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Anatomical Study of Frontal Recess and Ostium Via Cadaveric Dissection: Surgical Insights for Frontal Sinusotomy

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A B S T R A C T

Introduction: The frontal sinus is one of the most anatomically variable and surgically challenging regions of the paranasal sinuses. Precise understanding of frontal recess anatomy is essential for safe and effective frontal sinusotomy. This cadaveric study aims to evaluate key anatomical features of the frontal recess and ostium, providing clinically relevant data to enhance surgical outcomes.

Methods: A descriptive anatomical study was conducted on 10 formalin-preserved, sagittally sectioned cadaveric heads in the Department of Anatomy and Otorhinolaryngology, Dayanand Medical College and Hospital, Ludhiana. Measurements were taken from the anterior nasal spine and the middle turbinate to the frontal sinus ostium using calibrated scales. The size and shape of the ostium were recorded, and patency was assessed with suction tips of varying diameters (3 mm, 4 mm, 5 mm). The presence of agger nasi cells was also noted.

Results: The frontal sinus ostium was located 5.6–6 cm from the anterior nasal spine in 60% of specimens and 2.1–2.5 cm from the middle turbinate in 80%. The ostial diameter was predominantly between 3.6–4.0 mm (70%). Agger nasi cells were present in 80% of specimens. These findings correlate with previous cadaveric studies, reinforcing the anatomical variability of the region and the importance of key landmarks.

Conclusion: This cadaveric analysis highlights essential anatomical considerations for frontal sinusotomy. The consistent presence of agger nasi cells and narrow frontal ostium dimensions underscore the technical demands of the procedure.

Keywords: Frontal sinus, Frontal ostium, Frontal recess, Cadaveric study, Agger nasi.

INTRODUCTION

The frontal sinus is anatomically and surgically one of the most complex paranasal sinuses, primarily due to its variable configuration and narrow drainage pathway through the frontal recess. Unlike a defined anatomical structure, the frontal recess is a dynamic, three-dimensional space bordered by critical ethmoidal landmarks such as the agger nasi cells, uncinate process, bulla ethmoidalis, and the lamina papyracea.[1,2]. A comprehensive understanding of these relationships is essential for safe and effective surgical intervention.

Frontal sinusitis, when not adequately addressed, has the potential to progress into serious complications such as chronic inflammation, mucocele formation, osteomyelitis, and in rare cases, intracranial extension [3]. Although the advent of functional endoscopic sinus surgery (FESS) has significantly improved the

management of chronic rhinosinusitis through minimally invasive techniques, accessing the frontal sinus remains a technically complex task. This is due not only to the deep and narrow anatomy of the frontal recess but also to its frequent anatomical variations.
These variations—such as the presence of frontal cells (Kuhn Types I–IV), supraorbital ethmoid cells, or differing insertions of the uncinate process—can obscure critical landmarks, narrow the surgical corridor, and increase the risk of complications, especially in less experienced hands [4].

This study aims to bridge this gap by conducting a detailed cadaveric analysis of the frontal recess and frontal ostium. By evaluating key anatomical landmarks, ostial dimensions, and variations such as the presence of agger nasi cells, we seek to provide otolaryngologists with practical anatomical data and evidence-based guidance for improving frontal sinus access and surgical outcomes.

MATERIALS AND METHODS

Study Setting:

An anthropometric evaluation of the frontal sinus was carried out in formalin preserved cadaveric specimen in the Department of Anatomy, Dayanand Medical College and Hospital.

Method of Data Collection:

- ***Inclusion Criteria:***

The study included 10 sagittally sectioned, formalin-preserved cadaveric heads.

- ***Exclusion Criteria:***

Specimens that were damaged or shredded were excluded from the analysis.

Study Objectives and Measurements:

1. ***Frontal Sinus Ostium Localization:***
- The distance of the frontal sinus ostium was measured from two anatomical landmarks: the anterior nasal spine and the anterior part of the middle turbinate, using a calibrated measuring scale.
2. ***Morphological Assessment:***
- The shape and orientation of the frontal sinus ostium were documented.
3. ***Ostial Caliber Evaluation:***
- Patency of the frontal ostium was assessed using suction tips of varying diameters (3 mm, 4 mm, and 5 mm) to determine ostial size.
4. ***Anatomical Variations:***
- The presence of agger nasi cells was noted in each cadaveric specimen.

RESULTS

In the present study, 10 formalin-preserved cadaveric specimens meeting the inclusion and exclusion criteria were analyzed in the Department of Otorhinolaryngology at Dayanand Medical College and Hospital, Ludhiana. Frontal sinuses were examined in fresh-frozen, sagittally sectioned heads to assess anatomical parameters.

Observation tables of cadaveric study

1. **Distance of frontal ostium from the anterior nasal spine:**

In the present study It was seen that frontal ostium lies at a distance of 5.6-6cm in majority of specimens 6(60%) followed by 5-5.5cm (30%). In majority of cadavers the distance between frontal sinus ostium and nasal spine was 6 cm (60%).

Table.1, Distance of frontal ostium from the anterior nasal spine (n=10)

NS-FO (in cms)	No. of cadavers	%age
5-5.5	3	30.0
5.6-6	6	60.0
6.1-6.5	1	10.0
Total	10	100.0

N= total no of specimen NS= nasal spine FO= frontal ostiu

fig 2: Distance of frontal sinus from anterior nasal spine

2. Distance of middle turbinate to frontal ostium:

In this study Majority of cadavers had distance of about 2.1-2.5 cm from middle turbinate to frontal ostium. Majority of cadavers had distance of about 2.1-2.5 cm from middle turbinate to frontal ostium.

Table.2. Distance of middle turbinate to frontal ostium.

MT-FO (in cms)	No. of cadavers	%age
1.6-2	1	10.0
2.1-2.5	8	80.0
2.6-3	0	.0
3.1-3.5	1	10.0

MT=middle turbinate FO=frontal ostium

fig:3. *Distance between frontal sinus and middle turbinate*

3. Size of frontal sinus ostium in mm:

In this study Majority of cadavers had frontal sinus ostium size between 3.6-4 mm followed by 4.6-5 mm and most of them is 4 mm.

Size of Frontal Ostium (in mms)	No. of cadavers	%age
3-3.5	2	20
3.6-4	7	70.0
4.1-4.5	0	.0
4.6-5	1	10.0
Total	10	100.0

Fig. 4. Ritters suction tip in frontal sinus

4. Presence of agger nasi cell**:**

Agger nasi cell was present in 8 cadaveric specimen (80%)

Table.4. Presence of agger nasi cell

Presence of Agger nasi cell	No. of cadavers	%age
Absent	2	10.0
Present	8	80.0
Total	10	100.0

Fig 5. Presence of agger nasi cells

Summary of Observations

- Cadaveric dissections supported the finding that **anatomical variability**, particularly in agger nasi cell prevalence and ostium location, plays a crucial role in surgical outcomes.

DISCUSSION

The frontal recess is one of the most anatomically complex and variable regions of the paranasal sinuses, and its proper understanding is crucial for the success of frontal sinus surgery. In this cadaveric study, key anatomical features such as the size, location, and spatial relationship of the frontal sinus ostium, along with the prevalence of agger nasi cells, were assessed to provide clinically relevant insights for frontal sinusotomy.

Agger nasi (AN) cells are the most consistent anterior ethmoidal air cells and serve as an important landmark during endoscopic sinus surgery. In the current study, AN cells were identified in 8 out of 10 cadaveric specimens (80%), aligning closely with findings from previous studies. Gaafar et al. (2001) [5] reported the presence of AN cells in 23 out of 30 embalmed half-head specimens, with variability in cell number per specimen—14 had one cell, 6 had two, and 3 had three cells. Similarly, Ximendes et al. (2018) [6] found AN cells in 23 of 26 sides examined from 13 cadavers. Orhan et al. (2017) [7] observed AN cells in 8 of 20 cadavers in a Turkish population, further emphasizing the variability across demographics and sample sizes.

With respect to the frontal sinus ostium, our findings indicate that the majority of specimens had ostium sizes ranging from **3.6–4.0 mm**, followed by **4.6–5.0 mm**, suggesting a relatively narrow caliber that may influence instrumentation choice during sinusotomy. Comparatively, Gaafar et al. (2001) [8,9] found a slightly higher mean ostium diameter of **5.6 ± 0.9 mm**, which could be attributed to differences in measurement techniques or specimen preservation.

In terms of anatomical location, the frontal ostium was found to be **5.6–6.0 cm** from the anterior nasal spine in 60% of specimens and **5.0–5.5 cm** in 30%. Additionally, the distance from the anterior part of the middle turbinate to the frontal ostium was most commonly observed in the range of **2.1–2.5 cm**, a consistent and reliable intraoperative reference for locating the frontal recess.[10]

These anatomical insights are critical for endoscopic surgeons, particularly in navigating narrow frontal recesses or cases with prominent agger nasi cells. Accurate localization and assessment of the frontal ostium reduce the risk of iatrogenic injury and improve surgical outcomes by ensuring complete and precise drainage of the frontal sinus.

In summary, the present cadaveric study supports the high prevalence of agger nasi cells and provides valuable morphometric data on the frontal sinus ostium. These findings offer practical surgical guidance and enhance anatomical understanding essential for successful frontal sinusotomy.

CONCLUSION

This cadaveric study highlights key anatomical parameters of the frontal recess and frontal sinus ostium that are critical for safe and effective surgical intervention. The frontal ostium was most commonly located at a distance of 5.6–6 cm from the anterior nasal spine and 2.1–2.5 cm from the anterior aspect of the middle turbinate. The majority of specimens exhibited an ostium size between 3.6–4 mm, and agger nasi cells were present in 80% of cases. These findings provide practical anatomical data for identifying key landmarks, anticipating variations, and improving surgical outcomes. A more precise understanding of the frontal sinus and its adjacent structures may help minimize intraoperative risks and support better planning, especially in complex or revision cases.

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