5 Surgical Anatomy of the Paranasal Sinuses

Yeşim Başal, Sema Başak, and Jeffrey C. Bedrosian

5.1 Introduction

The paranasal sinuses are air-filled cavities, located inside the bones of the skull, with their ostia opening into the nasal cavity. The maxillary, ethmoid, sphenoid and frontal sinus, ethmoid sinus, and sphenoid sinus are named after the bone in which they are located [1].

The anatomy of the paranasal sinuses is quite complex and prone to individual variation; however, basic surgical anatomy should be understood in order to avoid complications. This chapter aims to present the anatomy of paranasal sinuses, emphasizing their surgical anatomic characteristics.

5.2 The Maxillary Sinus

The maxillary sinus is the largest paranasal sinus. In adults, the maxillary sinus is a pyramidal cavity, with a length of 22 mm, height of 33 mm, and depth of 34 mm, having an average volume of 15 ml [2]. It is bounded by the maxillary surface anteriorly, the orbital floor superiorly, the hard palate and the alveolar ridge inferiorly, the zygomatic process laterally, and the outer lateral wall of the nasal cavity medially. It is separated from the infratemporal fossa and the pterygopalatine fossa by a thin bony layer posteriorly. The anterior wall thickness of the maxillary sinus varies between 2 and 5 mm. While the floor of the maxillary sinus is at or above the level of the nasal floor in children, it is approximately 5–10 mm lower in adults [3].

The bone-free part of the medial wall of the maxillary sinus is a membranous fontanelle consisting of mucosa and connective tissue [3]. While the natural ostium of the maxillary sinus is located at the anterior part of membranous fontanelle, an accessory ostium may be present with a rate of 20–25% in the posterior part (Fig. 5.1). The size of the accessory ostium varies between 1 and 10 mm. Following an incomplete uncinectomy, the accessory ostium may be confused with the natural ostium [4]; however, when its round shape and posterior fontanelle location is considered, the accessory ostium can be easily differentiated from the natural ostium.

The natural ostium of the maxillary sinus opens into the ethmoidal infundibulum. The ethmoidal infundibulum is a funnel-shaped, three-dimensional space that comprises a part of the osteomeatal complex. It is bordered by the uncinate process medially, the lamina papyracea laterally, the maxillary frontal process anterosuperiorly, and the lacrimal bone superolaterally. The anterior wall of the ethmoidal bulla constitutes the posterior border of the ethmoidal infundibulum. To reach the ethmoidal infundibulum via the nasal passage, one must pass through a two-dimensional plane named the hiatus semilunaris. The hiatus semilunaris is a crescent-shaped interspace, located between the free edge of the uncinate process and the anterior wall of the ethmoidal bulla.

The natural ostium of the maxillary sinus opens into the anterior one-third part of the ethmoidal infundibulum with a rate of 5.5%, into the middle one-third part of the ethmoidal infundibulum with a rate of 11%, and into the posteroinferior part of the ethmoidal infundibulum with a rate of 72% [5]. The natural ostium can be reached by elevating the uncinate process, which constitutes the inner lateral wall of the ethmoidal infundibulum, during endoscopic surgery. The canine fossa is present in the anterior wall of the maxillary sinus, between the infraorbital foramen and the alveolar process. The anterior superior alveolar artery and nerve course inside the bony wall between the canine fossa and the maxillary sinus. The thickness of the bony wall decreases down to 1 mm at the deepest part of the canine fossa. The relationship between the maxillary sinus and the teeth may vary depending on the degree of pneumatization. While the maxillary third molar tooth is closest to the floor, the canine tooth or

Y. Başal (✉) · S. Başak
Department of Otorhinolaryngology, Medical Faculty, Adnan Menderes University, Aydın, Turkey

J. C. Bedrosian
Rhinology and Skull Base Surgery, Specialty Physician Associates, St. Luke's Medical Centre, Bethlehem, PA, USA

C. Cingi, N. Bayar Muluk (eds.), *All Around the Nose*, https://doi.org/10.1007/978-3-030-21217-9_5

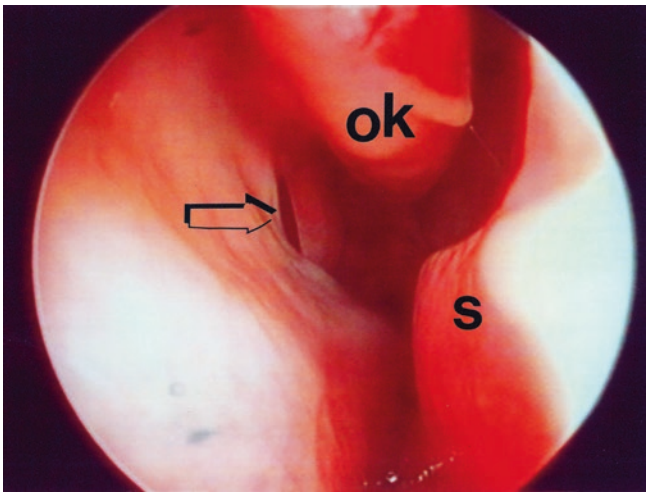

Fig. 5.1 Accessory ostium of maxillary sinus

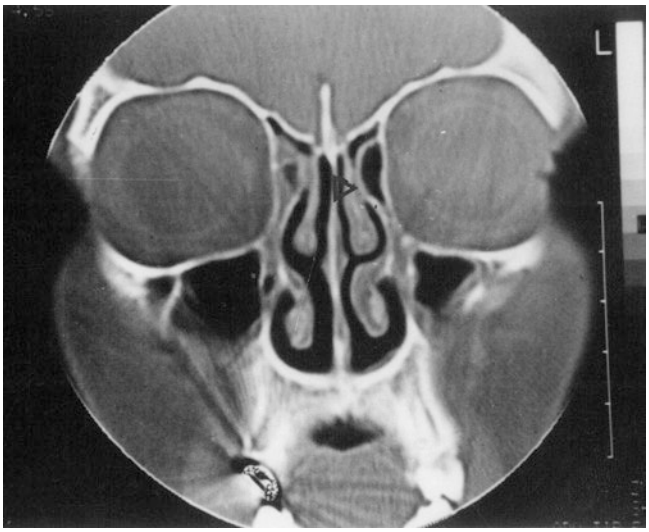

Fig. 5.2 Maxillary sinus hypoplasia

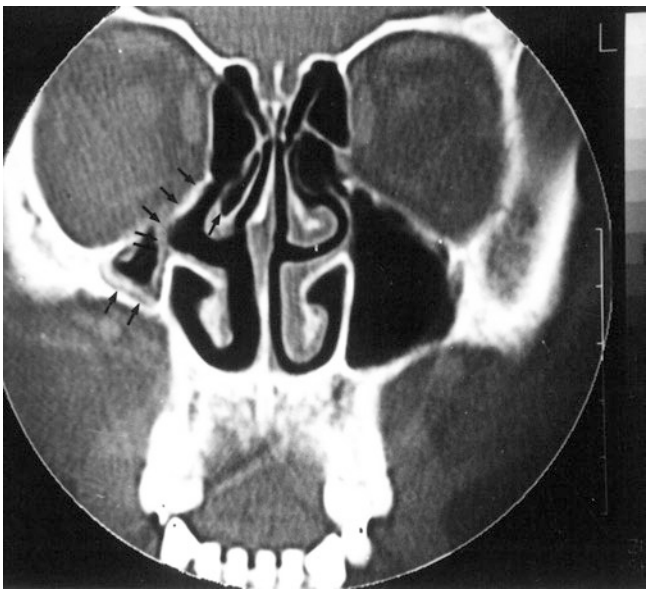

Fig. 5.3 Bulging of inferomedial orbital rim to nasal cavity and maxillary sinus hypoplasia

the first and second molar teeth rarely reach the floor of the sinus. Dehiscence of a tooth root into the maxillary sinus may result in an oroantral fistula.

Some variations of the maxillary sinus should be considered prior to surgery. A Haller cell is the most frequently met anatomical variation. This infraorbital ethmoid cell is located between the orbital floor and the roof of the maxillary sinus, below the ethmoidal bulla, and lateral to the uncinate process. Haller cells originate from anterior ethmoidal cells with a rate of 88% and posterior ethmoidal cells with a rate of 12% [6]. The dimensions of a Haller cell vary widely. Sometimes, it can display such an extensive pneumatization that it may lead to the appearance of a "second maxillary sinus." A large Haller cell may obstruct the natural ostium of the maxillary sinus, leading to rhinosinusitis. Additionally, Haller cells can create some difficulty when identifying the maxillary sinus natural ostium during endoscopic sinus surgery.

Other anatomic variations of the maxillary sinus include maxillary hypoplasia and atelectasis [7, 8] (Fig. 5.2). Maxillary sinus hypoplasia or atelectasis may be interpreted as sinus opacity radiologically. Since the maxillary sinus and the uncinate process develop from the cartilaginous nasal capsule, their anomalies frequently occur together [9]. Maxillary sinus hypoplasia and aplasia are commonly accompanied by the anomalies of the uncinate process and the ethmoidal infundibulum. Therefore, it is important to know these variations before endoscopic surgery to avoid complications. Variations such as the lateralization, hypoplasia, aplasia of the uncinate process, atelectasis of the ethmoidal infundibulum, and lateralization of the membranous fontanelle into the sinus may be present [10]. In such situations, the uncinate process might not be able to be identified, and orbital complications can develop during middle meatal antrostomy [7, 11] (Figs. 5.3 and 5.4). The maxillary sinus may contain partial septations that can block the sinus drainage. Among these, the most frequently seen are located at the anterosuperomedial part [12]. The septations are mostly incomplete; however, rarely, these septae reach sizes that can completely separate the sinus into two.

The maxillary sinus arteries are the anterosuperior and the posterosuperior branches of the greater palatine artery branch of the maxillary artery. Its venous drainage occurs via the anterior facial vein into the jugular vein and the pterygoid venous plexus. Its lymphatic drainage is into the submandibular lymph nodes. Its sensorial innervation is via the greater palatine and infraorbital branches of the maxillary nerve [1].

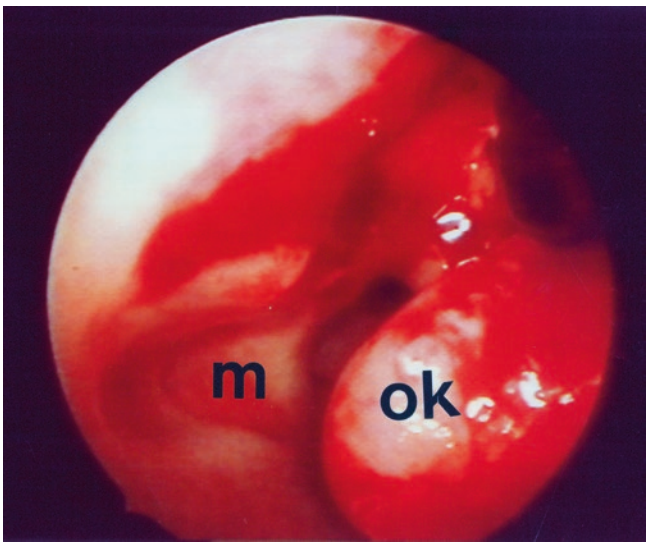

Fig. 5.4 Endoscopic image of the same patient

5.3 Ethmoid Sinuses

The ethmoid sinus is considered a labyrinthine structure, due to its complexity and individual variations. It consists of 3–18 cells, having a honeycomb appearance. The anteroposterior distance is 4–5 cm and it has a height of 2–3 cm, while its width is 0.5 cm anteriorly and 1.5 cm posteriorly and its volume is 14 ml on average. The ethmoidal labyrinth consists of obliquely oriented, parallel lamellae. The first lamella is the uncinate process, the second is the ethmoid bulla, and the third lamella is the basal lamella of the middle concha. The basal lamella is a key surgical landmark as it separates the anterior and posterior ethmoidal cells from each other. Conservation of this lamellar structure from person to person makes it helpful during surgery [11]. Anterior and posterior ethmoid cells are also differentiated from each other by the drainage site of their ostia.

5.3.1 Anterior Ethmoid Sinus

The ostia of the anterior ethmoid cells open into the middle meatus. This region involves some surgically significant cells, processes, and spaces.

5.3.1.1 Uncinate Process

The uncinate process is a sickle-shaped bone, with a very tiny structure. It has a width of 3–4 mm and a length of 1.5–2 cm. This bone inserts on the lateral nasal wall anterosuperiorly and to the inferior concha posteroinferiorly. There is large variation of the insertion point on the superior part of the uncinate. Stammberger described these variations, stating that the uncinate process might terminate freely or might adhere to the lamina papyracea, the skull base, or the middle concha [13]. It is important to pay attention to the insertion point in order to avoid complications that may develop during surgery. Utmost attention should be paid particularly when the uncinate process inserts superiorly onto the skull base (Fig. 5.5). Additionally, in cases of maxillary sinus hypoplasia, uncinated atelectasis may closely contour the inferomedial wall of the orbit and may provide a basis for orbital complications.

5.3.1.2 Bulla Ethmoidalis

The ethmoid bulla is the largest anterior ethmoid sinus and has the least variability regarding location among all ethmoid sinuses (Fig. 5.6). The ethmoid bulla is the frontmost anterior ethmoidal cell, adjacent to the middle

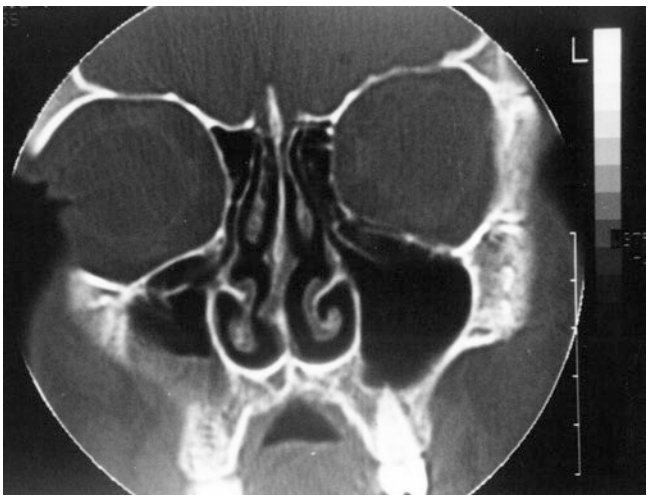

Fig. 5.5 Uncinate process adheres to the skull base

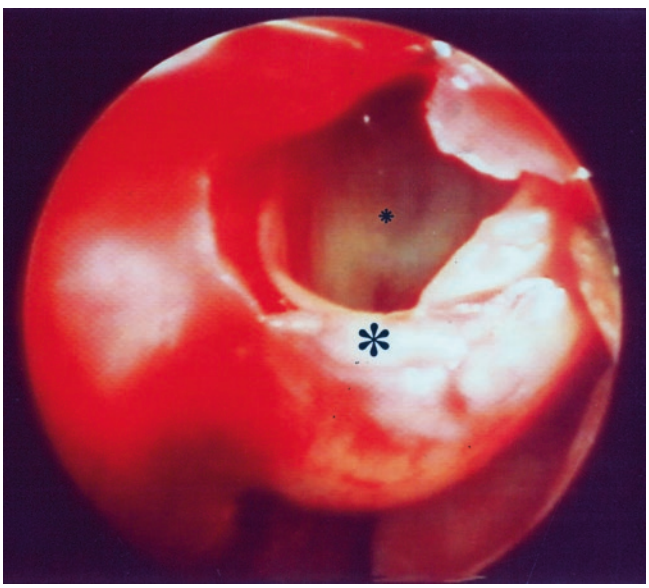

Fig. 5.6 Ethmoid bulla and posterior wall of ethmoid bulla

meatus. This cell is located posterior to the uncinate process, lateral to the lamina papyracea, and anterior to the basal lamella of the middle concha. It may manifest various degrees of pneumatization. An extensively pneumatized ethmoid bulla may contribute to rhinosinusitis. In situations in which it is not pneumatized, it is replaced by a bony process named the torus lateralis, originated from the lamina papyracea. The natural ostium of the ethmoid bulla is usually located posteromedially, within the retrobullar recess.

5.3.1.3 Retrobullar and Suprabullar Recesses

The retrobullar recess or the sinus lateralis is the space immediately posterior to the ethmoid bulla and anterior to the basal lamella. It is bordered by the fovea ethmoidalis superiorly, the lamina papyracea anterolaterally, and the roof of the ethmoid bulla inferiorly [13]. If the ethmoid bulla does not extend to the skull base, the retrobullar recess will be contiguous with the suprabullar recess. The suprabullar recess is located between the lamina papyracea laterally, the roof of the ethmoid bulla inferiorly, and the skull base superiorly. The basal lamella of the middle concha constitutes the posterior border. If the lamella of ethmoid bulla does not extend to the skull base, the suprabullar recess opens into the frontal recess. These recesses can be reached superiorly from the hiatus semilunaris.

5.3.1.4 Ostiomeatal Unit

The ostiomeatal unit is a space that plays a significant role in the etiology of rhinosinusitis. It is the last common pathway of the maxillary, frontal, and anterior ethmoid sinuses. It is the functional space between the lateral nasal wall, the ethmoid bulla, and the middle concha [14].

One of the major complications that can occur during endoscopic sinus surgery is the injury to the anterior skull base. Keros defined the depth of the lamina cribrosa in three categories [15]. The depth is 1–3 mm in Keros type I, 4–7 mm in Keros type II, and 8–16 mm in Keros type III. As the lamina cribrosa gets deeper, the lateral lamella gets thinner, and the ethmoidal roof is displaced onto the cribriform plate [11, 13]. Skull base injury along the lateral lamella is most likely to occur in Keros type III anatomy. The existence of an asymmetry between the two sides should be investigated during the assessment of the computerized tomographic images preoperatively.

The anterior ethmoidal artery enters the nasal cavity through the foramen at the frontoethmoidal suture line (Fig. 5.7). The thickness at the site that the artery emerges from the skull base is 0.5 mm at the ethmoid bone side and may be violated during endoscopic sinus surgery; cerebrospinal fluid leakage is encountered most frequently in this site [16]. The artery courses inside canalis ethmoidalis anterior within the nasal cavity. This canal can course along the skull base, or it might run freely in a mesentery between the ethmoidal cells. The free course of the artery can provide a basis for the development of complications. The entrance of the artery into the orbit is through the anterior ethmoidal foramen, located 18 mm posterior to the lacrimal crest (frontomaxillolacrimal suture). This foramen can be identified as a "V"-shaped protrusion on CT—an important landmark for identifying the free course of the artery or its course along the skull base [17].

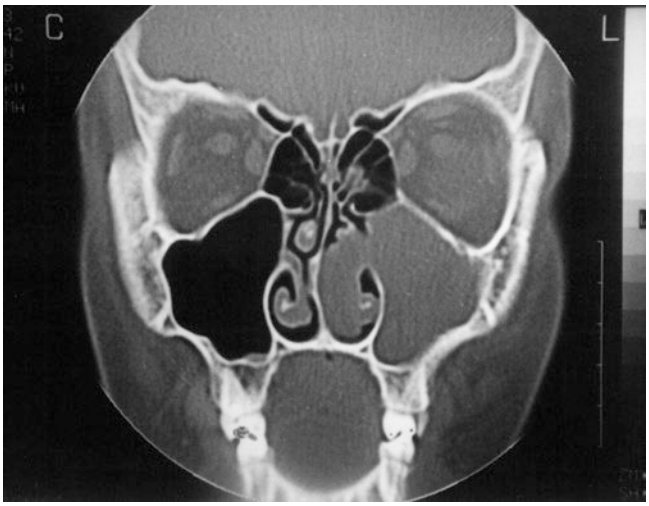

Fig. 5.7 Anterior ethmoidal artery

5.3.2 Posterior Ethmoid Sinuses

The posterior ethmoid sinus consists of one to five cells. It is bordered by the basal lamella of the middle concha anteriorly; the anterior wall of the sphenoid sinus posteriorly; the lamina papyracea laterally; the superior concha, the vertical part of the concha suprema, and the associated meatuses medially; and the ethmoidal roof superiorly [11]. Its dimensions may vary over a wide range. The posterior ethmoidal cells may extend posterolaterally or posterosuperiorly, and it may lie directly adjacent to the optic nerve (Onodi cell) (Fig. 5.8). If an Onodi cell is present during surgery, the risk of optic nerve-related complications is high. The apex of the posterior-most ethmoid cell can always be observed as a posterosuperolaterally localized pyramid-shaped structure; therefore, it can be used as a reliable landmark during surgery. The posterior ethmoidal artery, after exiting the skull base, courses within the nasal passage and enters the orbit through the posterior ethmoidal foramen, located 12 mm posterior to the anterior ethmoidal foramen. The distance of this foramen to the optic nerve is 6 mm.

Fig. 5.8 Onodi cell

5.4 Sphenoid Sinus

The sphenoid sinus is located in the corpus of the sphenoid bone, located at the center of the skull base. The right and left sphenoid sinuses are separated from each other by the intersinus septum. Its vertical diameter is 20 mm, its transverse diameter is 18 mm, its anteroposterior diameter is 21 mm, and its volume is approximately 7.5 ml. The pituitary gland, the optic nerve, and the optic chiasm are located posterosuperiorly to the sphenoid sinus. The carotid artery, the optic nerve, the cavernous sinus, and third, fourth, fifth, sixth cranial nerves are present lateral to the sphenoid sinus [18]. If the sphenoid sinus is extensively pneumatized, the optic nerve and the carotid artery may extend into the sinus. Dehiscence of these structures is observed in some situations. The dehiscence rate of the carotid canal was reported to be 22.8% unilaterally and 7.6% bilaterally [19].

The anterior edge of the sphenoid sinus is adjacent to the posterior wall of the orbit. The floor of the sphenoid sinus constitutes the roof of the nasopharynx. The nerve of the pterygoid canal passes through the bony wall at the floor of the sphenoid sinus. The sphenoid sinus is separated from the pons and the basilar artery by the clivus. Onodi cells may pneumatize superiorly and laterally to the sphenoid sinus as a pyramid-shaped structure. Therefore, the presence and degree of pneumatization are important in sphenoid sinus surgery.

The sphenoid sinus drains into the sphenoethmoid recess by a single ostium. This ostium is 2 × 3 mm in size, and since it is 1 cm above the floor of the sinus, mucociliary activity is required for the drainage of the sinus [20]. The natural ostium was reported to be located at the upper one-third part at a rate of 52% and at the middle one-third part at a rate of 34% [20]. The sphenoid ostium drains medially to the superior concha with a frequency of 83% and laterally with a frequency of 17% [21].

The ostium of the sphenoid sinus is 7 cm from the columella, when viewed from the base of the nose with a 30° angle to the parasagittal plane. It is located 10–12 mm superior to the upper limit of choana, 5 mm lateral to the nasal septum, and 1–1.5 cm superior to the sinus floor [22]. The carotid artery is located inferolateral to the ostium with 45° angle and a distance of approximately 25 mm. The optic canal is located superolateral to the ostium with 60° angle and a distance of 15 mm [23]. The upper wall of the sphenoid sinus constitutes the floor of the sella turcica, and the pneumatization of the sphenoid sinus is classified in three forms. In the conchal type, pneumatization is not present. In the presellar type, the sphenoid sinus shows pneumatization toward the frontal plane of the sella. The sellar type is the most common type, in which the sphenoid sinus is extensively pneumatized and the floor of the sella is located within the sinus [24].

The variations of the sphenoid sinus should be taken into consideration during surgery. The existence of numerous variations can be detected by a detailed evaluation of CT. The relationship of the sinus with the carotid artery and the optic nerve should be evaluated. The protrusion of these structures into the sinus and the possible bony dehiscence should be noted. Importantly, the bony canal of one carotid artery may be contiguous with the intersphenoid sinus septum. Inadvertent septal fracture in these cases places the artery at risk of rupture. [17] (Fig. 5.9).

Fig. 5.9 Dangerous intersphenoid septum

5.5 Frontal Sinus

The frontal sinus has close embryological and anatomic relationship with the ethmoid sinuses. The right and left frontal sinuses develop independently of one another, and they are frequently asymmetrical. Dominancy, hypoplasia, aplasia, or extensive pneumatization may be identified. Every frontal sinus cavity is pyramid-shaped. The anterior wall of the frontal recess is formed by the thick bone of the frontal process of the maxilla. It starts from the nasofrontal suture line and is also called the beak of the frontal process [25]. The dimensions of this process vary depending on the pneumatization of the agger nasi cells—the anterior-most ethmoid cells. In the presence of less pneumatized agger nasi cell, the frontal process extends significantly toward the recess and the frontal ostium is narrowed.

In adults, the frontal sinus has a height of 3 cm, a width of 2.5 cm, and a depth of 1.9 cm, on average. Its interior volume is 10 ml; however, it may sometimes reach 37 ml. The frontal sinus is divided into partitions by incomplete septae [26]. The height of the frontal sinus cavity varies between 1 and 6 cm, depending on the degree of pneumatization. The cortical bone thickness of the anterior wall is between 4 and 12 mm, and it is covered by pericranium, the frontal muscle layer, subcutaneous fat tissue, and the skin. The pericranial layer is used in the repair of anterior skull base defects and for the obliteration of the frontal sinus. The posterior wall of the frontal sinus is formed by the upward continuation of the anterior face of the ethmoid bulla. When the anterior wall of bulla cannot reach the skull base, the suprabullar recess continues as the frontal recess.

The frontal sinus opens into the frontal recess or the anterior part of the infundibulum. The frontal recess is hourglass-shaped. It is neighbored by the uncinate process and any agger nasi anteriorly, the ethmoid bulla and the suprabullar lamella posteriorly, the lamina papyracea laterally, the hiatus semilunaris and the middle concha medially, the ethmoid infundibulum inferiorly, and the fovea ethmoidalis, supraorbital cells, the anterior ethmoidal artery, and the frontal ostium superiorly [27]. The ostium of the frontal sinus is located at the posteromedial part of the sinus floor. The sinus drains either through the nasofrontal duct or directly into the infundibulum.

The ostium of the frontal sinus is located along the coronal plane of the natural ostium of the maxillary sinus, a few millimeters posterior to the attachment site of the middle concha, and parallel to the convexity of the lacrimal bone [28]. The safe method for opening the frontal sinus is to open the agger nasi cell and to find the ostium anteriorly to the anterior ethmoidal artery. The fovea ethmoidalis constitutes the roof of the frontal recess. This bone is thick and resistant to penetration. The right fovea ethmoidalis is located higher than the left one with a frequency of 59% [29].

5.5.1 Agger Nasi Cell

Agger nasi cells are most commonly seen nasofrontal cells. They are found with an incidence of more than 90% in cadaver dissections [30]. However, their recognizability on CT is lower. Preoperative understanding of the relationship between the agger nasi cell and the uncinate process is necessary. The uncinate process or the medial wall of the agger nasi cell may adhere to the lamina papyracea (Fig. 5.10). In most of these patients, the upper extension of the adherence site reveals a bony layer which divides the frontal recess vertically. The frontal sinus drains medial to this bony layer [25]. In the presence of a large agger nasi cell, the upward extension of the uncinate process is pushed medially and the uncinate process adheres to the middle concha. Thus, the drainage pathway of the frontal sinus is pushed posteriorly and the surgeon cannot reach the frontal sinus from the medial aspect of the uncinate process.

The presence of frontal cell variations can affect the drainage of the frontal sinus [31]. The classification suggested by Kuhn concerning the cells located in the frontal region is shown in Table 5.1. The arteries of the frontal sinus stem from the supraorbital and supratrochlear branches of the ophthalmic artery. Venous drainage is into the cavernous sinus, via the ophthalmic vein. Lymphatic drainage is into the submandibular lymph nodes. Their innervation is by the supraorbital and supratrochlear branches of the ophthalmic nerve [32].

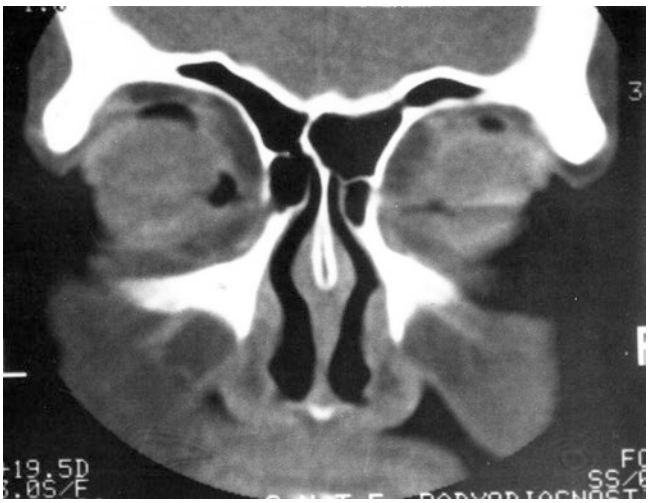

Fig. 5.10 Agger nasi cell

Table 5.1 The classification of the frontal cells

Type 1	Single cell of the AN cell
Type 2	Cluster of cells on the AN cell
Type 3	Single cell extending from the AN cell to the frontal sinus, pneumatizing the lumen
Type 4	Isolated cell within the frontal sinus, covering entire space

5.6 Conclusion

The anatomy of the paranasal sinuses is complex and variable. Particularly, the anatomy of the ethmoid sinus varies from person to person. A sound surgical anatomy and intimate acquaintance with potential variations that may be encountered are of great importance for the prevention of complications in endoscopic sinus surgery.

References

1. Çakır N. Otolaryngology head and neck surgery. Istanbul: Nobel Medical Bookstores; 1999.
2. Arıkan OK. Anatomy and physiology of the paranasal sinuses. In: Koç C, editor. Otolaryngology and head and neck surgery. Ankara: Güneş Bookstores; 2004.
3. Van Cauwenberge P, Sys L, De Belder T, et al. Anatomy and physiology of the nose and the paranasal sinuses. Immunol Allergy Clin N Am. 2004;24:1–17.
4. Sargi ZB, Casiano RR. Surgical anatomy of the paranasal sinuses. In: Kountakis SE, Önerci M, editors. Rhinologic and sleep apnea surgical techniques. Heidelberg: Springer; 2007.
5. Van Alyae OE. Ostium maxillare: anatomic study of its surgical accessibility. Arch Otolaryngol Head Neck Surg. 1936;24:552–69.
6. Kainz J, Braun H, Genser P. Haller's cells: morphologic evaluation and clinico-surgical relevance. Laryngorhinootologie. 1993;72:599–604.
7. Bolger WE, Woodruff WW Jr, Morehead J, et al. Maxillary sinus hypoplasia: classification and description of associated uncinate process hypoplasia. Otolaryngol Head Neck Surg. 1990;103:759–65.
8. Bolger WE, Kennedy DW. Atelectasis of the maxillary sinus. J Respir Dis. 1992;13:1448–50.
9. Wang RG, Jiang SC, Gu R. The cartilaginous nasal capsule and embryonic development of human paranasal sinuses. J Otolaryngol. 1994;23:239–43.
10. Wood S, Sinus M. In: Youngs R, Evans K, Watson M, editors. The paranasal sinuses. London: Taylor & Francis; 2006.
11. Bolger E. Anatomy of the paranasal sinuses. In: Kennedy DW, Bolger WE, Zinreich SJ, editors. Sinus diseases. Istanbul: Nobel Medical Bookstores; 2003.
12. Karmody CS, Carter B, Vincent ME. Developmental anatomy of the maxillary sinus. Trans Am Acad Ophthalmol Otolaryngol. 1997;84:723–80.
13. Stammberger H. Functional endoscopic sinus surgery: the Messerklinger technique. Philadelphia: BC Decker; 1991.
14. Nauman H. Patholische anatomic der chronischen rhinitis und sinisitis. In: Proceedings VIII International Congress of Otorhinolaryngology, Amsterdam, 1965. Excerpta Medica, p 12.
15. Keros S. Uber die praktische beteudung der Niveau-Unterschiede der lamina cribrosa des ethmoids. In: Nauman HH, editor. Head and neck surgery. Philadelphia: WB Saunders; 1980.
16. Kainz J, Stammberger H. The roof of the anterior ethmoid: a place of least resistance in the skull base. Am J Rhinol. 1989;3:191–9.
17. Basak S, Karaman CZ, Akdilli A, et al. Evaluation of some important anatomical variations and dangerous areas of the paranasal sinuses by CT for safer endonasal surgery. Rhinology. 1998;36:162–7.
18. Wyllie JW, Kern EB, Djalilian M. Isolated sphenoid sinusitis of the nose. Bailliere. London: Tindalland Cox; 1910.
19. Sirikci A, Bayazit YA, Bayram M, et al. Variations of sphenoid and related structures. Eur Radiol. 2000;10:844–8.
20. Kim HU, Kim SS, Kang SS, et al. Surgical anatomy of the natural ostium of the sphenoid sinus. Laryngoscope. 2001;111:1599–602.
21. Lang J, Bressel S, Pahnke J. The sphenoid sinus, clinical anatomy of approaches to the pituitary region. Gegenbaurs Morphol Jahrb. 1988;134:291–307.
22. Dixon FN. A comparative study of the sphenoid sinus (a study of 1600 skulls). Ann Otol Rhinol Laryngol. 1937;46:687–98.
23. Enatsu K, Takasaki K, Kase K, et al. Surgical anatomy of the sphenoid sinus on the CT using multiplanar reconstruction technique. Otolaryngol Head Neck Surg. 2008;138:182–6.
24. Sethi DS, Stanley RE, Pillay PK. Endoscopic anatomy of the sphenoid sinus and Sella turcica. J Laryngol Otol. 1995;109:951–5.
25. Wormald PJ. Endoscopic Sinus surgery, anatomy, three-dimensional reconstruction, and surgical technique. New York: Thieme Medical Publishers; 2009.
26. Skinner D, White P. Anterior ethmoid sinus and frontal sinus. In: Youngs R, Evans K, Watson M, editors. The paranasal sinuses. London: Taylor & Francis; 2006.
27. Stammberger HR, Bolger WE, Clement PAR, et al. Anatomic terminology and nomenculature in sinusitis. Ann Otol Rhinol Laryngol Supp. 1995;104:7–19.
28. Casiano RR. A stepwise surgical technique using the medial orbital floor as the key landmark in performing endoscopic sinus surgery. Laryngoscope. 2001;111(6):964–74.
29. Floreani SR, Nair SB, Switajewski MC, et al. Endoscopic anterior ethmoidal artery ligation: a cadaver study. Laryngoscope. 2006;116:1263–7.
30. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope. 1991;101(1. Pt 1):56–64.
31. Bent JP, Cuilty-Siller C, Kuhn FA. The frontal cell as a cause of frontal cell obstruction. Am J Rhinol. 1994;8:185–91.
32. Kuhn FA. Surgery of the frontal sinus in disease of the sinuses; diagnosis and management. In: Kennedy DW, editor. Diseases of the sinuses. London: BC Decker; 2001.