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Prevalence of the Onodi cell in the Polish adult population: an anatomical computed tomography study

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Background: *Onodi cell is a posterior ethmoid air cell with the optic canal bulging into it; the common position of the bulge is into the sphenoid sinus, usually immediately posterior to the posterior ethmoid air cells. Variable pneumatisation patterns lead to various structures of lamellae and sinuses occasionally exposing important nerves and vessels, such as the optic and vidian nerves, internal carotid artery and cavernous sinus. In clinical practice, special imaging techniques are used to navigate through the paranasal sinuses and hence avoid injury to these structures. This study is aimed to determine the prevalence of the Onodi cell in the Polish population and compare it with other reported occurrences.*

Materials and methods: *A retrospective analysis of 296 computed tomography (CT) scans of patients treated in Krakow, Poland, using a Siemens Somatom Sensation 16 spiral CT scanner. No contrast medium was administered.*

Results: *The Onodi cell was found in 31 out of the 296 patients, or approximately 10.5%, consistent with the majority of research reporting on Onodi variants. Additionally, there was one presentation of a bilateral Onodi cell in a male patient. No statistically significant difference was found between the male and female populations with a positive identification of the variant (p = 0.095, Chi*^{2} *test).*

Conclusions: *This study helped approximate the Onodi variant prevalence of 10.47%, falling within a commonly reported range 8–14%. This gives clinicians and surgeons a better understanding of this variant's structure and significance, and therefore an opportunity to improve treatment outcomes and research.* (Folia Morphol 2023; 82, 4: 885–891)

Key words: Onodi cell, sphenoid sinus, anatomy, computed tomography

INTRODUCTION

The paranasal sinuses are air-filled cavities that communicate with and create a functional unit with the nasal cavity [27]. Ostia are the openings between the paranasal sinuses and nasal cavity that permit aeration and drainage, including a path for sinusitis

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infections and blockage [4]. Anatomical variations of bony structures within this region happen to be relatively common including subsequent clinical symptoms such as sinusitis, deviated septum, and various air cells [23].

The Onodi cell, or posterior sphenoethmoid cell, is an anatomical variant of the posterior-most ethmoidal air cells, pneumatised posteriorly to the extent that the optic canal is visible from within the cell [17]. It was first introduced by Onodi in 1904 [25]. Even though it is contraindicated to use eponyms in everyday clinical practice, they are still popular as they denote the same feature/condition in a much shorter, more appealing to medical professionals version [3]. It is also true in the case of the Onodi cell. A similar term, "posterior overriding ethmoid cell," has been reported by Ozturan et al. [26] which is defined as a posterior ethmoid cell that is pneumatised into the sphenoid bone and sinus, but is not characterised by an optic canal bulge. Since the internal carotid artery normally bulges into the sphenoid sinus, a patient with a positive identification of an Onodi cell will also, in most cases, present with a landmark often seen in transsphenoidal sinusoidal surgeries recess [32]. Other relevant structures mostly pertain to the lateral wall of the sphenoid sinus and ethmoid including the cavernous sinus and all its enclosed structures (cranial nerves III, IV, VI, V_1, and V_2) and the vidian nerve, as well as even the brain stem behind the clival part of the sphenoid bone. Anatomic variants of the paranasal sinuses and nasal cavity may be more common, and may even overlap leading to complicated structure and function [7–16].

The process of paranasal cavity expansion is called pneumatisation and its pattern of development can lead to abnormal sinus architecture. Pneumatisation of ethmoid air cells takes place bilaterally inside the ethmoid labyrinth, and can extend into surrounding paranasal sinuses creating the Haller cells, agger nasi cells, and Onodi cells [23].

The extent of pneumatisation of the ethmoid and sphenoid sinuses impacts the thickness of bone between the sinus and surrounding structures, and walls as thin as 0.5 mm separating the sphenoidal sinus from surrounding structures have been reported, sometimes even less [32]. During the pneumatisation of the sphenoid sinus, it will develop into one of three types of sinus: conchal, presellar, and sellar. Most common according to Lu et al. [21] is the sellar type which pneumatised posterior and inferior to the sella. The sphenoid sinus usually has bilateral cavities with an intersphenoid septum [14].

Modern imaging and surgical equipment such as computed tomography (CT) and endoscopes have improved visualisation and subsequently surgical procedures in the nasal and paranasal regions, even as far posteriorly as the petrous apex [21] and the hypophyseal fossa. It would be dangerous to assume a patient's anatomy to follow a standard textbook description, especially with so many variations in the paranasal architecture. Anatomical variants can be classified as normal since no human is the same and variation is inevitable [33]. That is why every variation must be studied and recorded, and identified before surgery takes place, or at least a surgeon ought to be prepared for variation and potential risks it bears.

To the best knowledge of the authors, there is a scarcity of information regarding the Onodi cells among the Polish adults. Henceforth, the main purpose for conducting this study was to determine more accurately the prevalence of Onodi cells in the Polish adult population. Moreover, a subgroup analysis based on the sex of the patients was planned in order to probe for any potential differences that might arise because of it.

MATERIALS AND METHODS

The following study was conducted as a retrospective analysis of CT scans of a total of 359 patients, derived from the Department of Medical Imaging, University Hospital in Krakow, Poland. For the patients to be included, they had to be over 18 years of age and had a CT scan involving the paranasal sinuses. The exclusion criteria comprised any visible pathology, trauma or surgical intervention involving either the nasal, orbital or cranial basis (63 patients). Ultimately, 296 patients (147 females, 149 males) were included in this analysis.

Medical imaging of the paranasal sinuses was obtained with the help of the Siemens Somatom Sensation 16 spiral CT scanner. Standard procedure applied, utilising Siemens CARE Dose 4D option. At no point in the present study was the contrast medium administered to any of the patients. Multiplanar reconstruction tool was used for better visualisation of the paranasal sinuses in frontal and sagittal planes, reconstructed from the original images in the transverse plane. The authors processed the obtained imaging data via the Siemens Volume Wizard diagnostic station.

The authors analysed the data by searching for the presence of the Onodi cell, as per the definition stated above. Whenever present, its laterality and sex of the patient was noted. Examples of the CT images presenting the Onodi cell were anonymised and attached in this work.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statistical analysis

The statistical analysis for the present study was performed with STATISTICA version 13.3 by TIBCO Software Inc®. Chi-squared and Fisher's exact tests applied, depending on the fulfilment of their criteria. P-value of < 0.05 was chosen to represent statistically significant results.

Table 1. Prevalence of the Onodi cell

The Onodi cell	F	F%	M	M%	F + M	F% + M%
Present	11	7.48%	20	13.42%	31	10.47%
Absent	136	92.52%	129	86.58%	265	89.53%

F — females; F% — the percentage of females; M — males; M% — the percentage of males

Table 2. Prevalence of the unilateral and bilateral Onodi cell in the total research group

The Onodi cell	F	F%	M	M%	F + M	F% + M%
Unilateral	11	7.48%	19	12.75%	30	10.14%
Bilateral	0	0%	1	0.67%	1	0.34%
Absent	136	92.52%	129	86.58%	265	89.52%

F — females; F% — the percentage of females; M — males; M% — the percentage of males

Table 3. Prevalence of the unilateral Onodi cell in the total research group

The Onodi cell	F	F%	M	M%	F + M	F% + M%
Right	5	3.4%	7	4.7%	12	4.05%
Left	6	4.08%	12	8.05%	18	6.08%

F — females; F% — the percentage of females; M — males; M% — the percentage of males

RESULTS

Presence of the Onodi cell was relatively frequently noted in the whole research material — it was found in 31 patients, more often in men (20 patients) than females (11 patients). There was no side predilection for this anatomical variation in the female group (5 were identified on the right side, whereas 6 on the left side). In the male group, the Onodi cell was prevalent more often on the left side (in 12 patients) than on the right side (7 patients). Bilateral Onodi cells were noted only in a single male patient.

No statistically significant differences were found between the presence and absence of the Onodi cell in the female and male groups ($p = 0.095$, Chi-squared test). In approximately 90% of men and women the Onodi cell was absent (Tables 1, 2).

Due to the fact that bilateral Onodi cells were noted only in a single case, the statistical analysis was not performed in this instance.

Within the group of patients with a unilateral Onodi cell, no statistically significant difference was found between the males and females which had right- or left-sided variants ($p = 0.712$, Fisher's exact test; Table 3).

For the female group with a unilateral Onodi cell, the variant was present on the right side in 45.5% and in 54.5% on the left side. In juxtaposition, a unilateral Onodi cell was found in males more often on the left side (63.2%) than on the right side (36.8%).

Figures 1–4 present examples of the identified Onodi cells in both transverse and frontal planes.

DISCUSSION

As shown in this study, the Onodi cell is a relatively frequent finding on the CT scans of paranasal sinuses of the Polish adult population. Its prevalence was found to be 10.5% for the whole research group. When present, it was noted more often on the left side in males (63.2%), whereas in females there was not a clear side predilection visible.

Concurrent results are given by Perez-Pinas et al. [27], assessing the presence of the Onodi cell at 10.9% (study of 110 CTs of the Spanish population), as well as Sethi et al. [30] — 13% (a dissection study of 30 Asian skulls).

A lower incidence of Onodi cells was reported by Elwany et al. [6] — 7.5%, determining the bilateral variant to be present in 5.3%. The reason for the discrepancies between the results may be attrib-

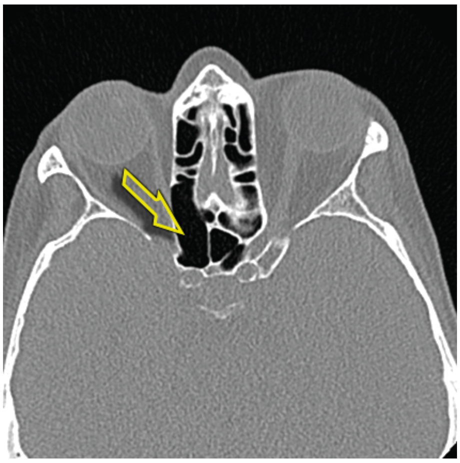

Figure 1. A computed tomography scan of the paranasal sinuses, transverse section. The Onodi cell is marked on the right side.

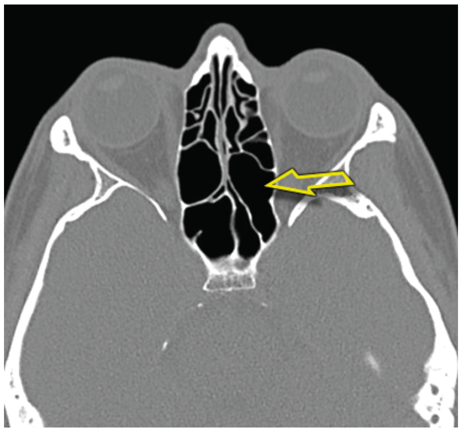

Figure 3. A computed tomography scan of the paranasal sinuses, transverse section. The Onodi cell is marked on the left side.

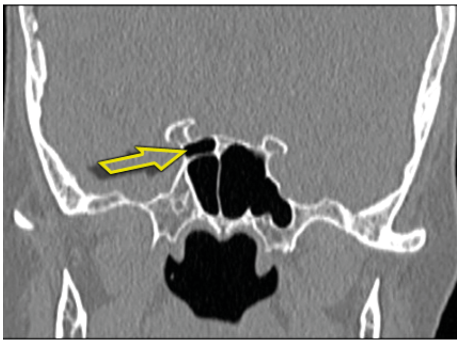

Figure 2. A computed tomography scan of the paranasal sinuses, frontal section. The Onodi cell is marked on the right side.

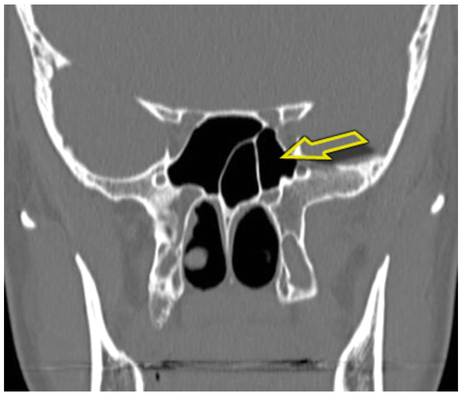

Figure 4. A computed tomography scan of the paranasal sinuses, frontal section. The Onodi cell is marked on the left side.

uted to the method of sinus evaluation (cadaveric endoscopic examination) and the number of sinuses examined (93 patients). A much lower prevalence of this variant was reported by Seddighi et al. [29] (1.56%), Kazkayasi et al. [19] (1.5%), and Daghighi and Daryani [4] (0.4%). In the case of the latter researchers, the study population (Iranian) and the age of the respondents (under 18) could have caused such different results.

Higher incidence of Onodi cells was reported by Ozturan et al. [26] — 16.6%, Tan and Ong [32] — 15%, Anusha et al. [2] — 14.3%, Lupascu et al. [22] — 18% (noting that the presence of the Onodi cell is associated with a smaller dimension of the sphenoid sinuses) and Earwaker [5] — 24%, of which bilateral cells were found in 9.36%. Similar results of the bilateral variant of the Onodi cell are presented by Kaplanoglu et al. [18] — 10.33%; however, giving a much higher incidence of unilateral incidence — 44%. The different results may possibly be related to the analysed ethnic group (Turkish).

Nitinavakarn et al. [24] reported the Onodi cell prevalence three times higher — 31.8% while investigating the adult Thai population (88 CT scans). A high frequency of this variant is also reported by Kainz and Stammberger [17] — 42%. It may be related to the number of examined heads (52) and the method of evaluation (cadaveric endoscopic examination). The highest incidence of Onodi cells was presented by Chinese researchers, Lu et al. [21], after endoscopic examination of 18 skulls — 61.1%, but the results refer to both sides of the skulls (i.e., 36).

Completely different results are presented by Sareen et al. [28], who did not find a single case of the Onodi cell, which could be due to the small number of sinuses (20 skulls) and the method of observations (autopsy).

Detailed comparison of the present work with the previously published data can be found in Table 4.

Table 4. Onodi cell prevalence in the previous studies

Author (materials and methods)	Present	Unilateral	Unilaterally on the right	Unilaterally on the left	Bilateral
Perenz-Pinas et al. (110 CT)	10.9%				
Sethi et al. (30 skulls, dissection study)	13%	10%	–	–	3%
Elwany et al. (93 skulls, endoscopic and dissection study)	7.5%	–	–	–	5.3%
Seddighi et al. (64 CT and MRI)	1.56%				
Kazkayasi et al. (267 CT)	1.5%	1.5%	–	–	0%
Daghighi and Daryani (292 CT)	0.4%				
Ozturan et al. (999 CT)	16.6%				
Tan and Ong (48 skulls, endoscopic and dissection study)	15%				
Anusha et al. (300 CT)	14.3%	72.1%	32.6%	39.5%	27.9%
Lupascu et al. (200 CT)	18%	–	–	–	–
Earwaker (800 CT)	24%	–	–	–	9.36%
Kaplanoglu et al. (300 CT)	54.33%	44%	22%	22%	10.33%
Nitinavakarn et al. (88 CT)	31.8%	13.6%	–	–	18.2%
Kainz and Stammberger (52 skulls, endoscopic study)	42%				
Lu et al. (18 skulls, endoscopic study)	61.1%				
Sareen et al. (20 skulls, dissection study)	0%				
Jaworek-Troć et al. (296 CT)	10.47%	10.14%	4.05%	6.08%	0.34%

CT — computed tomography; MRI — magnetic resonance imaging

Each paranasal sinus develops as an extension of the nasal cavity, through which they also drain and receive air. Furthermore, the sinuses develop differently and at points in life, leading to variable anatomy of the nasal and paranasal regions [23]. With an increased extent of pneumatisation, important anatomical entities (namely neurovascular) that pass around the paranasal sinuses may become dehiscent further increasing the risk of iatrogenic injury during surgery and trauma. Recesses in the sphenoid sinus have been found in 93.92% of the Polish adult patient population, in which case access is improved due to less need for bone drilling [10].

An Onodi cell develops when the posterior ethmoid cell's pneumatisation makes the optic canal visible from inside the cell [17]. Various patterns complicate both general anatomical terminology and surgical procedures; the paranasal sinuses are under constant review and research to discover and classify new variations and structures [23].

The sphenoid sinus is most commonly a sellar type sinus at the end of its development that usually occurs in the third decade of life. Next in order of frequency, are pre-sellar and conchal types [32]. Depending on the pattern of pneumatisation, the sphenoid sinus can have various anatomical variations e.g. accessory septae, deviated interspinous septae [32]. The ostia are found on the sphenoid bone's anterior aspect as a continuation of the sphenoethmoidal recess, and are closely associated with the posterior group of ethmoid air cells [11, 18].

The Onodi cell is important due to its relation to several vital structures such as the optic nerve, internal carotid artery, among others. Complications during surgery, trauma, and/or disease related to paranasal sinuses can affect these nerves and openings, and hence require special imaging to identify potential risks due to anatomy. Pneumatisation of the posterior ethmoid cell and subsequent bulging of the optic canal poses an increased risk due to increased exposure, e.g., during surgical excision of the inflammatory tissue from the ethmoid labyrinth. It is important to mention that the wall thickness and extent of protrusion of the optic canal is likewise variable from case to case. Injury to the optic nerve results in amaurosis. Studies have also shown that although the occurrence of Onodi cells are generally low, individuals with the Onodi variant have increased chances of bulging of other structures such as the internal carotid canal, creating a spheno-carotid recess, a landmark for otolaryngologists operating in the sphenoid sinus.

Limitations to studies searching for anatomical variations include sample size, equipment, and discrepancies in accepted terminology. Since the anatomy of the bony structures includes a considerable amount of variation, it is important to learn and understand each one to fully grasp the anatomy and importance of these structures. With the advent of modern imaging techniques, it has become much easier to visualise difficult to reach structures deep within the nasal cavity, such as the sphenoid sinus ostia. One of such techniques is utilising virtual dissection tables [31]. Endoscopic techniques have revolutionised procedures within this region and therefore continuing research into the structure will cooperatively develop surgical and other clinical procedures of the paranasal sinuses and associated structures [1].

In the future, focus can be shifted on the other air cells of the ethmoid and their invasion paths into the other paranasal sinuses. The Onodi cell is but one variant among many within the nasal and paranasal spaces, and therefore in many cases closely related to other anomalies. Additionally, CT may not be the only tool available in the near future; in development three-dimensional imaging and mixed reality (MR) technology may allow researchers and clinicians an even better approach to the paranasal structures, furthering this research [20]. The present study is limited by the sole use of two-dimensional imaging, however a comprehensive three-dimensional evaluation of the Onodi cell, as well as other paranasal sinuses and their variants could be of clinical interest to the surgeons having to operate in those oftentimes difficult to access regions. Finally, a wider sample size study could be carried out to quantify the prevalence of the cell in the polish population, as well as to identify other potential variations of paranasal anatomy.

CONCLUSIONS

Various studies have been done on the presence of anatomical variants of the paranasal sinuses that are helpful to the medical community in solidifying the terminology and specifications of anatomic variants, and determining their occurrence and clinical significance. Among the latter, of most importance, are surgical procedures involving endoscopic entry through the nasal cavity of anything in between that and the skull base. Imaging allows surgeons better preoperative planning and decreased chance of iatrogenic injury. In this study, we specifically determined the prevalence of the Onodi cell in the Polish population to be approximately 10% based on 296 CT scans.

This report, along with the studies conducted by the referred authors and many more, serves as continuing research into the anatomy of the paranasal structure; this then can be employed by surgeons, clinicians, and researches to further their expertise and treatment of individuals with normal and abnormal anatomical variants such as the Onodi cell. This study not only widens our knowledge of the prevalence of this variant in the Polish population, it also confirms a general trend of prevalence (8–14%), and contributes data required for understanding the paranasal architecture.

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Conflict of interest: None declared

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