ORIGINAL ARTICLE

The dimensions of the sphenoid sinuses: evaluation before the functional endoscopic sinus surgery

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Background: The following study aimed to evaluate the dimensions (anteroposterior, transverse and vertical) of the sphenoid sinuses in the adult population.
Materials and methods: The study was conducted as a retrospective analysis of the computed tomography (CT) scans of the paranasal sinuses of 296 patients (147 females and 149 males), who did not present any pathology in the sphenoid sinuses. The CT scans of the paranasal sinuses were done with the spiral CT scanner, without using any contrast medium. After obtaining transverse planes, frontal and sagittal planes were created using secondary reconstruction tool.
Results: The anteroposterior dimension was found to be 2.65 cm on average, in the range of 0.5–4.3 cm. The transverse dimension was on average 1.98 cm, ranging from 0.5 cm to 4.9 cm. The average vertical dimension was found to be 2.1 cm, in the range of 0.7–3.7 cm.
Conclusions: Due to the high incidence of the anatomical variants of the paranasal sinuses, a CT scan is recommended in all patients before a planned surgery in order to avoid the potential iatrogenic complications. Dimensions of the sphenoid sinuses might point towards more at risk variants, but there is still a substantial amount of research that needs to be done in that aspect. (Folia Morphol 2021; 80, 2: 275–282)

Key words: sphenoid sinus, anatomy, dimensions, functional endoscopic sinus surgery

INTRODUCTION

Sphenoid sinuses are located in the diaphysis of the sphenoid bone. They are air-filled spaces that are lined up with mucous membrane. There is a high incidence of variance in their size, shape, the number of the septa present and the extent of their filling with air [9, 10, 12].

A surgeon, before carrying out an invasive procedure in the paranasal sinuses, has to take into account the adjoining structures (nervous and vascular) that are next to the walls of the sphenoid sinuses. It is crucial to evaluate the anatomical parameters of the sinuses ahead of the planned surgery (including endoscopy), as to minimise the surgical risk and avoid complications that might arise during the procedure [1, 6, 8, 11, 13, 14, 17–20, 22].

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A clear-cut image of the osseous structures of the paranasal sinuses can be obtained by the computed tomography (CT), which is regarded as one of the most accurate methods of imaging of the sinuses (it allows for a distinction between the anatomical variants of the sinuses).

Recently it has been possible to notice the advancement of the functional endoscopic sinus surgery (FESS) [3, 4]. The minor number of the classical extensive surgeries of the paranasal sinuses still carried out was obtained thanks to the minimally invasive endoscopic procedures.

In the surgical treatment of the chronic paranasal sinusitis, the FESS is commonly regarded as a method of choice. In comparison to classical surgeries, endoscopic techniques allow for a better insight into the otherwise difficult to assess places, cause less collateral damage during the operation and facilitate a shorter recovery period for the patients [6, 15].

MATERIALS AND METHODS

Two hundred ninety-six patients (n = 296; 147 females, 149 males) were referred to the Department of Medical Imaging of the University Hospital in Krakow, Poland. People over 18 years of age, without any visible/confirmed pathology in the sphenoid sinuses, were included in this retrospective analysis of the paranasal sinuses CT scans. The patients who suffered from a head injury or underwent a surgical procedure involving nasal, orbital, or cranial basis regions were excluded from the study.

Standard procedure in the option Siemens CARE Dose 4D applied while obtaining the CT scans of the paranasal sinuses, using spiral CT scanner (Siemens Somatom Sensation 16). No contrast medium was given to the patients. Sagittal and frontal planes were obtained by using the multiplanar reconstruction (MPR) tool, after the images of transverse planes were taken. Siemens Volume Wizard diagnostic station was used in order to evaluate the data.

The analysis of the obtained images involved the three dimensions of each of the sphenoid sinuses studied: anteroposterior (in the longest part of the sinuses), transverse (in the widest part of the sinuses) and vertical dimensions (in the highest part of the sinuses).

RESULTS

The anteroposterior dimension was on average 2.65 cm (2.6 cm in females, 2.7 cm in males), in the range of 0.5–4.3 cm (0.5–4.2 cm in females, 0.6–4.3 cm in males). The smallest anteroposterior dimension of the right sphenoid sinuses noted was 0.6 cm (1 cm in females, 0.6 cm in males), and 0.5 cm of the left sphenoid sinuses (0.5 cm in females, 0.8 cm in males). On the other side, the biggest anteroposterior dimension of the right sphenoid sinuses was 4.1 cm (4 cm in females, 4.1 cm in males), and 4.3 cm of the left sphenoid sinuses (4.2 cm in females, 4.3 in males).

The median value of the anteroposterior dimension of the female sphenoid sinuses (2.55 cm; 2.25––2.9 cm) was significantly different from the median value of the same dimension in the males (2.8 cm; 2.4–3.1 cm; p = 0.001, Mann-Whitney's test). Moreover, there was a significant variation found between the median value of the anteroposterior dimension of the right sphenoid sinuses in females (2.7 cm; 2.05–3.0 cm) and males (2.8 cm; 2.2–3.2 cm; p = 0.021, Mann-Whitney's test). Similarly, the median value of the anteroposterior dimension of the left sphenoid sinuses in females (2.7 cm; 2.1–3.0 cm) was significantly different to the one in males (2.9 cm; 2.3–3.4 cm; p = 0.005, Manna-Whitney's test).

Rarely there were sphenoid sinuses found that would have the same anteroposterior dimension — they were noted only in 17 patients (12 females, 5 males).

No statistically significant differences were found between the prevalence of the different/equal anteroposterior dimension of the right and left sphenoid sinuses in females and males (p = 0.075, χ^2 test). In both males and females the different dimension of the right and left sphenoid sinuses comprised over 90% of the cases (Tables 1, 2, Fig. 1).

The transverse dimension was 1.98 cm on average (1.85 cm in females, 2.1 cm in males), in the range of 0.5–4.9 cm (0.7–3.7 cm in females, 0.5–4.9 cm in males). The smallest transverse dimension of the right sphenoid sinuses was 0.5 cm (0.7 cm in females, 0.5 cm in males), and 0.8 cm in the case of the left sinuses (0.9 cm in females, 0.8 cm in males). On the other side, the biggest transverse dimension of the right sphenoid sinuses was 4.9 cm (3.2 cm in females, 4.9 cm in males), and 4.6 cm of the left sinuses (3.7 cm in females, 4.6 cm in males).

The median value of the transverse dimension of the female sphenoid sinuses (1.75 cm; 1.6–2 cm) was significantly different to the one of males (2 cm; 1.75–2.4 cm; p = 0.001, Mann-Whitney's test). Moreover, there was a significant variation between

Table 1. The anteroposterior dimensions of the sphenoid sinuses in centimetre

The anteroposterior dimension	Females	Males	Total
Overall			
Mean ± standard deviation	2.6 ± 0.52	2.75 ± 0.54	2.65 ± 0.54
Median (Q_1–Q_3)	2.55 (2.25–2.9)	2.8 (2.4–3.1)	2.7 (2.35–3)
Minimum–maximum	0.5–4.3	0.6–4.3	0.5–4.3
Right sphenoid sinus			
Mean ± standard deviation	2.56 ± 0.65	2.71 ± 0.72	2.63 ± 0.69
Median (Q_1–Q_3)	2.7 (2.05–3.0)	2.8 (2.2–3.2)	2.7 (2.175–3.2)
Minimum–maximum	1–4	0.6–4.1	0.6–4.1
Left sphenoid sinus			
Mean ± standard deviation	2.55 ± 0.72	2.79 ± 0.78	2.67 ± 0.76
Median (Q_1–Q_3)	2.7 (2.1–3.0)	2.9 (2.3–3.4)	2.8 (2.2–3.2)
Minimum–maximum	0.5–4.3	0.8–4.3	0.5–4.3

Table 2. The prevalence of the different/equal anteroposterior (AP) dimensions of the right and left sphenoid sinuses

	F	F%	M	M%	F + M	F + M%
AP RSS≠LSS	135	91.84%	144	96.64%	279	94.26%
AP RSS=LSS	12	8.16%	5	3.36%	17	5.74%

RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different anteroposterior dimensions; RSS=LSS — equal anteroposterior dimensions; F — females, F% — the percentage of females, M — males; M% — the percentage of males

Figure 1. A computed tomography scan of the paranasal sinuses, transverse plane. The measurement method of the anteroposterior dimensions of the right and left sphenoid sinuses.

the median value of the transverse dimension of the right sphenoid sinuses in females (1.8 cm; 1.5–2.1 cm) and males (1.9 cm; 1.5–2.4 cm; p = 0.031, Mann-Whit-ney's test). Similarly, the median value of the transverse dimension of the left sphenoid sinuses in females (1.7 cm; 1.5–2.3 cm) differed significantly from the one in males (2.1 cm; 1.7–2.7 cm; p < 0.001, Mann-Whitney's test).

Likewise in the case of this dimension there were not many sinuses with equal transverse dimensions found — such situation was noted only in 14 patients (7 females, 7 males).

No statistically significant relations were found between the prevalence of the different/equal transverse dimensions of the right and left sphenoid sinuses in females and males (p = 0.979, χ^2 test). In both female and male groups, the sinuses that had different transverse dimensions of the right and left sphenoid sinuses predominated (95%; Tables 3, 4, Fig. 2).

The vertical dimension was 2.1 cm on average (2 cm in females, 2.2 cm in males), in the range of 0.7–3.7 cm (0.7–3.7 cm in females, 1–3.4 cm in males). The smallest vertical dimension of the right sphenoid sinuses was 1 cm (1.1 cm in females, 1 cm in males), and 0.7 cm of the left sphenoid sinuses (0.7 cm in females, 1.1 cm in males), and the biggest vertical dimension of the right sphenoid sinuses was 3.7 cm

Table 3. The transverse dimensions of the sphenoid sinuses in centimetre

The transverse dimension	Females	Males	Total
Overall			
Mean ± standard deviation	1.85 ± 0.38	2.12 ± 0.54	1.98 ± 0.49
Median (Q_1–Q_3)	1.75 (1.6–2)	2 (1.75–2.4)	1.85 (1.65–2.15)
Minimum–maximum	0.7–3.7	0.5–4.1	0.5–4.9
Right sphenoid sinus			
Mean ± standard deviation	1.82 ± 0.48	2.04 ± 0.76	1.93 ± 0.64
Median (Q_1–Q_3)	1.8 (1.5–2.1)	1.9 (1.5–2.4)	1.8 (1.5–2.2)
Minimum–maximum	0.7–3.2	0.5–4.9	0.5–4.9
Left sphenoid sinus			
Mean ± standard deviation	1.88 ± 0.60	2.21 ± 0.75	2.05 ± 0.70
Median (Q_1–Q_3)	1.7 (1.5–2.3)	2.1 (1.7–2.7)	1.9 (1.5–2.5)
Minimum–maximum	0.9–3.7	0.8–4.6	0.8–4.6

Table 4. The prevalence of the different/equal transverse dimensions (Transv.) of the right and left sphenoid sinuses

	F	F%	M	M%	F + M	F + M%
Transv. RSS≠LSS	140	95.24%	142	95.3%	282	95.27%
Transv. RSS=LSS	7	4.76%	7	4.7%	14	4.73%

RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different transverse dimensions; RSS=LSS — equal transverse dimensions; F — females; F% — the percentage of females; M — males; M% — the percentage of males

Figure 2. A computed tomography scan of the paranasal sinuses, transverse plane. The measurement method of the transverse dimensions of the right and left sphenoid sinuses.

(3.7 cm in females, 3.4 cm in males), and 3.2 cm of the left sphenoid sinuses (3.1 cm in females, 3.2 cm in males).

The median value of the vertical dimension of the female sphenoid sinuses (2 cm; 1.85–2.2 cm) was significantly different from the ones of males (2.2 cm; 1.95–2.45 cm; p = 0.001, Mann-Whitney's test). Moreover, there was a significant difference between the median values of the vertical dimension of the right sphenoid sinuses in females (2.1 cm; 1.8–2.3 cm) and males (2.2 cm; 1.9–2.5 cm; p = 0.002, Mann-Whitney's test). Similarly, the median value of the vertical dimension of the left sphenoid sinuses in females (2 cm; 1.7–2.25 cm) differed significantly from the one of males (2.2 cm; 1.9–2.5 cm; p < 0.001, Mann-Whitney's test).

Likewise in the case of this dimension, there were not many sinuses with equal vertical dimensions — such situation was noted only in 24 patients (12 females, 12 males).

No statistically significant relations were found between the prevalence of the different/equal vertical dimensions of the right and left sphenoid sinuses in females and males (p = 0.972, χ^2 test). In both female and male groups the sphenoid sinuses with varied vertical dimensions predominated (92%; Tables 5, 6, Fig. 3).

Table 5. The vertical dimensions of the sphenoid sinuses in centimetre

The vertical dimension	Females	Males	Total
Overall			
Mean ± standard deviation	2.02 ± 0.31	2.21 ± 0.31	2.12 ± 0.35
Median (Q_1–Q_3)	2 (1.85–2.2)	2.2 (1.95–2.45)	2.1 (1.9–2.3)
Minimum–maximum	0.7–3.7	1.0–3.4	0.7–3.7
Right sphenoid sinus			
Mean ± standard deviation	2.05 ± 0.39	2.2 ± 0.49	2.125 ± 0.44
Median (Q_1–Q_3)	2.1 (1.8–2.3)	2.2 (1.9–2.5)	2.1 (1.8–2.4)
Minimum–maximum	1.1–3.7	1–3.4	1–3.7
Left sphenoid sinus			
Mean ± standard deviation	1.99 ± 0.40	2.23 ± 0.42	2.11 ± 0.43
Median (Q_1–Q_3)	2 (1.7–2.25)	2.2 (1.9–2.5)	2.1 (1.8–2.4)
Minimum–maximum	0.7–3.1	1.1–3.2	0.7–3.2

Table 6. The prevalence of the different/equal vertical dimensions (Vert.) of the right and left sphenoid sinuses

	F	F%	M	M%	F + M	F + M%
Vert. RSS≠LSS	135	91.84%	137	91.95%	272	91.89%
Vert. RSS=LSS	12	8.16%	12	8.05%	24	8.11%

RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different vertical dimensions; RSS=LSS — equal vertical dimensions; F — females; F% — the percentage of females; M — males; M% — the percentage of males

Figure 3. A computed tomography scan of the paranasal sinuses, frontal plane. The measurement method of the vertical dimensions of the right and left sphenoid sinuses.

DISCUSSION

The average dimensions of the sphenoid sinuses did not differ significantly amongst the genders.

The anteroposterior dimension was 2.65 cm on average, in the range of 0.5–4.3 cm. The different anteroposterior dimension of the two sphenoid sinuses in one patient was the most prevalent variant — 94.26% of the patients.

Similar results were obtained by Mutlu et al. [18], who found the anteroposterior dimension to be 2.76 cm on average (ranging from 1.07 to 4.17 cm), and Sareen et al. [20], who determined it to be 2.5 cm on average (in the range of 1.3–3.4 cm).

Elwany et al. [5] provided the following data for the anteroposterior dimension of the sphenoid sinuses: the mean of 1.6 cm (the presellar type) and 3.1 cm (the postsellar type), the smallest 1.2 cm (the presellar type) and 2.6 cm (the postsellar type), as well as the biggest 1.8 cm (the presellar type) and 3.9 cm (the postsellar type). On the other hand, Stokovic et al. [21] evaluated the average anteroposterior dimension to be 1.66 cm (in the range of 0.65–3.45 cm) (Table 7).

The transverse dimension was 1.98 cm on average, in the range of 0.5–4.9 cm. The different anteroposterior dimensions of the two sphenoid sinuses in one patient was the most prevalent variant — 95.27% of the patients (95.24% of females, 95.3% of males).

Table 7. The reported anteroposterior dimensions of the sphenoid sinuses (cm)

Author (material and methods)	The mean	The smallest	The biggest	RSS=LSS	RSS≠LSS
Mutlu et al. (69 HRCT)	2.76	1.07	4.17	-	-
Sareen et al. (20 skulls, dissection study)	2.5	1.3	3.4	-	-
Elwany et al. 1983 (100 X-rays, 100 skulls X-rayed, 50 skulls — dissection study)	1.6/3.1	1.2/2.6	1.8/3.9	-	-
Stokovic et al. (51 skulls CBCT)	1.66	0.65	3.45	-	-
Jaworek-Troć et al. (296 CT scans)	2.65	0.5	4.3	5.74%	94.26%

CT — computed tomography; CBCT — cone-beam computed tomography; HRCT — high-resolution CT; RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different anteroposterior dimensions; RSS=LSS — equal anteroposterior dimensions

Table 8. The reported transverse dimensions of the sphenoid sinuses (cm)

Author (material and methods)	The mean	The smallest	The biggest	RSS=LSS	RSS≠LSS
Mutlu et al. (69 HRCT)	3.18	2.13	5.54	-	-
Elwany et al. 1983 (100 X-rays, 100 skulls X-rayed, 50 skulls — dissection study)	1.2/1.9	0.7/1.4	1.4/2.4	-	-
Stokovic et al. (51 skulls CBCT)	1.43	0.55	3.5	-	-
Jaworek-Troć et al. (296 CT scans)	1.98	0.5	4.9	4.73%	95.27%

CT — computed tomography; CBCT — cone-beam computed tomography; HRCT — high-resolution CT; RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different transverse dimensions; RSS=LSS — equal transverse dimensions

Table 9. The reported vertical dimensions of the sphenoid sinuses (cm)

Author (material and methods)	The mean	The smallest	The biggest	RSS=LSS	RSS≠LSS
Sareen et al. (20 skulls, dissection study)	2.2	1.4	3.6		
Awadalla et al. (25 skulls, dissection study and 364 CT and/or MRI scans)	1.89			-	-
Elwany et al. 1983 (100 X-rays, 100 skulls X-rayed, 50 skulls — dissection study)	1.4/2.6	1.0/2.4	1.6/2.9	-	-
Stokovic et al. (51 skulls CBCT)	1.71	0.96	3.25	-	-
Jaworek-Troć et al. (296 CT scans)	2.1	0.7	3.7	8.11%	91.89%

CT — computed tomography; CBCT — cone-beam computed tomography; HRCT — high-resolution CT; MRI — magnetic resonance imaging; RSS — right sphenoid sinus; LSS — left sphenoid sinus; RSS≠LSS — different vertical dimensions; RSS=LSS — equal vertical dimensions

Mutlu et al. [18] obtained similar results, evaluating the mean transverse dimension of the right and left sphenoid sinuses as 3.18 cm (in the range of 2.13–5.54 cm). However, the aforementioned researchers provided the total dimension of the both sinuses (combining the measurement of the right and left sphenoid sinuses).

Elwany et al. [5] provided the following transverse dimensions of the sphenoid sinuses: the mean of 1.2 cm (the presellar type) and 1.9 cm (the postsellar type), the smallest 0.7 cm (the presellar type) and 1.4 cm (the postsellar type) and the biggest 1.4 cm (the presellar type) and 2.4 cm (the postsellar type). On the other hand, Stokovic et al. [21] estimated the average transverse dimension as 1.43 cm (ranging from 0.55 to 3.5 cm) (Table 8).

The vertical dimension was 2.1 cm on average, in the range of 0.7–3.7 cm. The different vertical dimensions in one patient was the most often variant — in 91.89% of the patients (91.84% females, 91.95% males).

Similar results were obtained by Sareen et al. [20], who assessed the mean vertical dimension of the sphenoid sinuses to be 2.2 cm (ranging from 1.4 to 3.6 cm).

Awadalla et al. [2] provided a different method of measuring the sphenoid sinuses by taking the length of the sinuses in their superior (the mean length was 13.9 mm) and inferior parts (the mean length was 25.9 mm), as well as the height in their anterior (the mean height was 18.9 mm) and posterior parts (the mean height was 12.1 mm). The mean height obtained by the aforementioned scientists in the

anterior part of the sinuses is akin to the average vertical dimension obtained in the present study. The discrepancies may be due to the method of measuring the dimensions of the sphenoid sinuses.

Elwany et al. [5] reported the following data for the vertical dimensions of the sphenoid sinuses: the mean of 1.4 cm (the presellar type) and 2.6 cm (the postsellar type), the smallest 1.0 cm (the presellar type) and 2.4 cm (the postsellar type), as well as the biggest 1.6 cm (the presellar type) and 2.9 cm (the postsellar type). On the other hand, Stokovic et al. [21] evaluated the average vertical dimension of the sphenoid sinuses to be 1.71 cm (ranging from 0.96 to 2.5 cm) (Table 9).

Lupascu et al. [16] evaluated the mean dimensions of the sphenoid sinuses as 24/20.5/ /18 mm (23.4/22.1/19.2 mm for the male group and 24.5/18.6/17.1 mm for the female group), but they did not provide the methods or the information to which dimension the obtained data applies.

The size of the sphenoid sinuses can be a predictor of the thickness of its walls, as suggested by Elwany et al. [5] who noted an inverse correlation between them, i.e. the bigger the sinus, the thinner its walls. That fact is of immense importance, as there is a higher risk of iatrogenic injuries done to the neighbouring critical neurovascular structures, namely the carotid artery or the optic nerve, when the walls of the sphenoid sinus are thinner [5]. The aforementioned authors have also found that the intercarotid distance was 4–9 mm shorter than the transverse dimension of the sinus, possibly allowing to pinpoint the location of the carotid arteries without any carotid dehiscence visible within the lumen of the sinus during the surgery [5].

Furthermore, there are studies that have found a correlation between the presence of the protrusion of the carotid canal or the optic nerve into the lumen of the sphenoid sinus and its type or dimensions [7, 21]. Stokovic et al. [21] noticed that in the case of the sellar type of the sinuses, chance of it being of "high risk" (defined as "pneumatisation extensions to all parts of the sphenoid and protrusions of all neurovascular structures," i.e. the maxillary nerve, pterygoid nerve, optic nerve and internal carotid artery) increased with its dimensions. The aforementioned authors have divided it further into three subcategories: a) the first one with high probabilities of pterygoid process pneumatisation and optic and pterygoid nerve protru-

sions increased with sinus' height; b) the second one with high probabilities of pterygoid process and greater wings pneumatisation and maxillary nerve protrusions associated with width; c) and the third one with contra- and ipsi-lateral internal carotid protrusion with higher odds in the postsellar type and with greater sinus' length [21]. Notwithstanding, the authors themselves state that more research should be carried out due to the limited sample they had (51 skulls).

CONCLUSIONS

As pointed by our analysis, the anteroposterior dimension was on average 2.65 cm, the transverse dimension 1.98 cm, and the vertical dimension 2.1 cm. The great variance in the anatomy of the paranasal sinuses may complicate the surgical procedures undertaken in the aforementioned region. Knowledge of the dimensions of the sphenoid sinuses might point towards a higher chance of various neurovascular structures protrusion that might not be noted on standard imaging. Nonetheless, there is still a need of further research in this aspect that might hopefully prove useful in avoiding iatrogenic injuries to critical neurovascular structures surrounding the sphenoid sinuses. As such a study has not yet been conducted in the Polish population, we aimed to present the up-to-date representation of sphenoid sinuses' dimensions combined with deductions of other, referenced here authors, in furtherance of diminishing the number of iatrogenic complications in the meantime.

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