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Original Research Article

A Study of Frontal Recess Anatomy and Complications during Surgery in Patients of Chronic Rhinosinusitis in a Tertiary Care Centre

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Abstract

Background: The frontal recess is a critical anatomical region implicated in chronic rhinosinusitis (CRS), a condition with significant implications for patient quality of life. Complications during surgery can arise due to the intricate nature of the frontal recess and its proximity to vital structures such as the orbit and anterior cranial fossa.

Materials and Methods: This study was a cross-sectional study, here 100 consecutive patients (200 sides) who were complaining of at least two of the following symptoms (nasal block, nasal/postnasal discharge, facial pain/pressure, or reduction/loss of smell) for at least 12 weeks during the study period, and the study was conducted at Osmania Medical College, Hyderabad.

Results: In the prevalence and infection rates of frontal recess cells in patients with chronic rhinosinusitis, categorized into anterior, posterior, and medial cell groups. The anterior group, was statistically significant.

In the chi-square tests for specific frontal recess cells versus the overall infection rate indicate varying levels of significance. The Supra Agar Cell (SAC) shows a chi-square value of 5.35 and a p-value of 0.021, marking it as significant (S).

Conclusion: The study contributes to the existing literature by providing new insights into the complex anatomy of the frontal recess and its role in chronic rhinosinusitis. These findings underscore the importance of detailed preoperative assessment and complete surgical excision of frontal recess cells to improve outcomes and prevent complications in patients with chronic rhinosinusitis.

Keywords: Frontal recess anatomy, complications, surgery, chronic rhino sinusitis.

Introduction

The frontal recess is a critical anatomical region implicated in chronic rhinosinusitis (CRS), a condition with significant implications for patient quality of life. The complexity of the frontal recess anatomy poses challenges for endoscopic sinus surgery (ESS), particularly in the management of frontal sinusitis. Complications during surgery can arise due to the intricate nature of the frontal recess and its proximity to vital structures such as the orbit and anterior cranial fossa [1]. Studies have shown a high prevalence of frontal recess cells in populations suffering from frontal sinusitis, with variations in anatomy that can complicate surgical intervention [2]. Interestingly, while the agger nasi cell is commonly found across different ethnicities, other frontal recess cells show variation, which may influence surgical. The presence of residual frontal recess cells has been identified as an independent risk factor for postoperative complications, underscoring the importance of complete surgical excision [3][4]. Moreover, the International Frontal Sinus Anatomy Classification (IFAC) has emerged as a valuable tool for preoperative assessment, although its application can be challenging in patients with diffuse primary CRS [5]. In summary, the study of frontal recess anatomy in patients with CRS at a tertiary care centre is pivotal for understanding the surgical challenges and potential complications. A thorough grasp of the anatomical variations and the adoption of standardized classification systems like the IFAC are essential for improving surgical outcomes and minimizing risks [6][7]. This study aims to elucidate these aspects, contributing to the body of

knowledge that facilitates safer and more effective management of CRS.

Materials and Methods

Design: This study was a fundamental research cross-sectional study, which was conducted at Osmania Medical College, Hyderabad, over a period of 24 months, this was approved by the IEC of OMC

Participants: A total of 100 patients treated during the study period. Patients were selected with the following inclusion and exclusion criteria. Inclusion criteria comprise, Age 12-60 years, Patients willing for surgery offered to him/her, Patients giving consent for the study upon him/her. Exclusion criteria comprise, Patients not willing for surgery, Patients not giving consent for study upon him/her, bilateral frontal sinus agenesis, Prior history of nasal trauma, and history of sinonasal surgery.

Study procedure: Here 100 consecutive patients (200 sides) who were complaining of at least two of the following symptoms (nasal block, nasal/postnasal discharge, facial pain/pressure, or reduction/loss of smell) for at least 12 weeks during the study period. They did not improve by the medical treatment and all were operated on due to nasal and/or sinus pathology according to the individual pathology of each. Informed written consent was signed by all subjects to share in the study after an explanation of its purpose and after approval of the institutional review board. The assessment of the frontal recess cells and frontal sinus was done in to two steps. The first step is to study non-contrast CT scans of the maxillofacial area of the patients in a triplanner manner by two separate Otolaryngologists. Each side was judged separately (200 sides). The second step is to evaluate each cell throughout its presence, extending, type, and involvement by polyps or pus during FESS with multiple times intraoperative revisions of the CT scan in a triplanner manner.

The frontal recess cell or frontal sinus is considered infected if there is opacification or mucosal thickening within the sinus or the cells in the CT scan confirmed by presence of pus or polypoidal mucosa during FESS. All the CT scans were done just after medical management to eliminate acute infection and control the allergic symptoms before doing the CT scan. Patients less than 16 years old, previous nasal surgery, and suspected nasal or sinus neoplasm were excluded from the study. The CT scans were done with a 64-slice CT scan (Light speed volume VCT, GE medical system, Milwaukee, WI, USA). The protocol of 64-slice MDCT was performed with a 0.625 mm detector width, a 1 mm section width and a 0.5 mm interval reconstruction. Axial, coronal, and sagittal reformatted CT scan were reviewed in synapse Fujifilm's medical imaging and information management system, SYNAPSE with comprehensive PACS (Picture Archiving and Communication System) which allows simultaneous viewing of the CT scan in axial, coronal, and sagittal planes with localizing ability. All the observations were performed independently by two readers (the authors). If there is any difference they reviewed the scans together to reach a consensus and confirmed with the second step by evaluating the cell during FESS with multiple times intraoperative revisions of the CT scan in a triplanner manner. The data was collected, tabulated and analyzed. The frontal recess cells were studied based on IFAC [5]. The anterior cells include agger nasi cell (ANC), supra agger cell (SAC), and supra agger frontal cell (SAFC). The posterior cells include supra bulla cell (SBC), supra bulla frontal cell (SBFC), and supra orbital ethmoid cell (SOEC). The medial cells include the frontal septal cell (FSC)

Raw data coding: After the data have been collected. The analysis of data requires several closely related operations such as the establishment of categories, and the application of these categories to raw data through coding, tabulation and then drawing statistical inferences. Then classification of the raw data into required variables based on the objectives was done. Coding operation is usually done at this stage through which the categories of data are transformed into symbols that may be tabulated and counted in M.S. Excel with coding the stage is ready for tabulation. Tabulation is a part of the technical procedure wherein the classified data are put in the form of tables.

Data analysis: The medical software version 18.2.1 was utilised to determine the sample size. We used the following parameters to determine the sample size and also Specificity and sensitivity tests were done. SPSS (version 23.0) program was used to input and analyse data. The qualitative data were described in terms of numbers and percentages. Subgroup analyses may be performed based on demographic or clinical characteristics.

The quantitative data were described using the range, mean, standard deviation, and median. The nonparametric quantitative data, which were given as the median and interquartile range (IQR), were analysed using the Mann-Whitney test. The obtained results were considered significant at the 95% level. MDcalc is used for the standard values of confirmatory tests.

Result

Table 1: Distribution of study subjects based on age

S. No	Age group(year)	Number of patients(n)	Percentage%
1	<16	1	1
2	16-29	16	16
3	30-42	34	34
4	43-55	34	34
5	>56	15	15
Total		100	100

The study of frontal recess anatomy and complications during surgery in patients with chronic rhinosinusitis at a tertiary care centre reveals that the distribution of patients is predominantly within the age groups of 30-42 and 43-55 years, each comprising 34% of the total 100 patients. The age group 16-29 accounts for 16% of the patients, while those older than 56 years represent 15%. The least represented age group is under 16 years, with only 1% of the patients. This distribution suggests that middle-aged adults are the most affected by chronic rhinosinusitis requiring surgical intervention, while it is relatively rare in children and the elderly.

Table 2: Distribution of study subjects based on gender

Gender	Number of patients (n)	Percentage (%)
Male	67	67
Female	33	33

The study also shows a gender distribution among the 100 patients with chronic rhinosinusitis undergoing surgery, with males being more commonly affected than females. Specifically, 67% of the patients are male, while 33% are female. This indicates a significant male predominance in the incidence of chronic rhinosinusitis requiring surgical intervention in the studied population at the tertiary care center.

Table 3: Prevalence and infection rates of frontal recess cells

Prevalence and Infection Rates of Frontal Recess Cells				
Cell Type	**Total Number**	**Infected (%)**	**Non-Infected (%)**	**p-value**
Anterior Group				0.0474 (S)
* agger Nasi				
Cell (ANC)	194 (97%)	50 (25.8%)	144 (74.2%)	
* Supra agger				
Cell (SAC)	96 (48%)	38 (39.6%)	58 (60.4%)	
* Supra agger				
frontal Cell (SAFC)	22 (11%)	8 (36.4%)	14 (63.6%)	
	Posterior Group			0.067 (NS)
* Supra bulla				
Cell (SBC)	144 (72%)	44 (30.6%)	100 (69.4%)	
* Supra bulla				
frontal Cell (SBFC)	46 (23%)	8 (17.4%)	38 (82.6%)	
* Supra orbital				
rthmoidal Cell (SOEC)	84 (42%)	16 (19%)	68 (81%)	
	Medial Cells			
* Frontal Septal				
Cell (FSC)	42 (21%)	14 (33.3%)	28 (66.7%)	

The table presents the prevalence and infection rates of frontal recess cells in patients with chronic rhinosinusitis, categorized into anterior, posterior, and medial cell groups.

In the anterior group, with a statistically significant difference ($p = 0.0474$), the Agger nasi Cell (ANC) is the most prevalent (97%) with a 25.8% infection rate, followed by the Supra agger Cell (SAC) at 48% prevalence and 39.6% infection rate, and the Supra agger frontal Cell (SAFC) at 11% prevalence and 36.4% infection rate. The posterior group, which does not show a statistically significant difference ($p = 0.067$), includes the Supra bulla Cell (SBC) as the most common (72%) with a 30.6% infection rate, the Supra bulla Frontal Cell (SBFC) at 23% prevalence and 17.4% infection rate, and the Supra Orbital Ethmoid Cell (SOEC) at 42% prevalence and 19% infection rate.

For medial cells, the Frontal Septal Cell (FSC) is present in 21% of cases with a 33.3% infection rate. These findings highlight the varying prevalence and infection rates of different frontal recess cells, with significant findings in the anterior group.

Table 4: Chi-square test: specific cells vs. overall infection rate

	Chi-Square Tests: Specific Cells vs. Overall Infection Rate			
Cell Type	**Chi-Square (X^2)**	**Degrees of Freedom**	**p-value**	**Significance**
ANC	0.01	1	0.92	NS
SAC	5.35	1	0.021	S
SAFC	1.35	1	0.245	NS
SBC	0	1	0.98	NS
SBFC	0.55	1	0.46	NS
SPEC	1.85	1	0.174	NS
FSC	0.02	1	0.89	NS

The chi-square tests for specific frontal recess cells versus the overall infection rate indicate varying levels of significance. The Agger nasi Cell (ANC) has a chi-square value of 0.01 and a p-value of 0.92, indicating no significant difference (NS). The Supra agger Cell (SAC) shows a chi-square value of 5.35 and a p-value of 0.021, marking it as significant (S). The Supra agger Frontal Cell (SAFC), with a chi-square value of 1.35 and a p-value of 0.245, is not significant (NS). Similarly, the Supra Bulla Cell (SBC) with a chi-square value of 0 and a p-value of 0.98, the Supra Bulla Frontal Cell (SBFC) with a chi-square value of 0.55 and a p-value of 0.46, and the Supra Orbital Ethmoid Cell (SOEC) with a chi-square value of 1.85 and a p-value of 0.174, are all not significant (NS). The Frontal Septal Cell (FSC) has a chi-square value of 0.02 and a p-value of 0.89, also indicating no significance (NS). Thus, among these cells, only the SAC shows a statistically significant difference in infection rates.

Discussion

The anatomical complexity of the frontal recess is a significant factor in the surgical management of chronic rhinosinusitis (CRS), as evidenced by the high prevalence of frontal recess cells in patients with frontal sinusitis (Sagar et al., 2013). Due to its intricate structure and variability, the frontal recess area poses challenges during endoscopic sinus surgery (ESS), which is considered the gold standard for treating medically refractory CRS (Kim & Kang, 2014; Otto & Delgaudio, 2009). Complications during surgery can arise from the presence of various frontal recess cells, which are associated with recurrent and surgical failure (Nakayama et al., 2018; Otto & Delgaudio, 2009). Interestingly, while the use of frontal sinus stents has been introduced to mitigate re-stenosis post-surgery, complications such as postoperative sinonasal infection still occur in a significant proportion of patients (Bandino et al., 2023). Moreover, the presence of residual frontal recess cells, particularly suprabullar cells (SBCs) and suprabullar frontal cells (SBFCs), has been identified as an independent risk factor for postoperative frontal sinus opacification, emphasizing the need for complete surgical excision of these cells (Nakayama et al., 2018). In conclusion, the successful surgical management of CRS in the frontal recess requires a thorough understanding of the frontal recess anatomy and a comprehensive approach to address all factors contributing to obstruction. The high prevalence of frontal recess cells in the Indian population (Sagar et al., 2013) and the significant association of frontal bullar cells with the development of frontal sinusitis in Malaysian subjects (Johari et al., 2018) underscore the importance of detailed preoperative assessment using standardized classification methods, such as the International Frontal Sinus Anatomy Classification (IFAC), to improve surgical outcomes and prevent complications (Habsi et al., 2023; Habsi et al., 2024). The study focuses on the distribution of patients with chronic rhinosinusitis at a tertiary care center, revealing that the majority of patients are aged 30-42 and 43-55 years, accounting for 34% of the total 100 patients. Middle-aged adults are the most affected by chronic rhinosinusitis requiring surgical intervention, while it is relatively rare in children and the elderly.

The gender distribution also shows a significant male predominance in the incidence of chronic rhinosinusitis requiring surgical intervention. 67% of the patients are male, while 33% are female. The table presents the prevalence and infection rates of frontal recess cells in patients with chronic rhinosinusitis, categorized into anterior, posterior, and medial cell groups.

In the anterior group, the Agger nasi Cell (ANC) is the most prevalent (97%) with a 25.8% infection rate, followed by the Supra agger Cell (SAC) at 48% prevalence and 39.6% infection rate, and the Supra agger Frontal Cell (SAFC) at 11% prevalence and 36.4% infection rate. The posterior group, which does not show a statistically significant difference ($p = 0.067$), includes the Supra bulla Cell (SBC) as the most common (72% with a 30.6% infection rate), the Supra bullar Frontal Cell (SBFC) at 23% prevalence and 17.4% infection rate, and the Supra Orbital Ethmoid Cell (SOEC) at 42% prevalence and 19% infection rate. For medial cells, the Frontal Septal Cell (FSC) is present in 21% of cases with a 33.3% infection

rate. The findings highlight the varying prevalence and infection rates of different frontal recess cells, with significant findings in the anterior group. The Chi-square test was used to compare specific cells vs. overall infection rate, with significant results in the anterior group.

The study focuses on the prevalence and infection rates of frontal recess cells in patients with infected frontal sinuses. The results show that the Agger Nasi Cell (ANC) is highly prevalent at 97%, with equal infection and non-infection rates of 50%. The Supra agger Cell (SAC) has a prevalence of 54.90%, with a high infection rate of 70.60% compared to 29.40% in non-infected cases. The Supra agger Frontal Cell (SAFC) is present in 19.40% of cases, with an infection rate of 67% and a noninfection rate of 33.30%. The Supra bulla Cell (SBC) shows a prevalence of 80.60%, with an infection rate of 64% and a non-infection rate of 36%. The Supra bulla Frontal Cell (SBFC) has a lower prevalence of 22.60%, with a significantly lower infection rate of 28.60% and a non-infection rate of 71.40%. The Supra Orbital Ethmoid Cell (SOEC) is present in 41.90% of cases, with an infection rate of 53.80% and a non-infection rate of 46.10%. Lastly, the Frontal Septal Cell (FSC) has a prevalence of 22.60%, with all cases being infected, showing an infection rate of 100% and a non-infection rate of 0%.

The table also examines the prevalence and infection rates of frontal recess cells in non-infected frontal sinus cases. The agger nasi Cell (ANC) shows a prevalence of 97%, with a 14.90% infection rate and an 85.10% non-infection rate. The Supra agger Cell (SAC) has a prevalence of 44.90%, with a 22.60% infection rate and a 77.40% non-infection rate. The Supra agger Frontal Cell (SAFC) is present in 7.20% of cases, all non-infected (100%). The Supra bullar Cell (SBC) shows a prevalence of 68.10%, with a 12.80% infection rate and an 87.20% non-infection rate. The Supra bullar Frontal Cell (SBFC) has a prevalence of 23.20%, with a 12.50% infection rate and an 87.20% non-infection rate. The Supra Orbital Ethmoid Cell (SOEC) is present in 42% of cases, with a 3.50% infection rate and a 96.50% non-infection rate. Finally, the Frontal Septal Cell (FSC) has a prevalence of 22.60%, with all cases being infected.

Patient Demographics

1. The current study's finding that middle-aged adults are most affected by chronic rhinosinusitis requiring surgical intervention aligns with other studies. However, the 67% male predominance is higher than in some similar studies.
2. Further research is needed to explain the age and gender distribution of chronic rhinosinusitis requiring surgery.

Frontal Recess Cell Prevalence and Infection Rates in Infected Frontal Sinuses

1. The high prevalence of the Agger nasi Cell (ANC) in infected frontal sinuses (97%) is consistent with Choby et al. [8] (96.5%) and Tran et al. [163] (95.7%).
2. The Supra agger Cell (SAC) had a higher prevalence in infected sinuses (54.90%) compared to Sommer et al. [9] (49%) and Tran et al. [10] (16.3%).
3. The Supra agger Frontal Cell (SAFC) had a lower prevalence in infected sinuses (19.40%) compared to Sommer et al. [9] (24.9%) and Tran et al. [10] (13%).
4. The Supra bullar Cell (SBC) had a higher prevalence in infected sinuses (80.60%) compared to Choby et al. [8] (72%) and Tran et al. [10] (46.2%).
5. The Supra bullar Frontal Cell (SBFC) had a lower prevalence in infected sinuses (22.60%) compared to Sommer et al. [9] (26.5%) and Tran et al. [10] (17.3%).
6. The Supra Orbital Ethmoid Cell (SOEC) had a similar prevalence in infected sinuses (41.90%) compared to Choby et al. [8] (30%) and Tran et al. [10] (10.6%).
7. The Frontal Septal Cell (FSC) had a higher prevalence in infected sinuses (22.60%) compared to Sommer et al. [9] (9.2%) and Tran et al. [10] (4.3%).

Frontal Recess Cell Prevalence and Infection Rates in Non-Infected Frontal Sinuses

1. The agger nasi Cell (ANC) had a similar prevalence in non-infected frontal sinuses (97%) compared to Choby et al. [8] (96.5%) and Tran et al. [10] (95.7%).
2. The Supra agger cell (SAC) had a lower prevalence in non-infected sinuses (44.90%) compared to Sommer et al. [9] (49%) and Tran et al. [11] (16.3%).
3. The Supra agger Frontal Cell (SAFC) had a lower prevalence in non-infected sinuses (7.20%) compared to Sommer et al. [12] (24.9%) and Tran et al. [10] (13%).
4. The Supra bulla Cell (SBC) had a similar prevalence in non-infected sinuses (68.10%) compared to Choby et al. [8] (72%) and Tran et al. [10] (46.2%).
5. The Supra bulla Frontal Cell (SBFC) had a similar prevalence in non-infected sinuses (23.20%) compared to Sommer et al. [9] (26.5%) and Tran et al. [10] (17.3%).
6. The Supra Orbital Ethmoid Cell (SOEC) had a similar prevalence in noninfected sinuses

(42%) compared to Choby et al. [8] (30%) and Tran et al. [10] (10.6%).
7. The Frontal Septal Cell (FSC) had a higher prevalence in non-infected sinuses (22.60%) compared to Sommer et al. [9] (9.2%) and Tran et al. [1] (4.3%).

Comparison with Other Studies (Table 4)

1. The current study found a higher prevalence of the Agger nasi Cell (ANC) compared to all other studies.
2. The prevalence of the Supra agger Cell (SAC) was lower in the current study compared to Sommer et al. [9] but similar to Tran et al. [10].
3. The Supra agger Frontal Cell (SAFC) had the lowest prevalence in the current study compared to others.
4. The Supra bulla Cell (SBC) had a similar prevalence in the current study and Choby et al. [8].
5. The Supra bulla Frontal Cell (SBFC) had a higher prevalence in the current study compared to Choby et al. [8] and Tran et al. [10].
6. The Supra Orbital Ethmoid Cell (SOEC) had a similar prevalence in the current study and Choby et al. [8].
7. The Frontal Septal Cell (FSC) had a higher prevalence in the current study compared to all others.

Overall, the current study provides new insights into the prevalence and infection rates of frontal recess cells in both infected and non-infected frontal sinuses, with some differences compared to previous studies.

The high prevalence and infection rates of certain cells (like the ANC, SAC, SBC, SOEC, and FSC) in infected sinuses could have implications for the surgical management of chronic rhinosinusitis. The 100% infection rate of the FSC in non-infected sinuses is also noteworthy. Further research is needed to confirm these findings and explore their clinical significance.

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