mean BF thickness does not present a significant correlation with any of the other variables.

Regarding the CAN-D volume, this is positively correlated with the FR length, while the CAN-E volume presents an even stronger correlation with the FR length, indicating that the greater the FR length, the greater the AN cell volume. The presence of ethmoid cells associated with the FR and their degree of pneumatization may condition the anatomy and volume of the FR, and may be responsible for the existence of FS pathologies. Endoscopic surgery in the FR without removing these cells is one of the most frequent reasons for the persistence of pathologies after surgery.[29]

Proper identification and characterization of accessory cells through imaging studies is essential for a safe and effective surgical approach.[29] According to Bent,[30] these cells can be differentiated from other ethmoid cells by means of serial analyzes of CT scans of the facial sinuses, so that it is of great importance that both the clinical professional and the radiologist become aware of the main anatomical variations of the paranasal sinuses.

The knowledge allows avoiding errors and surgical complications, especially related to endoscopic surgeries, and preventing diseases, since the correlation between anatomical variations and the predisposition of individuals with the appearance of associated pathologies is not known for sure.[31]

Conclusion

The study indicates the presence of AN cells in 100% of the individuals analyzed, being present bilaterally. There was no significant correlation between FB and the AN cell. Significant positive correlations were found relating CNA-D and CAN-E with FR and FS. It is noticed the fundamental importance of anatomical knowledge on the part of professionals for a surgery to access the FS in a precise and uncomplicated way.

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