

Agenesis of the sphenoid sinus and a single sphenoid sinus: a computed tomography anatomical evaluation

J. Jaworek-Troć^{1, 2}, J.A. Walocha¹, M. Lipski¹, S. Popovchenko¹, K. Shafarenko¹, T. Gładysz³, P. Depukat¹, J.J. Zarzecki⁴, R. Chrzan², A. Urbanik², M.P. Zarzecki¹

¹Department of Anatomy, Jagiellonian University Medical College, Krakow, Poland

²Department of Radiology, Jagiellonian University Medical College, Krakow, Poland

³Department of Dental Surgery, Institute of Dentistry, Jagiellonian University Medical College, Krakow, Poland

⁴Medical University of Silesia, Katowice, Poland

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Background: Sphenoid sinuses are pneumatic spaces within the body of the sphenoid bone. Their development begins in the prenatal life and continues until the adulthood. Agenesis of the sphenoid sinuses is a situation in which they are undeveloped. On the other hand, a single sphenoid sinus lacks the presence of the main septum, leading to the formation of a single antrum. Contemporary use of transnasal transsphenoidal approaches for the pituitary surgery, as well as functional endoscopic sinus surgery urges medical professionals to be well acquainted with the aforementioned variant.

Materials and methods: Paranasal sinuses of 300 patients (150 females, 150 males) were evaluated using computed tomography, without the use of contrast medium. Inclusion criteria involved absence of any identifiable pathology within the sphenoid sinuses and age over 18 years. Subgroup analysis involved probing for potential sources of heterogeneity, namely gender.

Results: In the whole research material of 300 patients, agenesis of the sphenoid sinuses was noted in 1% of the patients. No statistically significant differences were noted between the absence of the sphenoid sinuses and gender ($p = 0.999$). A single sphenoid sinus was found in 0.33% of the patients. There were no statistically significant differences found between the presence of fully developed sphenoid sinuses and gender ($p = 0.498$).

Conclusions: Both agenesis of the sphenoid sinuses and a single sphenoid sinus are rare anatomical variants. Adequate planning for transsphenoidal surgeries with preoperative medical imaging is of essence in order to perform a safe and quality procedure. (Folia Morphol 2021; 80, 4: 947–953)

Key words: agenesis, sphenoid sinus, computed tomography, anatomy

INTRODUCTION

Undoubtedly sphenoid sinuses are an anatomical entity with one of the most variant anatomy, con-

cerning namely its septation, proximity to the nearby crucial neurovascular structures, pneumatisation patterns and others [19–27, 34]. Notwithstanding, there

Address for correspondence: Dr. M.P. Zarzecki, MD, Department of Anatomy, Jagiellonian University Medical College, ul. Kopernika 12, 31–034 Kraków, Poland, tel/fax: +48 12 422 95 11, e-mail: michal.zarzecki@uj.edu.pl

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is still a constant need for new reports regarding their variations due to the fact that they are of immense importance namely in functional endoscopic sinus surgery and transnasal transsphenoidal approaches for the pituitary surgery and medical professionals are still poorly acquainted with some of the anatomical features (e.g. the exact parasympathetic pathway of the ethmoid and sphenoid sinuses) [8].

Bilateral intussusception of the nasal mucosa posteriorly, in the direction of the sphenoid bone, is said to be the initial process of sphenoid sinus development, occurring around the 3rd–4th month of gestation [14, 35]. They resemble recesses (i.e. sphenopalatine recesses) and correspond to the later sphenoid sinus' ostia. The sphenoid sinuses can be noted in the neonates, having approximately 2 mm in dimension [9]. Nonetheless, their pneumatization is initiated in the postnatal life, roughly around the 3rd–4th year, and terminates following the puberty, around the 12th–16th year of life [36].

The presphenoidal area is the primary site of pneumatization of the sphenoid sinuses that in due time extends towards the anterior wall of the clivus, at the basisphenoidal area [9]. When a person reaches puberty, their sphenoid sinuses are said to be fully and properly developed; however, the process of pneumatization might advance outside the body of the sphenoid thus creating recesses of the sphenoid sinus in some individuals [3]. In their recent study, Jaworek-Troć et al. [21] have found that only in 18/296 patients studied via the computed tomography (CT) there were no recesses present. It is said that the pneumatization of the sphenoid sinuses terminates in the third decade of life of a human, what might be related to the potential aeration of the sphenoid bone even more posteriorly, towards the basis of the occipital bone that coincides with ossification of the sphenoid-occipital synchondrosis (approximately at the 20th year of age) [36]. Agenesis of the sphenoid sinuses is a situation in which the said anatomical entities do not develop in an individual.

The aim for the current study was to evaluate the prevalence of the agenesis of sphenoid sinuses, as well as single sphenoid sinuses, among Polish adult population and to probe for potential heterogeneity of the results in terms of gender.

MATERIALS AND METHODS

A total of 300 patients (150 females, 150 males) were included in this retrospective analysis of CT

evaluation of paranasal sinuses, conducted at the Department of Medical Imaging, University Hospital in Krakow, Poland. Only patients over 18 years of age with no identifiable pathology in the sphenoid sinuses were deemed eligible for this study. Any head trauma or a surgical intervention in the nasal, orbital or cranial basis region excluded patients from the research group.

A spiral CT scanner (Siemens Somatom Sensation 16) was utilised in a standard procedure, in the option Siemens CARE Dose 4D, in order to obtain images of the paranasal sinuses. No contrast medium was administered to any of the patients. Images in the frontal and sagittal planes were obtained with the secondary reconstruction tool (multiplans reconstruction) from the images in the transverse plane. The medical images were processed with the help of Siemens Volume Wizard diagnostic station.

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. For this type of study, formal consent is not required.

Statistical analysis

STATISTICA version 13.3 by TIBCO Software Inc.® was used for the statistical analysis in the current study. Fisher's exact test applied whilst probing for potential differences between the agenesis of the sphenoid sinuses and gender. Value of $p < 0.05$ was regarded as statistically significant.

RESULTS

The agenesis of the sphenoid sinuses was noted in 3 patients (2 females, 1 male) in the total research group of 300 patients (150 females, 150 males).

No statistically significant differences were found between the agenesis of the sphenoid sinuses and gender ($p = 0.999$, Fisher's exact test). Henceforth, the proportion of developed sphenoid sinuses and their agenesis is approximately similar in both sexes. The prevalence of fully developed sphenoid sinuses was approximately 99% for both the female and male research groups (Figs. 1–3, Table 1).

A single sphenoid sinus (with no visible main septum dividing the sinus into two antra) was found only

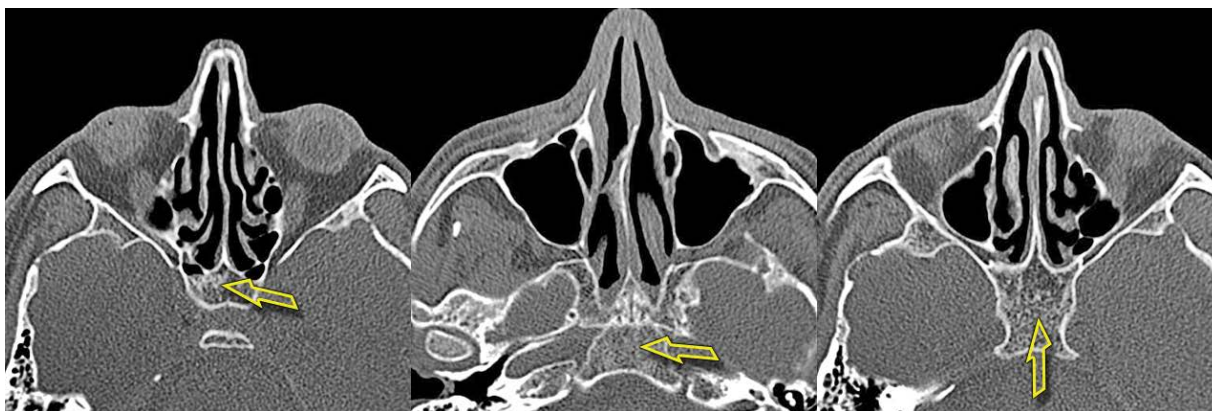


Figure 1. A computed tomography scan of the paranasal sinuses, three sequential images in the transverse plane, taken in a single patient, showing agenesis of the sphenoid sinuses.



Figure 2. A computed tomography scan of the paranasal sinuses, an image in the sagittal plane. The arrow shows no pneumatisation of the body of the sphenoid bone — agenesis of the sphenoid sinuses.



Figure 3. A computed tomography scan of the paranasal sinuses, an image in the frontal plane. The arrow shows no pneumatisation of the body of the sphenoid bone — agenesis of the sphenoid sinuses.

Table 1. Prevalence of the agenesis of the sphenoid sinuses

	F	F%	M	M%	F + M	F + M%
Agenetic SS	2	1.33%	1	0.67%	3	1%
Developed SS	148	98.67%	149	99.33%	297	99%

Agenetic SS — agenesis of the sphenoid sinuses; Developed SS — fully developed sphenoid sinuses; F — number of females; F% — the percentage of females; M — number of males; M% — the percentage of males

in 1 female patient (0.33% of all the patients). Fully developed sphenoid sinuses (i.e. having at least two antra) were noted in 296 (99.68%) patients. No statistically significant differences were found between the presence of a single sphenoid sinus or at least two sinuses and gender ($p = 0.498$, Fisher's exact test) (Figs. 4, 5).

DISCUSSION

In the current study, agenesis of the sphenoid sinus was found in 3 (1%) patients in the whole research material of 300 patients.

Earwaker [11] has estimated the frequency of prevalence of undeveloped sphenoid sinuses as 1.625% (13/800) in his CT study of paranasal sinuses, but the research group studied comprised also children (the age range of the patients studied was 12–81). Lower prevalence of the sphenoid sinus agenesis was found by Cakur et al. [7] who estimated it to be approximately 0.26%. The population studied involved patients of Turkish origins.

Different results were obtained by Aydinlioglu and Erdem [5] who did not find any cases of sphenoid sinus agenesis in their research group of 1526 patients (conducted on the CT scans). The said differ-

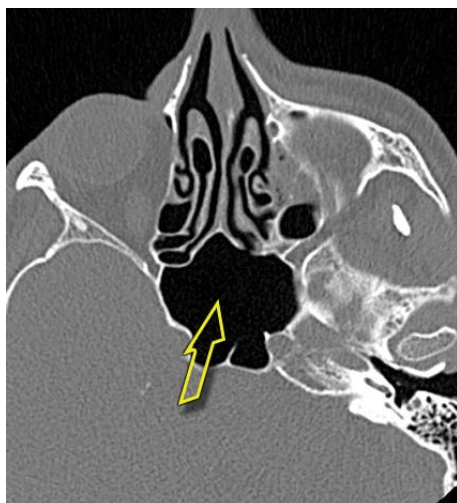


Figure 4. A computed tomography scan of the paranasal sinuses, an image in the transverse plane. A single sphenoid sinus — the main septum is absent.

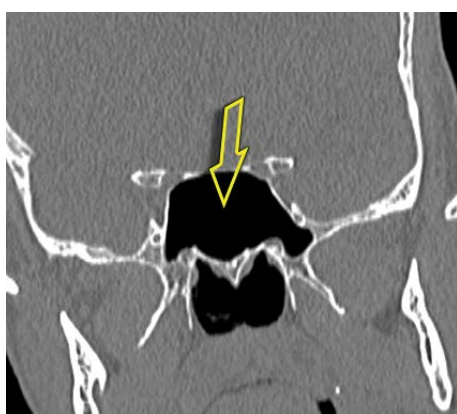


Figure 5. A computed tomography scan of the paranasal sinuses, an image in the frontal plane. A single sphenoid sinus — the main septum is absent.

Table 2. Prevalence of the agenesis of the sphenoid sinuses in the available literature

Authors (materials and methods)	Agenesis of the sphenoid sinuses
Earwaker (800 CT scans)	1.625%
Çakur et al. (384 DVCT scans)	0.26%
Aydinlioglu and Erdem (1526 CT scans)	0%
Yune et al. (–)	?
Anik et al. (–)	?
Haktanir et al. (–)	?
Degirmenci et al. (–)	?
Jaworek-Troć et al. (300 CT scans)	1%

? — the authors were aware of the said variant, but did not provide a specific numerical value; CT — computed tomography; DVCT — dental volumetric computed tomography

ences might possibly be put down to the population studied — the patients originated from Turkey. Yune et al. [37], Anik et al. [2], Haktanir et al. [16] and Degirmenci et al. [9] state that the sphenoid sinus agenesis is a rare finding, but provide no specific details on the matter (Table 2).

The present research did not find any statistically significant differences between gender and agenesis of the sphenoid sinuses ($p = 0.999$). Furthermore, this aspect was not previously investigated by other authors who have identified the aforementioned variant [7, 11]. Nonetheless, the presence of this variant is rare (1% in the current study) what might account for the lack of the observed differences that ought to be better addressed in studies involving bigger number of patients (counting possibly in thousands).

As shown in the present study, the sphenoid sinus is typically divided by at least one septum into 2 or more antra, whilst the presence of a single developed sphenoid sinus (with the main septum absent) was noted in 0.33% of all the patients.

Similar prevalence of a single sphenoid sinus was stated by Aydinlioglu and Erdem [5] — 0.13% (2/1526); however, one of their patients was under 18 years of age (they were 16 years old). Seddighi et al. [29] (in their research group of 64 CT and magnetic resonance imaging [MRI scans]), Abdullah et al. [1] (70 CT scans), and Tan and Ong [33] (cadaveric and endoscopic study of 48 human skulls) did not find a single case of absence of the main septum, which might possibly be put down to the limited number of the sinuses studied. Likewise, Hammer and Radberg [18] state the presence of at least one septum in 100%, which might be related to the diagnostic method used (120 skulls evaluated in X-ray and CT and 103 X-ray images). Battal et al. [6] found the frequency of the absence of the main septum of around 1.3%, but the study group included patients with the conchal (foetal) type of pneumatization (3 patients), as well as 1 patient in whom not a single septum was noted.

Slightly higher prevalence of a single sphenoid sinus was noted by Dündar et al. [10] — 2.2% (5/218) and Kapur et al. [28] — 2%. Hamid et al. [17] state even higher frequency of the said variant — 10.8% (32/296). The aforementioned differences might possibly be attributed to the research group studied (all the patients suffered from pituitary adenoma), as

Table 3. Prevalence of a single sphenoid sinus

Author (materials and methods)	Single sphenoid sinus: no main septum present
Aydinlioglu and Erdem (1526 CT)	0.13%
Seddighi et al. (64 CT and MRI)	0%
Abdullah et al. (70 CT)	0%
Tan and Ong (48 skulls, endoscopic and cadaveric study)	0%
Hammer and Radberg (120 skull X-ray and CT images and 103 X-ray images)	0%
Battal et al. (314 angio-CT)	1.3%
Dündar et al. (218 CT)	2.2%
Kapur et al. (200 CT)	2%
Hamid et al. (296 CT and MRI)	10.8%
Awadalla et al. (Gr. A: 25 skulls, cadaveric study)	16%
Awadalla et al. (Gr. B: 364 CT and/or MRI)	13%
ELKammash et al. (182 CT and MRI)	13.2%
Jaworek-Troć et al. (300 CT)	0.33%

CT — computed tomography; MRI — magnetic resonance imaging

well as the ethnicity of the patients (all patients were of Egyptian origin). Yet higher results were found by Awadalla et al. [4], noted for the two different study groups: group A — cadaveric evaluation of 25 skulls (the main septum was absent in 16%) and group B — radiologic evaluation (CT and/or MRI) of 364 patients (the main septum was absent in 13%). The said results pertain to the people of Egyptian origin and are akin to the one provided by Hamid et al. [17] for the same ethnic group. Moreover, ELKammash et al. [13] also studied the same population (182 CT and MRI scans in the Egyptians) and determined the main septum to be absent in 13.2% (Table 3).

Similarly to the agenesis of the sphenoid sinuses, there were no statistically significant differences between gender and prevalence of a single sphenoid sinus found in the present study ($p = 0.498$). Battal et al. [6] did not find any statistically significant differences between the numbers of septa and gender overall; however, they did not specify it for the single sphenoid sinus variant only. Likewise, it is possible that studies conducted on a larger sample of patients (counting in thousands) could potentially point towards the sex predilection of the said variant, as its prevalence is rare (0.33% in the current study).

Undoubtedly, adequate level of pneumatization of the sphenoid sinuses is crucial in order to perform the transnasal transsphenoidal approach for the pituitary

surgery. Should agenesis of the sinuses or the conchal (foetal) type of aeration be present, the said surgical approach might prove troublesome and posing a higher risk to the patient, as it would require drilling through the bone, potentially leading to iatrogenic injuries to the nearby neurovascular structures [5]. Nonetheless, extensive pneumatization of the sphenoid sinuses could also make the procedure prone to iatrogenic complications, but definitely facilitates surgical access [21]. There are reports in the available literature of agenesis and/or hypoplasia of a few paranasal sinuses in a single patient [15, 16, 30]; however, those are single cases and more large-scale studies ought to be performed in order to confirm or reject their potential association. Virtual dissection tables might become the future of anatomic evaluation of more complex variants [32], but conventional methods of imaging of the sphenoidal region still finds its use in orthodontics [31].

Aydinlioglu et al. [5] performed a study in 1,526 patients, presenting with a headache or undergoing diagnostic tests for possible sinusitis. We would like to acknowledge the aforementioned authors in saying that due to the agenesis of sphenoid sinuses being a rare variant, attributing its presence to extensive experience of symptoms (such as headache, infections) is yet to be determined on a larger and more varied group of patients [5].

In 2 out of 3 cases reported by Degirmenci et al. [9], sinusitis of different paranasal sinuses was found in addition to the agenesis of the sphenoid sinuses. It raises a question to the level of insufficiency of the ostiomeatal complex caused by the absence of sphenoid sinuses, and the subject definitely requires further research.

Eggesbø et al. [12] concluded that for the cystic fibrosis patients the pneumatization of the sphenoid sinuses does not reach beyond the presphenoidal area, and medical professionals who have found the aeration in the basisphenoidal area ought to reconsider the diagnosis of cystic fibrosis. Nonetheless, the said authors did not find any agenesis of the sphenoid sinuses neither in the study group, nor the controls [12]. Sharma et al. [30] report a case with a bilateral agenesis of both frontal and sphenoid sinuses in a patient with Kartagener's syndrome. Whilst there is still need for more studies regarding this topic across various populations, this concept raises an interesting question whether the agenesis of the sphenoid sinuses and / or their hypoplasia is a result of the defected

cilia; hence, possibly patients with other ciliary defects ought to be included in future study groups.

CONCLUSIONS

The absence of the sphenoid sinuses is a relatively rare variant, found in approximately 1%. A single sphenoid sinus, with the main septum absent, was noted only in 0.33% of the patients. Acquaintance with those variants (however rare) is of dire importance to medical professionals performing transsphenoidal surgical procedures. Nonetheless, there is still need for new reliable, large-scale studies that would attempt to correlate the agenesis of the sphenoid sinuses with potential clinical symptoms, as well as look into the potential cause and effect of ciliary defects.

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Conflict of interest: None declared

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