

Peer Reviewed Case Study

RARE ANATOMICAL VARIANTS OF THE SPHENOID AND ETHMOID SINUSES. A CASE SERIES

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Abstract

There are many established variants of the paranasal sinuses. An in-depth knowledge of the anatomy of the paranasal sinuses and their anatomical variants is crucial in the context of endoscopic endonasal transsphenoidal operations. The sphenoid sinus and body in particular are the focus of this case series. A range of rare anatomical variations of the sphenoid and ethmoid sinuses are discussed, namely, a rare position of the Onodi air cell, a dominant Onodi air cell with an intra-Onodi air cell accessory sphenoid septation, and a case that demonstrates protrusion of the sphenoid body into the right sphenoid sinus.

Contributions: This case series aims to add to the normal anatomical variants of the sphenoidal sinuses and to increase awareness of the existence of these variations in anatomy. To the authors' knowledge, there are no reported cases of these variants in the English literature, with the exception of the central Onodi air cell, where one previous case was reported, making it a rare case presentation.

Keywords: Onodi, variant, sphenoidal air cell

INTRODUCTION

Human paranasal sinuses comprise four pairs of sinuses: ethmoidal, sphenoidal, frontal and maxillary sinuses. These sinuses are lined with pseudostratified columnar epithelium. The paranasal sinuses serve to reduce the weight of the skull, humidifying and warming the air we breathe, as well as playing an important immunological role.^[1] The sinuses are housed within the bones which they are named after. These bones of the skull serve separate functions to the sinuses which they house. For example, the main function of the sphenoid bone is to allow for the passage of various neurovascular structures into and out of the cranium through various foramina and canals.^[2] A number of anatomical variants of the sinonasal structures are described in the English literature. One such variant is the Onodi air cell which was coined by the physician who first described this posterior-most ethmoidal air cell.^[3] The sphenoid sinuses may also exhibit variation in their normal anatomy, as seen in one of the cases presented below. With the increasing popularity of endoscopic transsphenoidal approaches for either intra-cranial access or sphenoid sinus access, there is a need for the identification and classification of the anatomy of the paranasal sinuses along with their variant anatomy.^[4]

This case series aims to add an additional case of a rare centrally positioned Onodi air cell and to introduce new an-

atomical variants: a dominant Onodi air cell and protrusion of the sphenoid body into the sphenoid sinus. The importance of recognising such variations in anatomy serves to limit the possibility of complications during transsphenoidal endoscopic surgeries.

CASE SERIES

Case 1

A 61-year-old male presented to the emergency centre with adult-onset generalised tonic-clonic seizures. The patient's medical history, examination and blood work were unremarkable. He had an unenhanced computed tomography (CT) head scan. The scan demonstrated an incidental finding of a central Onodi air cell. As shown in Figures 1 and 2 the Onodi air cell is adjacent to both optic canals. No evidence of associated dehiscence of the optic canals and Onodi air cell to the carotid canals. The inter-sphenoid septation is in contact with the Onodi air cell.

Case 2

A 26-year-old postpartum female, with a history of pre-eclampsia during pregnancy, developed seizures in the post-partum period. She did not respond to anti-epileptics. Clinically, the patient had no further neurological signs. The

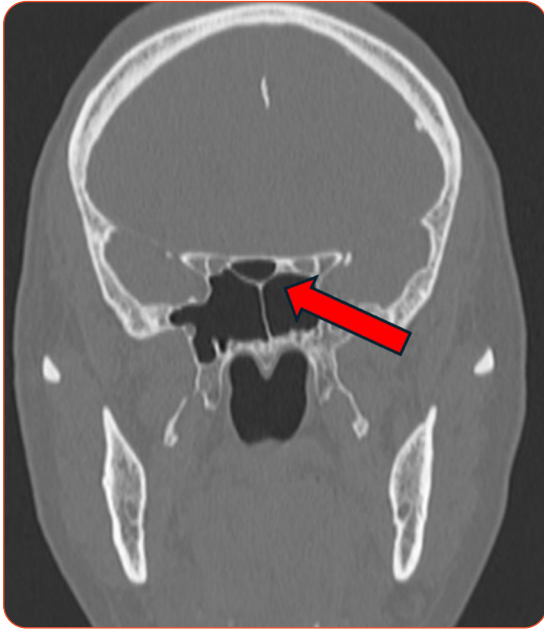


Figure 1. Non-contrasted CT head (bone window) demonstrating the central Onodi air cell.

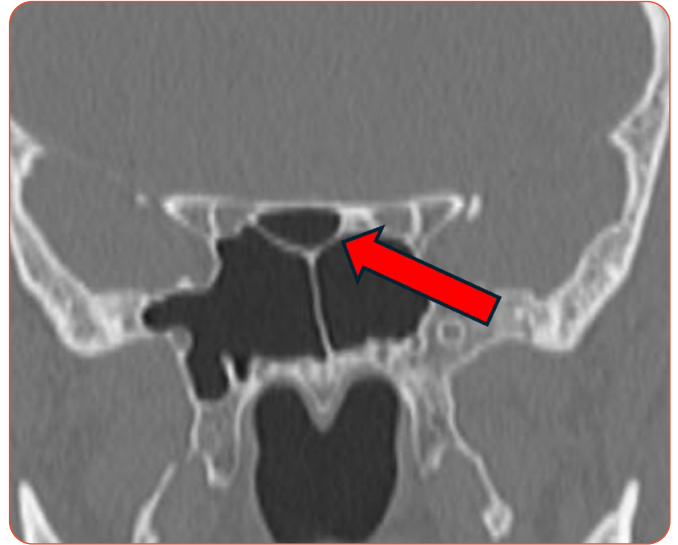


Figure 2. Non-contrasted CT head (bone window) demonstrating the central Onodi air cell in a magnified coronal view.

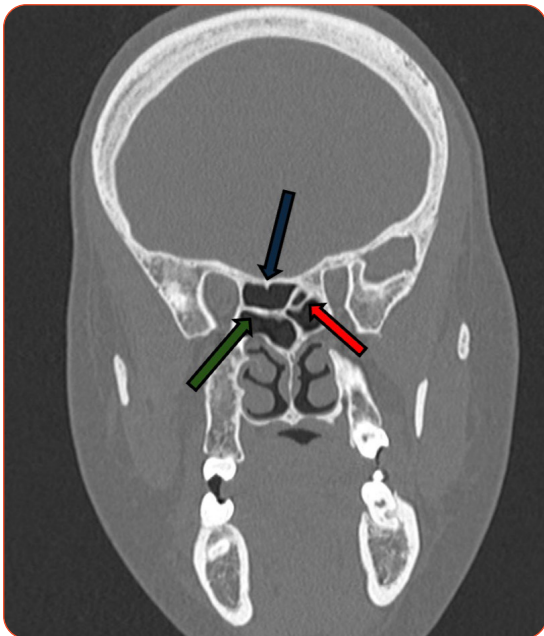


Figure 3. Non-contrasted CT head (bone window) coronal plane showing a dominant Onodi air cell (green arrow), a non-dominant Onodi air cell (red arrow) and an intra-Onodi air cell accessory sphenoid septation (blue arrow).

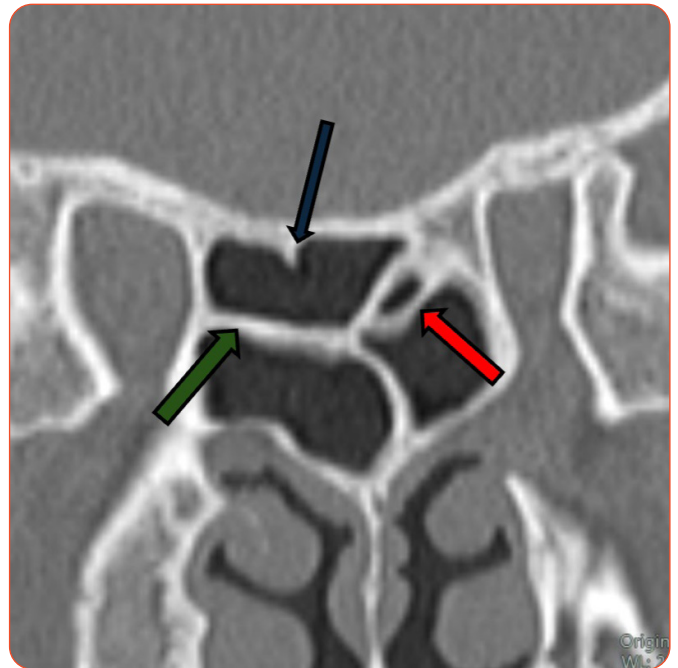


Figure 4. Non-contrasted CT head (bone window) coronal plane, magnified view, showing a dominant Onodi air cell (green arrow), a non-dominant Onodi air cell (red arrow) and an intra-Onodi air cell accessory sphenoid septation (blue arrow).

laboratory workup was unremarkable. An incidental finding of bilateral Onodi air cells was noted on her unenhanced CT head scan. As shown in Figures 3 and 4 a right Onodi cell is dominant as well as an incomplete accessory sphenoid septation. The latter has no relation to the optic or carotid canals.

Case 3

A 65-year-old male patient presented to the emergency

centre with a history of acute confusion of unknown duration and no other neurological signs. There was no significant medical history and laboratory workup was unremarkable. An incidental finding of a bony protrusion projecting posteriorly from the sphenoid body into the right sphenoid sinus was noted on his unenhanced CT scan of the brain. The bony protrusion measured 5.9mm x 9.5mm x 11.3mm (antero-posterior x transverse x cranio-caudal). As visualised in Figures 5 and 6 the protrusion has a wide base with a continuous cortex. The protrusion has a close relationship



Figure 5. Non-contrasted CT head (bone window) demonstrating the bony protrusion of the sphenoid body into the right sphenoid sinus in a magnified axial view.

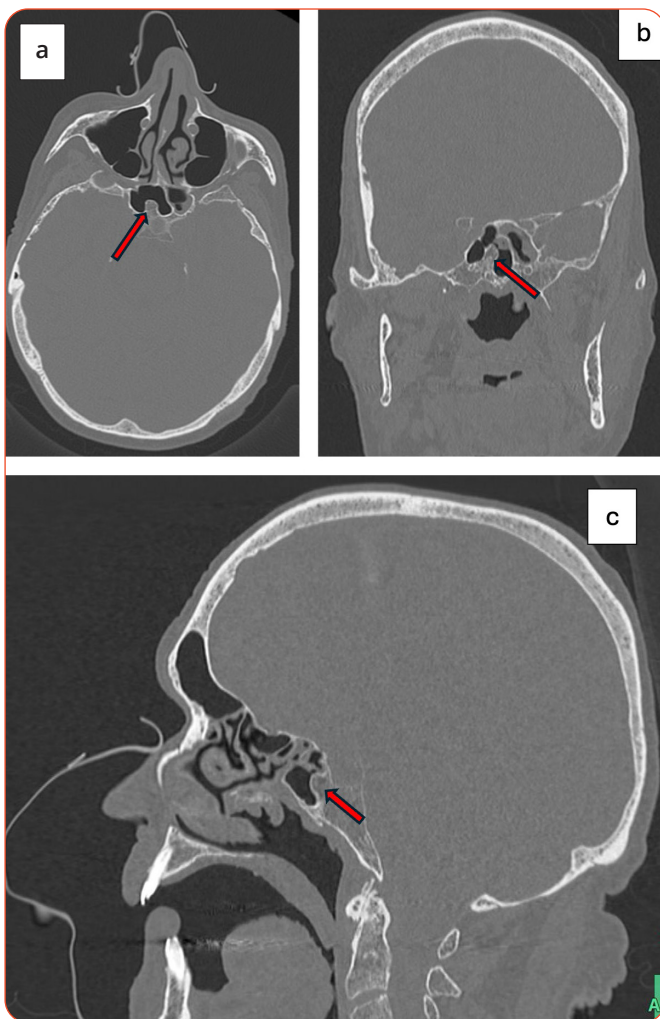


Figure 6. Non-contrasted CT head (bone windows) demonstrating the bony protrusion of the sphenoid body into the right sphenoid sinus in a) axial, b) coronal and c) sagittal views.

to the right Vidian canal (type 3), with no relation to the right carotid canal, optic canal or foramen rotundum. His scan showed a pre-sellar type of sphenoid sinus. The bony protrusion is limited to the right sphenoid sinus with no out-growths visualised in the left sphenoid sinus.

DISCUSSION

There are four pairs of paranasal sinuses, one on either side of the midline. Embryologically the paranasal sinuses begin to develop in the 8th week of gestation, with their pneumatization continuing until early adulthood. The respective sinuses are named after the bone wherein they line: sphenoid sinus, ethmoid sinus, maxillary sinus, and frontal sinus.^[1]

The ethmoid sinuses, also known as the ethmoid air cells, are located within the ethmoid labyrinth. They are present at birth and continue to develop until about age 12. One classification of the ethmoidal air cells, apart from being described as either anterior or posterior, is describing them as intramural or extramural. Intramural ethmoid air cells remain within the bone and include the ethmoid bullae, frontal bullae and suprabullae cells.^[1] The ethmoid air cells that develop external to the ethmoid labyrinth are referred to as extramural ethmoid air cells. Examples of these include agger nasi air cells, supraorbital air cells, Haller air cells and Onodi air cells. The presence of the extramural air cells varies from individual to individual.^[5]

The ethmoid air cell may pneumatise into the body of the upper sphenoid bone, in which case it is termed the Onodi air cell.^[5] They are understood to be lateral and posterior extensions of the posterior ethmoidal air cells.^[3] Another important characteristic of the Onodi air cell is its close association with the optic nerve^[3,5], which has serious implications in endoscopic surgery.

The occurrence of Onodi cells in literature was estimated to be 23.6% in a study by Dikici et al.^[6] Another study performed by Shyamlal et al found a prevalence of 24.4% in a study population of 900 adults.^[7] At least one Onodi cell was found in 39% of endoscopically inspected cadavers, as reported by Driben et al.^[8] This statement suggests that some of the cadavers studied may possess bilateral or multiple Onodi cells.

There are three established types of Onodi air cells according to Shyamlal et al. Type 1 air cells are those located superior and medial to the sphenoid sinus, type 2 air cells are those visible both superior and inferior to a horizontal line drawn at the highest point of the sphenoid sinus where the Onodi cell and body of sphenoid sinus meet on a coronal plane image, and finally type 3 Onodi cells are those solely visible inferior to this line.^[7]

In terms of sphenoid sinus variants, some of the reported variants include its pneumatization pattern. According to Hammer and Rådberg,^[9] pneumatization patterns are either described as conchal, presellar, sellar, and post-sellar types. Other sphenoid sinus variants include arrested pneumatization, pneumatization of the lateral recess, protrusion of the optic nerve, internal carotid artery, Vidian nerve and maxillary nerve into the sphenoid sinus, deflection of the

inter-sphenoid sinus septum to one side, accessory intrasphenoid septations and complete intrasphenoid septations.^[10] Additional variants include extension of pneumatization of the sphenoid sinus to involve the anterior clinoid processes, the pterygoid processes or the posterior portion of the maxillary sinus.^[11] There are no reported variants of the sphenoid body itself. There are also no reported variants of accessory septations occurring inside other known variants such as Onodi cells.

Compared to other paranasal sinuses, the sphenoid sinus has considerable variation in its anatomy and its pattern of pneumatization.^[12] The importance of understanding the anatomy of the sphenoid sinus and its anatomical variants poses importance with endoscopic sinus operations and their possible complications.^[11]

Transsphenoidal sinus surgeries have become increasingly common for surgical resection of pituitary masses. Such surgeries can complicate with injury to the optic and carotid canals. The surgery relies on knowledge of the posterior extent of pneumatization of the sphenoid sinus to assess the degree of difficulty in accessing the sellar floor during the procedure. Additionally, functional endoscopic sinus surgeries (a procedure used to treat chronic sinusitis) possess associated risks to the carotid canal, optic canal and Vidian canal and foramen rotundum.^[12] To minimise risks of endoscopic sinus surgery, meticulous pre-operative planning is imperative to understand the possible anatomical variants and how these may pose potential intra-operative complications.^[11]

» Central Onodi

Cherla et al^[5] were the first to describe the central Onodi air cell as a new variant of the established Onodi air cell. In their journal article, they describe the discovery of a centrally positioned posterior ethmoid air cell visualised on a pre-operative CT performed for a patient similar to the patient described above in case 1. In the journal article, the possibility of the development of a Onodi mucocele or pylocele and optic neuropathy was described.^[5]

Recognition of the normal anatomical variants is important, however it is also imperative to describe the type of variant in detail, to assist the endoscopic surgeon to better plan the procedure in order to minimise the occurrence of perioperative complications.^[12] Onodi air cells are typically described in terms of their laterality within the sphenoid sinus. Awareness of the existence of the central Onodi air cell intends to aid perioperative preparation, to avoid confusion to the endoscopic surgeon intra-operatively and emphasise the need for pre-operative planning.^[13] The patient described in case 1 may present as a complex case during sphenoidal surgery due to the close relation of the central Onodi cell to the optic canals. Case 1 adds to existing literature relating to a rare occurrence of a central Onodi air cell, and introduces the idea of the need of a more elaborate classification system for the Onodi air cell due to its relevance in endoscopic sinus surgeries.

» A dominant Onodi air cell with an intra-Onodi air cell accessory sphenoid septation

The CT images in patient in case 2 demonstrate a new anatomical variant not mentioned in literature – the presence of bilateral Onodi cells in which one cell is dominant over the other. In addition to this, the dominant Onodi cell demonstrates a variant inside a variant which we have termed an intra-Onodi cell accessory sphenoid septation. The knowledge of the complexity of sinus surgeries as previously mentioned provides adequate reason as to why the Onodi cell and its variations in anatomy pose relevance, mostly related to sinus surgeries.

The discovery of a new undocumented Onodi variant adds to existing literature and may aid sinus surgeons in their intra-operative success. The presence of bilateral Onodi cells in which one is dominant and in which there is an intra-Onodi air cell accessory sphenoid septation may make sinus surgeries difficult in such a patient. Possible new ways to navigate such complex variants may be warranted to avoid catastrophe.

» Protrusion of the right sphenoid body through the right sphenoid sinus

Case 3 describes a unique variant in which the sphenoid body demonstrates a bony protrusion into the right sphenoid sinus. The importance of the sphenoid body is its direct relations to important structures, namely the pituitary gland, the optic nerve and chiasm, the Vidian artery and nerve, the olfactory nerve, the ophthalmic artery and the cavernous sinus, which itself houses the internal carotid artery and multiple cranial nerves that enter and supply the orbit.^[11] As stated earlier, the close relations of the sphenoid sinus to many anatomical structures may pose potential risks in such surgeries as the protrusion of sphenoid body into the sinus may create difficulty in endoscopic sinus procedures.

CONCLUSION

This case series accentuates the importance of the knowledge of the normal anatomical variants of the paranasal sinuses, specifically the types of Onodi air cells, and the variant anatomy of the sphenoid body. It also highlights the need for a classification system for the anatomical variants described in this case series. This will enable surgeons to better plan and anticipate potential consequences – with the aim of minimising perioperative complications.

ETHICAL CONSIDERATIONS

The article followed all ethical standards for research. A written informed consent was obtained from the patients for publication along with approval from the management of the institution. Their identity is not disclosed.

COMPETING INTERESTS

The authors declare that they have no financial or person-

al relationship(s) that may have inappropriately influenced them in the writing and publishing of this article.

AUTHORS' CONTRIBUTIONS

SMM (WPH) and TVA (WPH) compiled the literature review and drafted the original manuscript. LG (WPH) analysed the images, edited the manuscript and provided mentorship guidance, and oversight.

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DISCLAIMER

The views and opinions expressed in this article are those of the authors and are the product of professional research. They do not reflect the views of the affiliated institutions or that of the publisher.

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