ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
National Library of Medicine - ID: 101731606

*International Journal of Medical Science and Innovative Research (IJMSIR)*
*IJMSIR : A Medical Publication Hub*
*Available Online at: www.ijmsir.com*
*Volume – 8, Issue – 5, September – 2023 , Page No. : 24 – 32*

# Assessment of frontal recess cells and the associated frontal sinusitis: Computed tomographic analysis using International Frontal Sinus Anatomy classification

[1]Chouhan Akanksha, MD Radiodiagnosis, Senior Resident, Department of Radiodiagnosis, Netaji Subhash Chandra Bose Medical College Jabalpur (M.P.)

[2]Agrawal Rekha, MD Radiodiagnosis, Definition of intellectual content, clinical studies, manuscript review Associate Professor, Department of Radiodiagnosis, Netaji Subhash Chandra Bose Medical College Jabalpur (M.P.)

[3]Ravi Saranya, MBBS, Literature search, Data acquisition, Data analysis, Resident Doctor, Department of Radiodiagnosis, Netaji Subhash Chandra Bose Medical College Jabalpur (M.P.)

[4]Dhakar Jagmohan S, MD Community Medicine, Statistical analysis, Statistician, Department of Community Medicine, Netaji Subhash Chandra Bose Medical College Jabalpur (M.P.)

**Corresponding Author:** Chouhan Akanksha, MD Radiodiagnosis, Senior Resident, Department of Radiodiagnosis, Netaji Subhash Chandra Bose Medical College Jabalpur (M.P.)

**Citation this Article:** Chouhan Akanksha, Agrawal Rekha, Ravi Saranya, Dhakar Jagmohan S, "Assessment of frontal recess cells and the associated frontal sinusitis: Computed tomographic analysis using International Frontal Sinus Anatomy classification", IJMSIR- September - 2023, Vol – 8, Issue - 5, P. No. 24 – 32.

**Type of Publication:** Original Research Article

**Conflicts of Interest:** Nil

## Abstract

**Introduction**: The frontal recess cells are the most complex of the paranasal cells, owing to their location, anatomical variations, and relationship with adjacent structures. The International Frontal Sinus Anatomy Classification aims to furnish a preoperative framework for FESS, facilitating clear and effective communication of reporting and outcomes while also mitigating complications during surgical procedures. Aim: To assess the frontal recess cells according to the International Frontal Sinus Anatomy Classification and evaluate their association with frontal sinusitis. Design: Cross-sectional retrospective study Material and Methods: This study comprised patients referred to the Department of Radio-Diagnosis with symptoms pertaining to sinusitis. All the patients were referred from the ENT OPD and wards over a period of 10 months. All the subjects underwent computed tomography of the paranasal sinus.

**Results:** Agger nasi cells (ANC) were the most common variation in 95 (95%), followed by suprabullar cells (SBC) in 74 (74%), and supraorbital ethmoidal cells (SOEC) in 57 (57%). Supra agger cells (SAC) were identified in 55(55%), supra agger frontal cells (SAFC) in 16(16%), supra bullar frontal cells (SBFC) in 15(15%); and frontal septal cells (FSC) in 18(18%). Patients with ANC, SACs, and SBFCs were more likely to develop frontal sinusitis. Isolated frontal sinusitis was found in 12 scans and was associated with FSC (OR = 1.88).

**Conclusion:** Given the results obtained, a high prevalence of frontal recess cells, was noted and some were associated with an increased risk of frontal sinusitis.

**Keywords:** International Frontal Sinus Anatomy Classification, frontal sinusitis, frontal recess cells, Computed tomography

## Introduction

The anatomy of the frontal sinus and its drainage pathway (FSDP) is complex and intricate. In recent times, surgical management of the frontal sinus has increased considerably owing to the availability of endoscopic methods. However, frontal sinus surgery is challenging due to the complex and variable anatomy of the FSDP and its proximity to important structures such as the skull base, orbit, and anterior ethmoidal artery [1]. The frontal recess can be compared to an inverted funnel with its apex at the frontal sinus ostium, located at the level of the nasofrontal process. The inferior portion flares out to form the frontal infundibulum. The frontal infundibulum, frontal ostium, and frontal recess form the frontal sinus outflow tract [2]. In 2016, the International Frontal Sinus Anatomy Classification (IFAC) was published to enhance communication and simplify terminology. Based on the anatomical location of the frontal recess cells in multi-planer CT scan, it categorizes the frontal recess into three groups. [3]. The anterior cells- agger nasi cells (ANC), supra agger cells (SAC), and supra agger frontal cells (SAFC)- can deviate the drainage pathway medially, posteriorly, or posteromedially -. The posterior cells, i.e., suprabullar cells (SBC), suprabullar frontal cells (SBFC), and supraorbital ethmoid cells (SOEC), push the drainage pathway anteriorly. The medial cells push the FSDP laterally and include frontal septal cells [3]. Frontal and maxillary sinusitis are more prevalent in the clinical scenario and are readily seen on radiographs. However, endoscopic sinus surgery necessitates a detailed description of Sino-nasal anatomy. The purpose of this study is to assess the frontal recess cells according to the International Frontal Sinus Anatomy Classification (IFAC) and evaluate their association with frontal sinusitis.

## Material and Methods

The present retrospective study was conducted in the radiology department of our institution over 10 months (September 2022–July 2023). The study included data from 100 patients referred to the Department of Radiodiagnosis with symptoms pertaining to sinusitis. Patients ≥ 18 years of age were included in the study. Patients with a history of facial injuries, positive paranasal sinus pathology, head and neck tumors, and prior surgery were not included. After approval of the study by our Institute's ethical committee, patients matching the inclusion criteria were enrolled in the study after obtaining informed consent. The CT examination was performed with GE Optima CT 660 M40 3.5 MID-BGJ Helical CT machine. Volumetric data is reconstructed in coronal, sagittal, and axial planes to give bone and soft tissue images. Image analysis and interpretation were performed to look for anatomical variation and sinus opacification. All the data analyses were performed using IBM SPSS ver. 23.0 software. Frequency distribution and cross-tabulation were done and appropriate statistical tests were applied. The outcomes are presented as mean ± standard deviation (SD) and median (minimum–maximum).

## Results

**Table 1** - This study included 100 patients with 53 male and 47 female study participants. The age of study participants ranged from 20 to 78 with a mean age of 41 ± 14.68 years. The total number of study participants who presented with frontal sinusitis is 45% out of which 33 (73.3%) had frontal sinusitis along with other paranasal sinusitis while only 12 (26.6%) had isolated

frontal sinusitis. Frontal sinusitis was absent in 55% of the study participants.

**Table 2** – This table documents the prevalence of frontal recess cells among the study population. Agger nasi cells were reported in 95%, supra agger cells in 55 %, and supra agger frontal cells in 16 % of study participants. Among the posterior cells, supra bullar cells were reported in 74 %, supra bullar frontal cells in 15 %, and supraorbital ethmoidal cells in 57 % of the study participants. Frontal septal cells in 18 % of the study participants.

**Table 3**- The below table shows the association between frontal recess classified according to IFSC and frontal sinusitis and no frontal sinusitis. Study participants with ANC, SAC, and SBFC had significantly higher odds of having frontal sinusitis with OR = 2.416, 95% CI 0.334 – 17.489; OR = 2.639, 95% CI 0.901 – 7.728 and OR = 1.625 95% CI 0.424 – 6.227 respectively. The rest of the other cells i.e., SAFC, SBC, SOEC, and FSC had no significant association with the development of frontal sinusitis. Study participants with SAFC, SBC, and SOEC had no significant association with the development of frontal sinusitis with OR = 3.419, 95% CI 0.988 – 11.829; OR = 1.671, 95% CI 0.567 – 4.930 and OR = 3.328 95% CI 1.271 – 8.714 respectively.

**Table 4** - The below table shows the association between frontal recess classified according to IFSC and isolated frontal sinusitis. Study participants with FSC had significantly higher odds of having isolated frontal sinusitis with OR =1.881. The rest of the cells had no significant association with the development of isolated frontal sinusitis.

**Discussion**

The present study consisted of 100 study participants, of which 53 were male and 47 female subjects. The age of study participants ranged from 20 to 78 years, with a mean age of 41 ± 14.68 years (Table 1). Agger nasi cells were the most prevalent among the frontal recess cells, reported in 95% of study participants, followed by SBC in 74 % and SOEC in 57 %. Supra agger cells were reported in 55 %, SAFC in 16 %, and FSC in 18 % of the study participants. Supra bullar frontal cells were the least common among the frontal recess cells, accounting for 15 % of the study participants (Table 2). This study identified 45% of study participants with frontal sinusitis, out of which 73.3% had frontal sinusitis concomitant with other paranasal sinusitis and only 23.3 % had isolated frontal sinusitis. The rest of the 55% of study participants had no frontal sinusitis (Table 1). The agger nasi cells are the most prevalent FRCs in this study, similar findings were noted in separate studies conducted by Choby et al. [4], Sommer et al. [5], and Trans et al. [6]. However, the prevalence of ANC in the literature varies widely, ranging from 1.9% to 98.5% [7, 8]. The frontal sinus's drainage pathway may become narrowed by an enlarged agger nasi cell, impeding drainage and leading to sinusitis [9, 10]. The prevalence of SAC was noted to be 55%, which is comparable to results reported by Fawzi et al. [11] and Sommer et al. [5]. Among the anterior FRCs, SAFC is the least common cell type, accounting for 16 % of the study population. Similarly, Pham et al. [12] also reported SAFC in 15.8% of the study participants. Regarding the posterior FRCs, SBCs are the most common, accounting for 74% of the study population, consistent with Choby et al.'s reported prevalence of 72% [4]. Various authors have reported the prevalence of SBC ranging from 13% (Al-Abri et al.) to 88 % (Sommer et al.) [13,5]. SBFCs were identified in 15% of the study population. Most of the studies reported a higher prevalence of SBFC compared to our study [5, 12] however, Kubota et al. reported a prevalence as low as 7% [14]. SOECs were identified in 57 % of the study

population, consistent with the study conducted by Comer et al. [15]. Several other studies have reported varying prevalence, ranging from 6-42.4% [16, 17]. FSCs were observed in 18% of the study population, closely resembling the study conducted by Pham et al. [12], which documented a prevalence of 14.3 % [Table 2]. This study found that the presence of ANC, SAC, and SBFC is associated with frontal sinusitis. Prior surgical and imaging studies, which reported ANC in 10% to 100% of study participants, have highlighted the role of ANC in causing frontal sinusitis [16, 17]. Studies carried out by Fadda et al. [18] and Langille et al. [19] demonstrated a statistically significant association between ANC and frontal sinusitis. The success of primary surgery might be compromised if agger nasi disease is left untreated, prompting secondary surgery [20]. This study reported a statistically significant association between SAC and frontal sinusitis, consistent with findings reported by Nofal et al. [21]. Numerous studies have reported a strong association between SBFC and frontal sinusitis, in alignment with our study [12, 14, 19]. The SBFC pneumatizes along the skull base and extends into the posterior region of the frontal sinus through the frontal ostium, potentially leading to the narrowing of the frontal ostium [3, 14]. Among the anterior group of cells, no increased risk of frontal sinusitis was noted in the presence of SAFC, similar to Sommer et al. [5]. Regarding the posterior FRCs, i.e., SBC and SOEC, no significant association was noted with the development of frontal sinusitis. Both Pham et al. [12] and Langille et al. [19] found no significant association between frontal sinusitis and the presence of SBC. Multiple studies have indicated that SOEC cells have no significant implication in the causation of frontal sinusitis, similar to our study [5, 14, 21, 22]. However, identification of SOEC is crucial during endoscopic dissection, as there is a possibility of these cells being mistaken for frontal ostium [23] [Table 3]. Isolated frontal sinusitis is an infrequent occurrence in patients, and limited studies have explored the prevalence and pathophysiology of isolated frontal sinusitis. Isolated frontal sinusitis may result from a structural abnormality or lesion in the frontal sinus ostium or surrounding structure [24,25]. The frontal septal cell can impede the drainage of the frontal sinus at the frontal ostium. In a study conducted in patients with isolated frontal sinusitis, type 2 and type 3 cells (SAC and SAFC) were pivotal in causing frontal recess obstruction (25). In this study, we found that FSC is statistically associated with the development of isolated frontal sinusitis [Table 4]. In a separate study by Nofal et al., all FSCs showed a high infection rate in association with infected frontal sinuses [21]. Similarly, Fawzi et al. [11] also noted a statistically significant association between FSC and frontal sinusitis (p-value 0.04).

However, there are certain limitations to this study, we have identified the association between FRC and mucosal thickening, but it does not necessarily establish causation. Multiple factors, such as nose and paranasal sinus variations, and mucosal inflammation, are associated with the development of frontal sinusitis and paranasal sinusitis in general. Our study consisted of a limited number of study participants with isolated frontal sinusitis; hence, it may not be representative of the prevalence of isolated frontal sinusitis in the population. Also, multiple studies have identified variations in sinonasal anatomy in different ethnic groups. However, there are not many studies that have evaluated anatomical variation in frontal recess cells in the Indian population. Hence, more studies are needed to assess the FRCs in the Indian population.

Table 1: Gender, age, and sinusitis distribution in this study

| S.N. | Variable | | Number | Percentage |
|---|---|---|---|---|
| 1. | Gender | Male | 53 | 53 % |
| | | Female | 47 | 47 % |
| 2. | Age | Range | 15-78 | |
| | | Mean | 41 ± 14.68 | |
| 3. | Total number of subjects with Frontal sinusitis | | 45 | 45 % |
| | Isolated frontal sinusitis | | 12 | 26.6 % |
| | Frontal sinusitis concomitant with other sinusitis | | 33 | 73.3 % |
| 4. | No Frontal sinusitis | | 55 | 55 % |

Table 2: Prevalence of frontal recess cells in the study population

| S.N. | Cell Type | | Number | Percentage |
|---|---|---|---|---|
| 1 | Anterior cell | ANC | 95 | 95 |
| | | SAC | 55 | 55 |
| | | SAFC | 16 | 16 |
| 2 | Posterior cells | SBC | 74 | 74 |
| | | SBFC | 15 | 15 |
| | | SOEC | 57 | 57 |
| 3 | Medial cells | FSC | 18 | 18 |

Table 3: The association Between Frontal recess cells and Frontal sinusitis and FRC and no frontal sinusitis

| | | Frontal Sinusitis | | | No frontal sinusitis | | |
|---|---|---|---|---|---|---|---|
| S.N. | FRC | P Value | Odds Ratio | 95% CI | P value | Odds Ratio | 95 % CI |
| 1 | ANC | .382 | 2.416 | 0.334 - 17.489 | .571 | .555 | .072 - 4.259 |
| 2 | SAC | .077 | 2.639 | 0.901 - 7.728 | .450 | .678 | .248- 1.857 |
| 3 | SAFC | .043 | 0.290 | 0.088 - 0.961 | .052 | 3.419 | .988- 11.829 |
| 4 | SBC | .948 | 0.964 | 0.323 - 2.880 | .352 | 1.671 | .567- 4.930 |
| 5 | SBFC | .478 | 1.625 | 0.424 - 6.227 | .111 | .331 | .085- 1.289 |
| 6 | SOEC | .104 | 0.430 | 0.155 - 1.189 | .014 | 3.328 | 1.271- 8.714 |
| 7 | FSC | .613 | 0.733 | 0.220 - 2.442 | .878 | .912 | .283- 2.945 |

Table 4: The association Between Frontal recess cells and isolated Frontal sinusitis

| S.N. | Frontal Recess Cell | P value | Odds Ratio | 95% C.I. | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| 1 | ANC | .999 | - | - | - |
| 2 | SAC | .425 | .492 | .086 | 2.819 |
| 3 | SAFC | .975 | .971 | .159 | 5.944 |
| 4 | SBC | .998 | - | - | - |
| 5 | SBFC | .402 | .405 | .049 | 3.359 |
| 6 | SOEC | .264 | .421 | .093 | 1.918 |
| 7 | FSC | .487 | 1.881 | .317 | 11.140 |

Figure 1: A) Sagittal and B) coronal CT PNS images show Agger nasi cell (arrow) and supra agger nasi cells posterior to which frontal sinus drainage pathway is seen (curved arrow)

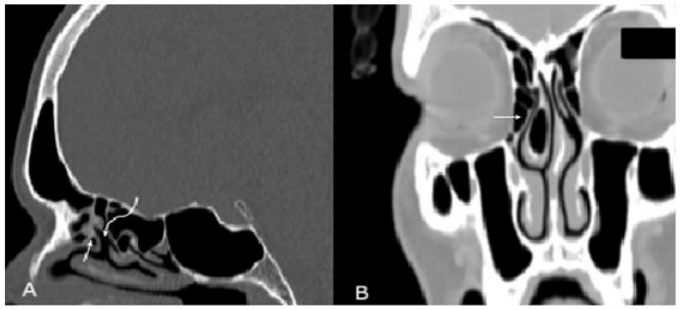



Figure 2 A: Computed tomography of the paranasal sinus (Sagittal section) shows agger nasi cell (red arrow), supra agger cell (blue arrow), supra bullar cell (curved arrow), and supra bullar cell (curved arrow), and supra bullar frontal cell (asterisk). 2B - Coronal non-contrast CT scans of the paranasal sinuses show an air cell within the intersinus septum (arrow) – Frontal septal cell.

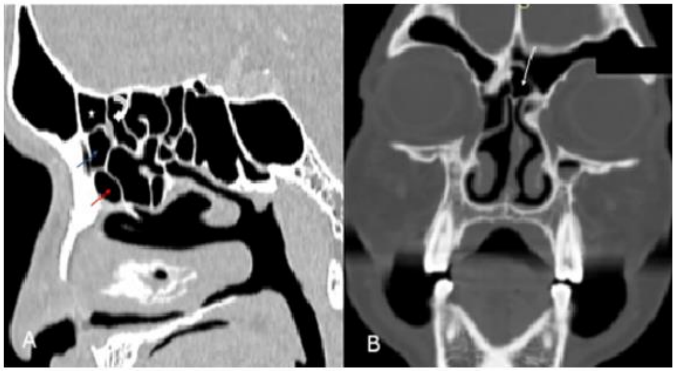



Figure 3: CT Paranasal sinus (sagittal section) (A) shows supra agger frontal cell (arrow). Coronal image (B) shows supra orbital ethmoidal cell (black arrow).

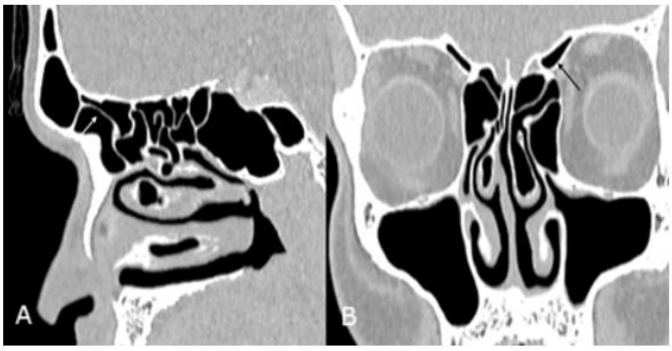
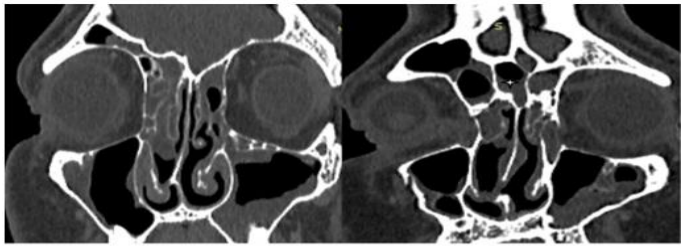
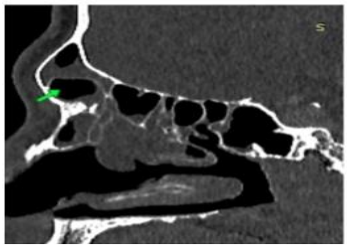



Figure 4: CT PNS (Coronal and sagittal images) shows opacification of frontal recess cells – ANC, SAFC (arrow), SBC, and FSC (asterisk). Frontal and bilateral maxillary sinusitis is seen.





**Conclusion**

This study showed a high prevalence of frontal recess cells in the population with ANC, SAC, and SBFC, all of which were linked to frontal sinusitis. Prior to planning surgery, a thorough analysis of the variable anatomy of frontal recess cells is essential to meticulously plan a strategy for dissecting obstructing cells in the nasofrontal recess. Failure to identify and eliminate the affected cells may result in treatment failure. Since the IFAC provides a straightforward and effective tool for classifying frontal recess cells based on their anatomical location, it simplifies cell names and avoids any confusion to effectively communicate and comprehend reports.

**Abbreviations**

FESS- Functional Endoscopic Sinus Surgery

ENT- Ear, Nose and Throat

OPD- Outpatient Department

CT- Computed Tomography

FRC- Frontal recess cells

IFAC- International Frontal Sinus Anatomy Classification

FSDP- Frontal sinus drainage pathway

ANC - Agger nasi cells suprabullar cells

SAC- Supra agger cell

SAFC- supra agger frontal cell

SBC- Supra bullar cell

SOEC- Supraorbital ethmoidal cell

SBFC- supra bullar frontal cell

FSC - Frontal septal cell

**Reference**


1. Ting JY, Wu A, Metson R. Frontal sinus drillout (modified Lothrop procedure): long-term results in 204 patients. Laryngoscope 2014;124(05):1066–1070 re
2. McLaughlin RB Jr, Rehl RM, Lanza DC. Clinically relevant frontal sinus anatomy and physiology. Otolaryngol Clin North Am 2001;34(1):1–22.
3. Wormald PJ, Hoseman W, Callejas C, Weber RK, Kennedy DW, Citardi MJ, Senior BA, Smith TL, Hwang PH, Orlandi RR, Kaschke O (2016) The international frontal sinus anatomy classification (IFAC) and classification of the extent of endoscopic frontal sinus surgery (EFSS). Int Forum Allergy Rhinol 6(7):677–696
4. Choby G, Thamboo A, Won TB, Kim J, Shih LC, Hwang PH: Computed tomography analysis of frontal cell prevalence according to the International Frontal Sinus Anatomy Classification. Int Forum Allergy Rhinol. 2018, 8:825-830.
5. Sommer F, Hoffmann TK, Harter L, Döscher J, Kleiner S, Lindemann J, Leunig A: Incidence of anatomical variations according to the International Frontal Sinus Anatomy Classification (IFAC) and their coincidence with radiological signs of opacification. Eur Arch Otorhinolaryngol. 2019, 276:3139-3146.
6. Tran LV, Ngo NH, Psaltis AJ (2019) A radiological study assessing the prevalence of frontal recess cells

and the most common frontal sinus drainage pathways. Am J Rhinol Allergy 33(3):323–330

7. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991; 101:56-64.
8. Aramani A, Karadi RN, Kumar S. Anatomical variation in osteomeatal complex. J Clin Diagn Res 2014; 8:1-4.
9. **Kantarci M**, Karasen RM, Alper F, Onbas O, Okur A, Karaman A. Remarkable anatomic variations in paranasal sinus region and their clinical importance. Eur J Radiol 2004; **50**: 296-302 [PMID: 15145491 DOI: 10.1016/j.ejrad.2003.08.012]
10. **Nitinavakarn B**, Thanaviratananich S, Sangsilp N. Anatomical variations of the lateral nasal wall and paranasal sinuses: A CT study for endoscopic sinus surgery (ESS) in Thai patients. J Med Assoc Thai 2005; **88**: 763-768 [PMID: 16083216]
11. Fawzi, N.E.A., Lazim, N.M., Aziz, M.E. et al. The prevalence of frontal cell variants according to the International Frontal Sinus Anatomy Classification and their associations with frontal sinusitis. Eur Arch Otorhinolaryngol **279**, 765–771 (2022). https://doi.org/10.1007/s00405-021-06843-0
12. Pham, Huu & Tran, Tai & Nguyen van, Thanh & Thai, Thanh Truc. (2021). Multiplanar Computed Tomographic Analysis of Frontal Cells According to International Frontal Sinus Anatomy Classification and Their Relation to Frontal Sinusitis. Reports in Medical Imaging. Volume 14. 1-7. 10.2147/RMI.S291339.
13. Al-Abri R, Bhargava D, Al-Bassam W, Al-Badaai Y, Sawhney S: Clinically significant anatomical variants of the paranasal sinuses. Oman Med J. 2014, 29:110-113. 10.5001/omj.2014.2
14. Kubota, K., Takeno, S. & Hirakawa, K. Frontal recess anatomy in Japanese subjects and its effect on the development of frontal sinusitis: computed tomography analysis. J of Otolaryngol – Head & Neck Surg 44,21 (2015).
15. Comer BT, Kincaid NW, Kountakis SE: The association between supraorbital ethmoid air cells and orbital proptosis in patients with chronic rhinosinusitis. Int Forum Allergy Rhinol. 2013, 3:147-149. 10.1002/alr.21073
16. Perez-Pinas I, Sabate J, Carmona A, Catalina-Harrera CJ, Jimenez-Castellanos J. Anatomical variations in the human paranasal sinus region studies by CT. J Anat 2000;197:221-7.
17. Messerklinger W. On the drainage of the normal frontal sinus of man. ACTA Otolaryngol 1967;63:176-81.
18. Fadda GL, Rosso S, Aversa S, Petrelli A, Ondolo C, Succo G. Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. Acta Otorhinolaryngol Ital. 2012;32(4):244-251.
19. Langille M, Walters E, Dziegielewski PT, Kotylak T, Wright ED. Frontal sinus cells: identification, prevalence, and association with frontal sinus mucosal thickening. Am J Rhinol Allergy. 2012;26(3): e107-e110. doi:10.2500/ajra.2012.26.3774
20. Bradley DT, Kountakis SE. The role of agger nasi air cells in patients requiring revision endoscopic frontal sinus surgery. Otolaryngol Head Neck Surg. 2004; 131:525–7.
21. Nofal AAB, El-Anwar MW. Frontal Recess Cells in International Frontal Sinus Anatomy Classification (IFAC); Prevalence, Infection Incidence, and Relation to Frontal Sinus Infection in Chronic

Sinusitis Patients. Indian J Otolaryngol Head Neck Surg. 2022;74(Suppl 3):4748-4755. doi:10.1007/s12070-021-03069-8

22. Dasar U, Gokce E. Evaluation of variations in the sinonasal region with computed tomography. World J Radiol. 2016;8(1):98-108. doi:10.4329/wjr.v8.i1.98
23. Turna O, Aybar M, Karagoz Y, Tuzcu G: Anatomic variations of the paranasal sinus region: evaluation with multidetector CT. Istanbul Med J. 2014, 15:104-109
24. Landsberg R, Segev Y, Friedman M, et al. A targeted endoscopic approach to chronic isolated frontal sinusitis. Otolaryngol Head Neck Surg. 2006;134(1):28–32. doi: 10.1016/j.otohns.2005.09.00917.
25. Ji JF, Cheng Y, Wang T-Y, et al. Isolated frontal sinusitis treated using an anterior-to-ethmoidal bulla surgical approach. Cell Biochem Biophys. 2014;70(2):1153–1157. doi:10.1007/s12013-014-0035-0