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A computed tomography comprehensive evaluation of the ostium of the sphenoid sinus and its clinical significance

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Background: *The purpose of this research was to evaluate the size of the sphenoid sinuses' ostia, the distance between them and the distance between the medial margin of the ostia and the median line in the Polish adult population.*

Materials and methods: *The analysis was undertaken as a retrospective study of 296 computed tomography (CT) scans of patients (147 females, 149 males) with no comorbidities in their sphenoid sinuses. The paranasal sinuses were investigated by using Spiral CT Scanner (Siemens Somatom Sensation 16), in the option Siemens CARE Dose 4D, without administering any contrast medium. Having obtained transverse planes, multiplans reconstruction tool was used in order to glean sagittal and frontal planes.*

Results: *The average size of both sphenoid sinus ostia was 0.31 cm for both genders (for females ranging from 0.1 to 0.5 cm and from 0.1 to 0.6 cm for males). The mean distance between both sphenoid sinus ostia was 0.6 cm for both genders (the range for females was 0.1–1.4 cm, whereas 0.1–1.8 cm for males). The average distance between the medial margin of the ostium and the median line was 0.32 cm for both genders (0.31 cm for females in the range of 0–0.9 cm and 0.32 cm for males in the range of 0–1 cm).*

Conclusions: *Intraoperative identification of the sphenoid sinus ostia might prove difficult and their inadequate excision could lead to potential iatrogenic complications, hence detailed anatomical descriptions are still warranted in specific populations in order to perform safe and effective procedures.* (Folia Morphol 2022; 81, 3: 694–700)

Key words: sphenoid sinus, sphenoid sinus ostium, anatomy

INTRODUCTION

The paranasal sinuses are pneumatic spaces that form a part of the upper respiratory tract and comprise of namely the sphenoid sinuses (typically two) that are of immense importance for trans-sphenoidal endoscopic or microscopic surgical approaches. Their

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development is initiated by the intussusception of the nasal mucosa towards the sphenoid [7, 24], extending the sphenoethmoidal recess posteriorly towards the skull base [17] thus in exchange allowing for a communication between them. Migration of the connective tissue into the viscerocranium is the secondary stage of sphenoid sinus aeration [17].

Notwithstanding, the sphenoid sinuses are to date assessed from every possible angle due to their vastly complicated and varied anatomy. Some of the most recognizable variants include their dimensions, extensive pneumatisation and hence presence of recesses, as well as relation to the neighboring neurovascular entities, namely the internal carotid canal [10–16, 22].

When surgically approaching the sphenoid sinus, its ostium is typically found medially and inferiorly to the rim of the superior turbinate [1]. Having identified the ostium, the anterior wall of the sphenoid sinus is typically excised around the both ostia, allowing for a facilitated access into the sinus [3]. In order to perform a safe trans-sphenoidal endoscopic or microscopic procedure, it is also imperative for the surgeon to be spatially orientated about the maximum diameter of the sinus, location of the carotid canal, the optic canal and other major surrounding neurovascular entities [1, 11, 13].

This study aimed primarily to present the up-to-date morphometric assessment of the ostia of the sphenoid sinuses of Polish adult patients by the means of computed tomography (CT) imaging. The subgroup analysis was conducted in order to evaluate the possibility of existence of statistically significant differences between the particular dimensions of the ostia between males and females. To the best knowledge of the authors this is the first study that measures the distance between the medial margin of the sphenoid sinus ostia and the median line varying with laterality of the sinuses, as well as provides a comparison of the distances between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses for the right and left sides, respectively.

MATERIALS AND METHODS

A total of 359 medical images of patients referred to the Department of Medical Imaging of the University Hospital in Krakow to undergo a CT scan were accessed by the researchers. The inclusion criteria for participation in this analysis were: age of the patients over eighteen years and no pathologies present in the sphenoid sinuses. Excluded patients (63) had suffered from a head trauma or had undergone nasal, orbital or cranial basis surgery prior to the research. The inclusion criteria were met by 296 patients (147 females, 149 males).

Spiral CT scanner Siemens Somatom Sensation 16 was used in the standard procedure in the option Siemens CARE Dose 4D. None of the patients had a contrast medium administered. Having obtained the images in the transverse planes, secondary reconstruction tool was applied — multiplans reconstruction — in order to glean images in the frontal and sagittal planes. Diagnostic station Siemens Volume Wizard was used in order to analyse the obtained data.

The analysis of the obtained images involved the location and size of the sphenoid sinus ostia — in reference to the median line (the size was measured from the medial margin of the ostia to the median line). Furthermore, the distance between the right sphenoid sinus ostium and the left sphenoid sinus ostium (between the medial margins of the ostia) as well as the distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses were also studied.

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

Statistical analysis in this study was conducted with the help of STATISTICA version 13.3 by TIBCO Software Inc®. Chi^2 test, Mann-Whitney test, Wilcoxon test and Fisher's exact test were utilised whilst probing for differences between the presence of the particular recesses and gender. A statistically significant value of $p < 0.05$ was chosen for all the results.

RESULTS

The average size of both sphenoid sinus ostia was 0.31 cm for both genders (0.29 cm for females and 0.33 cm for males). Statistically significant differences were found between the mean values for the sizes of sphenoid sinus ostia in females and males ($p < 0.001$, Mann-Whitney's test; Table 1, Fig. 1).

Table 1. The sizes of the sphenoid sinus ostia (SSO) in centimetre

The size of the SSO [cm]	Females	Males	Total
Mean ± standard deviation	0.29 ± 0.09	0.33 ± 0.09	0.31 ± 0.09
Median (Q_1–Q_3)	0.3 (0.2–0.35)	0.3 (0.25–0.4)	0.3 (0.2–0.4)
Minimum–maximum	0.1–0.5	0.1–0.6	0.1–0.6

Table 2. The distance between the sphenoid sinus ostia (SSO) in centimetre

The distance between the SSO [cm]	Females	Males	Total
Mean ± standard deviation	0.62 ± 0.24	0.65 ± 0.31	0.63 ± 0.28
Median (Q_1–Q_3)	0.6 (0.4–0.8)	0.6 (0.5–0.8)	0.6 (0.4–0.8)
Minimum–maximum	0.1–1.4	0.1–1.8	0.1–1.8

Figure 1. A computed tomography scan of female paranasal sinuses, transverse plane. The measurement method of the size of the sphenoid sinus ostium (on the right side).

Figure 2. A computed tomography scan of male paranasal sinuses, transverse plane. The measurement method of the distance between two sphenoid sinus ostia.

The average distance between the both sphenoid sinus ostia was 0.63 cm for both genders (0.62 cm for females, 0.65 cm for males). The mean value for the distance between the sphenoid sinus ostia did not differ significantly between the female and male groups (p = 0.480, Mann-Whitney's test; Table 2, Fig. 2).

The average distance between the medial margin of the ostia and the median line was 0.32 cm for both genders (0.31 cm for females and 0.32 cm for males). No statistically significant differences were found between the mean values of the distances between the medial margin of the sphenoid sinus ostium and the median line of males and females (p = 0.498, Mann-Whitney test). The average aforementioned distance for the right sphenoid sinus was 0.30 cm (0.29 cm for females and 0.31 cm for males), whereas 0.33 cm for the left sphenoid sinus (0.33 cm for females and 0.34 cm for males). Statistically significant results were found between the laterality of the results for both genders (p = 0.003, Wilcoxon test) and for females (p = 0.006, Wilcoxon test). However there were no statistically significant results amongst the distance between the medial margin of the ostium and the median line for right and left male sinuses (p = 0.125, Wilcoxon test; Table 3, Fig. 3).

Equal distance between the medial margin of the sphenoid sinus ostia and the median line for both of the sinuses was found in 80 patients (41 females, 39 males), whereas different distances between the right and left sides were found in the majority of the patients — 216 (106 females, 110 males). Moreover, the ostium comprised the direct extension of the sphenoethmoidal recess in the straight line (the distance from the medial margin of the ostium to the median line was zero) in 18 patients (6 females,

Table 3. The distance between the medial margin of the sphenoid sinus ostia (SSO) and the median line in centimetre

The distance between the medial margin of the SSO and the median line [cm]	Females	Males	Total
Mean ± standard deviation	0.31 ± 0.12	0.32 ± 0.15	0.32 ± 0.14
Median (Q_1–Q_3)	0.3 (0.2–0.4)	0.3 (0.25–0.4)	0.3 (0.2–0.4)
Minimum–maximum	0–0.9	0–1	0–1

Table 4. The distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses in centimetre

The distance between the lateral margin of the sphenoid sinus ostium and the sinuses' anterolateral wall [cm]	Females	Males	Total
Mean ± standard deviation	0.90 ± 0.20	0.98 ± 0.24	0.93 ± 0.23
Median (Q_1–Q_3)	0.85 (0.75–1.00)	0.95 (0.8–1.1)	0.9 (0.8–1.05)
Minimum–maximum	0.35–1.55	0.35–1.7	0.35–1.7

Figure 3. A computed tomography scan of male paranasal sinuses, transverse plane. The measurement method of the distance between the medial margin of the sphenoid sinus ostium and the median line.

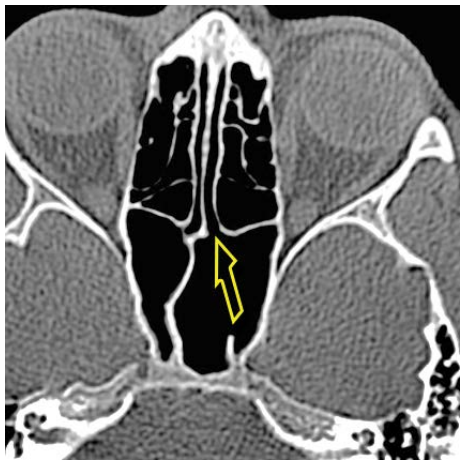

Figure 4. A computed tomography scan of female paranasal sinuses, transverse plane. The left sphenoid sinus ostium comprises the direct extension of the sphenoethmoidal recess in the straight line, as pointed by the arrow (the distance between the medial margin of the ostium and the median line is equal zero).

12 males): more frequently on the right side (12 patients: 4 females and 8 males) than on the left side (6 patients: 2 females and 4 males).

The frequency of the different/equal distances between the medial margin of the right and left sphenoid sinus ostia and the median line did not differ significantly between males and females ($p = 0.740$, χ^2 test). In both female and male groups, the different distances comprised approximately 73% of the cases.

Statistically significant differences were found between the distribution of the frequency of the distance between the medial margin of the sphenoid sinus ostia on the right or left sides and the median line equal zero ($p = 0.046$, Fisher's exact test; Fig. 4).

The average distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses was 0.9 cm for females, and 0.98 cm for males. The mean value for the distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses differed significantly between females and males ($p = 0.001$, Mann-Whitney's test; Table 4, Fig. 5).

Equal aforementioned distances for both of the sinuses were found in 64 patients (41 females, 23 males), but they were predominantly different between the right and left sides — in 232 patients (106 females, 126 males).

The frequency of the different or equal distances between the lateral margin of the right and left sphenoid sinus ostia and the anterolateral wall of the sinuses varied significantly between the female and male groups ($p = 0.009$, χ^2 test). The different

Figure 5. A computed tomography scan of male paranasal sinuses, transverse plane. The measurement method of the distance between the lateral margin of the ostium and the anterolateral wall of the sphenoid sinus.

distances were noted more often in males (126/232 cases, 54.3%), whereas the equal distances were more common in females (41/64 cases, 64.1%).

DISCUSSION

The average sizes of the sphenoid sinus ostia were equal in both genders. Moreover, they did not differ between the both sides of the main septum. They measured 0.35 cm on average in the range of 0.1–0.6 cm.

Elwany et al. [7] provided the following sizes of the sphenoid sinus ostia: the mean of 0.52 cm, the smallest 0.2 cm and the biggest 0.7 cm, but in another work they evaluated the mean size of the sinuses ostia as 0.28 cm [6]. This discrepancy may possibly be put down to the fact that in the second work the researchers stated the results only for the ostia defined by them as round in shape (that comprised 72% of all the ostia researched by them), but they did not measure the ostia that were defined as oval in shape.

The average distance between the ostia of both of the sinuses was 0.6 cm for both genders (for females in the range of 0.1–1.4 cm and 0.1–1.8 cm for males). Similar results were obtained by Mutlu et al. [18], who evaluated the mean distance between the right and left sphenoid sinus ostia as 0.8 cm (in the range of 0.13–1.5 cm).

The average distance between the medial margin of the ostium and the median line was 0.46 cm for both genders (0.45 cm for females ranging from 0 to 0.9 cm and 0.5 cm males in the range of 0–1 cm). Similar results were obtained by Elwany et al. [6] (endoscopic study of 93 cadavers), who provided the following results for the distances between the medial margin of the ostium and the median line: the average 0.52 cm, the smallest 0.14 cm and the biggest 0.88 cm. On the contrary, different results were given by Sareen et al. [19] who noted the said distances as 0.2 cm on average (in the range of 0.1–0.4 cm). Nonetheless, the aforementioned scientists only stated the distance from the ostium (not mentioning the method of measurement of the point of the ostium — the medial margin, the lateral, or the central part of the ostium).

The same distance between the medial margin of the sphenoid sinus ostia and the medial margin for both of the sinuses was found in 27.03% of the patients (27.89% females, 26.17% males), whereas they were different in the majority of the patients — 72.97% (72.11% females, 73.83% males). Furthermore, the ostium comprised the direct extension of the sphenoethmoidal recess in the straight line (the distance from the medial margin of the ostium to the median line was equal zero) in 6.08% of the patients (4.08% females, 8.05% males): more often on the right side (4.05% patients: 2.72% females, 5.37% males) than on the left side (2.03% of the patients: 1.36% females, 2.68% males). To the best knowledge of the authors, there were no studies found in the available literature regarding the measurement of the distance between the medial margin of the sphenoid sinus ostia and the median line as varying with laterality of the sinuses.

The average distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses was 0.90 cm for females, and 0.98 cm for males. In the total research group, the mean distance was 0.93 cm (ranging from 0.35 to 1.7 cm). Similar results were obtained by Mutlu et al. [18], who evaluated the average distance between the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses as 0.8 cm (in the range of 0.2–1.3 cm).

The same said distances for both of the sinuses were found in 21.62% of the patients (27.89% females, 15.44% males), whereas the distances differed between the right and left sides in the majority of the patients — in 78.38% (72.1% females, 84.56% males). To the best knowledge of the authors, there were no studies found in the available literature regarding the comparison of the distances between

the lateral margin of the sphenoid sinus ostia and the anterolateral wall of the sinuses for the right and left sides, respectively.

Identification of the sphenoid sinus ostium is one of the first steps undertaken during the trans-sphenoidal endoscopic or microscopic approach that can be achieved in two ways: by utilising anatomical landmarks close to the sinus (i.e. the sphenoethmoidal recess, upper turbinate, choanae and the sphenopalatine foramen) or by utilising landmarks located further from the sinus (namely the anterior nasal spine, the nasal floor and the nasal septum) [5]. The location of the ostium is usually close to the midline; however, it can be placed laterally to it by a few millimetres, and left and right ostia could possibly be placed on various horizontal levels [3], as shown by our analysis statistically significant for the overall and female results for the distance between the medial margin of the sphenoid sinus ostium and the median line. Henceforth, a surgeon has to be vigilant at all times and get acquainted with the possible anatomical variants, so as to avoid potential iatrogenic complications of the skull base. Excessive inferolateral excision upon the entrance to the sphenoid sinus could possibly result in damaging the sphenopalatine artery and its posterior septal branches (that lie inferiorly to the sphenoid sinus ostium) and hence iatrogenic bleeding hard to stop [8]. It is also worth noting that precise knowledge of parasympathetic innervation pathway of the sphenoid and ethmoid sinus is still poorly understood by both students and medical professionals [4].

Extensive pneumatisation of the sphenoid sinus, namely in the form of the septal recess and/or the vomeral recess, might obstruct the access towards the sphenoid sinus by constricting the sphenoethmoidal recess [2]. The aforementioned recesses were found in 8.78% and 25.34% of the patients of Polish origin, respectively [12]. Twigg et al. [23] report that they were not able to identify the ostia preoperatively on CT scans in 25% of their cases and they put it down to the fact that its dimensions might have been too small for the volume of the slices obtained by the CT. If a surgeon encounters difficulties in finding the sphenoid sinus ostium intraoperatively, they usually opt for accessing it approximately 15 mm superiorly to the choanae, or else at the crossing of the inferior 1/3 with the superior 2/3 of the superior turbinate [23].

The distance between the skull base and the ostium of the sphenoid sinus is of immense importance whilst widening the access to the sinus, especially with the cuts made superiorly. We would like to acknowledge Twigg et al. [23] in saying that the shorter the distance (the shortest distance measured by the said scientists was 2.7 mm), the higher the chance of iatrogenic injury and breaching the skull base that might lead to cerebrospinal fluid leakage and/or damage to the adjoining neurovascular and cerebral entities.

Henceforth, a detailed preoperative evaluation of the ostium of the sphenoid sinus is continuously warranted. Some of the most contemporary non-invasive methods of assessment of the sinuses might be utilizing three-dimensional CT imaging [9] or virtual dissection tables [21]. A surgeon might have a difficulty whilst attempting to find the ostium of the sphenoid sinus during a procedure and opt to use the C-arm fluoroscopy, but applying the aforementioned modern techniques might help diminish its intraoperative use [9]. CT scanning has superseded the use of lateral cephalometric radiographic evaluations, but the latter is still used in orthodontics [20].

Limitations of the study

This study has its limitations, as the only potentially confounding factor that could have influenced the results that was evaluated in this research was gender. Unfortunately, due to the scarce number of patients of a younger age (i.e. in the second, third and fourth decade of life), compared to the older participants, prevented us from reliably evaluating the potential effect of age upon the dimensions of the sphenoid sinus' ostia. Bearing in mind that the pneumatisation of the sphenoid sinuses is most commonly terminated in the third decade of life [25] it is plausible that the yet continued aeration process in patients in their 20s could lead to greater measurements if the CT scan was taken in the same person a few years later. Undoubtedly this aspect requires further research in a study that would recruit an objective proportion of patients across all ages.

CONCLUSIONS

The current study has found that the average size of both of the sphenoid sinus ostia was 0.31 cm, the average distance between them was 0.6 cm, and the average distance between the medial margin of the ostium and the median line was 0.32 cm for both genders. Intraoperative identification of the sphenoid sinus ostia might prove difficult due to the vast anatomical variety surrounding this anatomical entity

and their inadequate excision might lead to potential iatrogenic complications, hence detailed anatomical descriptions are still warranted for specific populations in order to perform safe and effective procedures.

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