FOLIA MEDICA CRACOVIENSIA
Vol. LVIII, 3, 2018: 67–81
PL ISSN 0015-5616
DOI: 10.24425/fmc.2018.125073

The total number of septa and antra in the sphenoid sinuses — evaluation before the FESS

Joanna Jaworek-Troć[1, 2], Michał Zarzecki[1], Izabela Mróz[1], Paweł Troć[2], Robert Chrzan[2], Jarosław Zawiliński[1], Jerzy Walocha[1], Andrzej Urbanik[2]

[1]Department of Anatomy, Jagiellonian University Medical College, Kraków, Poland
[2]Department of Radiology, Jagiellonian University Medical College, Kraków, Poland

Corresponding author: Jerzy Walocha, MD, PhD
Department of Anatomy, Jagiellonian University Medical College
ul. Kopernika 12, 31-034 Kraków, Poland
Phone: +48 12 422 95 11; E-mail: jwalocha@poczta.onet.pl

Abstract: Purpose: The purpose of this research is to define the total number of septa and the total number of antra in the sphenoid sinuses (created as a result of the presence of additional septa), as well as the relation between the number of the septa and their location 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 (Siemens Somatom Sensation 16) by using a standard procedure, in the option Siemens CARE Dose 4D, without using any contrast medium. After obtaining the transverse planes, the frontal and sagittal planes were created using secondary reconstruction tool (multiplans reconstruction — MPR).
Results: The analysis of the obtained images in the transverse plane and secondary CT reconstructions has shown the presence of only one sphenoid septum (main septum — MS) in 21.96% of the patients, which divided the sphenoid sinus into two sphenoid antra. In 78.04% of the patients, there were more than one sphenoid septa present in the posterior part of the sphenoid sinuses, hence there were additional septa (AS) present. One AS was present in 22.97% of the patients. The most common variant — two AS — was found in 32.09% of the cases. The presence of more than two AS was found in the following number of patients: three AS in 9.8%, four AS in 7.09%, five AS in 1.69%, six AS in 3.04% and seven AS in 1.01%. The rarest variant was the presence of more than seven AS: eight AS in 0.34% and nine AS also in 0.34%. There were no sphenoid sinuses that would have more than nine AS in the researched material.

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 complications that might arise as a result of the complicated structure of the paranasal sinuses.

Key words: main septum, additional septum, sphenoid sinus, FESS.

Introduction

Sphenoid sinuses are pneumatic spaces lined with mucous membrane, located in the diaphysis of the sphenoid bone. The sphenoid sinuses begin to develop around the 3rd–4th month of the foetal life [1, 2], as a result of a bilateral concavity of the mucous membrane of the nasal cavity posteriorly, towards the sphenoid bone. The concavity of the mucous membrane in the foetus have the form of recesses (sphenoethmoidal) and correspond to the ostia of the subsequent, fully-developed sinuses. The sphenoid sinuses are present as early as in the newborns, but they are not yet air-filled, and they do not exceed past the total size of 2 mm [3] — at this stage they are little antra (the size of a pea grain), being the extension of the sphenoethmoidal recesses. The filling in with air begins in the postnatal life [4], around the 3rd–4th year of life, and lasts until the puberty — the moment of reaching the full, definitive filling in with air is not precise and lies in the range of 12–16 years of age.

The morphology of the sinuses is characterised by a vast diversity. They vary in size, shape and number of the septa present (MS — main septum, AS — additional septum), as well as the degree of filling with the air.

The sphenoid sinuses adjoin important anatomical structures through their walls, both nervous and vascular — their neighbourhood, in addition to the anatomical arrangement of the sphenoid sinuses, is of great importance in the surgical procedures done in this region. The proper analysis of the anatomical parameters of the sphenoid sinuses is crucial before conducting a surgical procedure (including endoscopy) in order to diminish the surgical risk and avoid potential complications during the procedure [5–15].

The computed tomography (CT) is one of the most precise methods for the imaging of the paranasal sinuses. This method enables to distinguish the variations in the anatomical structures of the paranasal sinuses, due to the clear-cut representation of the osseous structures.

In the recent years, one can observe the dynamic development of the functional endoscopic sinus surgery (FESS) [16, 17]. The use of the minimally invasive endoscopic procedures decreases the number of the classical extensive surgeries of the paranasal sinuses. Since the beginning of the 1990s, the FESS method is commonly regarded as the method of choice in the surgical treatment of the chronic

inflammation of the paranasal sinuses. The endoscopic techniques allow for a good insight into the difficult to access regions, lower traumatisation and shorter period of recovery in comparison to the classical procedures [6, 18].

Materials and Methods

A retrospective analysis of the CT scans of the paranasal sinuses of 296 patients (147 females and 149 males) referred to the Department of Medical Imaging of the University Hospital in Kraków, Poland was carried out in this study. Patients over 18 years of age, who did not present any pathological changes in the sphenoid sinuses, qualified for the analysis presented in this work. The exclusion criteria for the researched group consisted also of: a head trauma, nasal or orbital cavity or cranial basis surgeries undergone in the past.

A spiral CT scanner (Siemens Somatom Sensation 16) was used to obtain the CT scans used in this study. In order to receive them, standard procedure was applied (in Siemens CARE Dose 4D option). Furthermore, no contrast medium was used. Secondary reconstruction tool (multiplans reconstruction — MPR) was used after obtaining the transverse planes, in furtherance of creating the frontal and sagittal planes. For the analysis of the graphic data, diagnostic station Siemens Volume Wizard was used.

The analysis of the obtained images involved the total number of septa and antra — the septum stretching from the anterior wall of the sphenoid sinuses to the posterior wall of the sinuses was regarded as the MS; the remaining septa were considered as the AS.

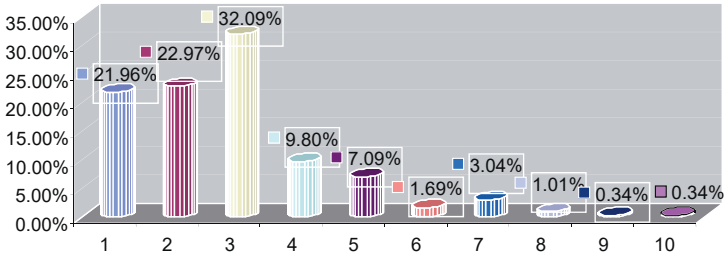
Results

The analysis of the obtained images in the transverse plane and the secondary CT reconstructions showed the presence of only one sphenoid septum in 65 patients (32 females, 33 males), that divided the sphenoid sinus into two sphenoid antra. In 231 patients, more than one sphenoid septum was found in the posterior part of the sphenoid sinuses, hence AS were present. One AS was found in 68 patients (33 females, 35 males). The most common variant — in 94 patients — was two AS (51 females, 43 males). The presence of more than two AS was noticed in the following number of patients: three AS in 29 patients (14 females, 15 males), four AS in 21 patients (13 females, 8 males), five AS in 5 patients (3 females, 2 males), six AS in 9 patients (0 females, 9 males), seven AS in 3 patients (1 female, 2 males). The rarest variant was the presence of more than seven AS: eight AS in 1 patient and nine AS also in 1 patient (in both cases it was a male). There were no sphenoid sinuses that would have more than nine AS in the researched material (Table 1, Fig. 1).

Table 1. The number of the additional septa present.

AS	F	F%	M	M %	F + M	F + M%
0	32	21.78	33	22.15	65	21.96
1	33	22.45	35	23.49	68	22.97
2	51	**34.69**	43	**28.86**	94	**32.09**
3	14	9.52	15	10.07	29	9.80
4	13	8.84	8	5.37	21	7.09
5	3	2.04	2	1.34	5	1.69
6	0	0.00	9	6.04	9	3.04
7	1	0.68	2	1.34	3	1.01
8	0	0.00	1	0.67	1	0.34
9	0	0.00	1	0.67	1	0.34

AS — additional septa, F — the total number of the AS in females, M — the total number of the AS in males, F% — the percentage of the AS in females, M% — the percentage of the AS in males.



1 — 0 AS (21.96 %); 2 — 1 AS (22.97%); 3 — 2 AS (32.09%); 4 — 3 AS (9.8%); 5 — 4 AS (7.09 %); 6 — 5 AS (1.69%); 7 — 6 AS (3.04%); 8 — 7 AS (1.01 %); 9 — 8 AS (0.34%); 10 — 9 AS (0.34%).

Fig. 1. The frequency prevalence of the additional septa (AS) in the total number of the patients.

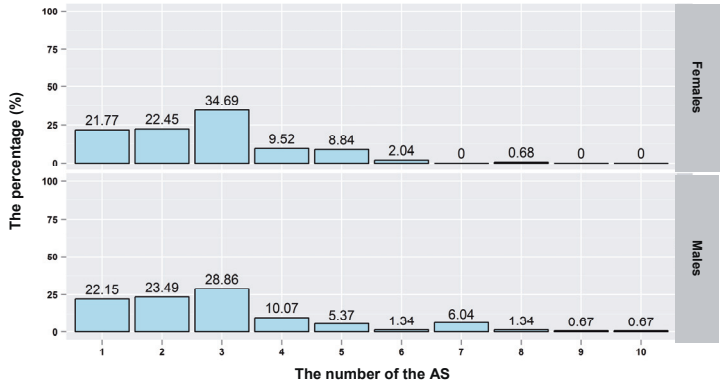


Fig. 2. The percentage distribution of the additional septa (AS) in females and males.

The distribution of the AS does not differ significantly amongst the females and males (p = 0.683, Manna-Whitney's test). Henceforth, we can assume that more or less the same number of females and males have only 1 septum, the same number of females and males have 2 septa, etc. (Fig. 2)

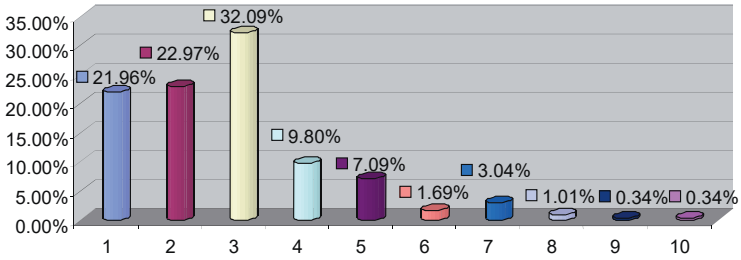
At the following stage, the total number of all septa (MS and AS) were counted, as well as the number of all the antra that were present in the posterior part of the sphenoid sinuses. In the majority of patients (241), there were more than two antra present in the posterior part of the sphenoid sinuses and within this group the most common (94 patients) were three septa and four antra. The presence of only one AS, hence in total two septa and three antra, was also very frequent (68 patients). In 65 cases there were no AS, hence there was only one septum present — the MS — and two antra (one in the anterior and one in the posterior part of the sinuses). Definitely, the least prevalent group of variants, consisted of patients with four septa in total and five antra (29 patients) or five septa and six antra (21 patients). The presence of a greater number of the septa and antra was sporadic and were as frequent as follows: six septa and seven antra — 5 patients, seven septa and eight antra — 9 patients, eight septa and nine antra — 3 patients, nine septa and ten antra — 1 patient, ten septa and eleven antra — 1 patient (Table 2, Fig. 3).

The distribution of the total number of the septa and antra does not differ significantly amongst the females and males (p = 0.683, Manna-Whitney's test). Henceforth, we can assume that more or less the same number of females and males has only 1 septum/2 antra, the same number of females and males 2 septa/3 antra, etc. (Fig. 4–14)

Table 2. The total number of septa and antra.

Septa/Antra	F	F%	M	M%	F + M	F% + M%
1/2	32	21.78	33	22.15	65	21.96
2/3	33	22.45	35	23.49	68	22.97
3/4	51	**34.69**	43	**28.86**	94	**32.09**
4/5	14	9.52	15	10.07	29	9.80
5/6	13	8.84	8	5.37	21	7.09
6/7	3	2.04	2	1.34	5	1.69
7/8	0	0.00	9	6.04	9	3.04
8/9	1	0.68	2	1.34	3	1.01
9/10	0	0.00	1	0.67	1	0.34
10/11	0	0.00	1	0.67	1	0.34

1/2 — one septum/two antra, 2/3 — two septa/three antra, 3/4 — three septa/four antra, 4/5 — four septa/five antra, 5/6 — five septa/six antra, 6/7 — six septa/seven antra, 7/8 — seven septa/eight antra, 8/9 — eight septa/nine antra, 9/10 — nine septa/ten antra, 10/11 — ten septa/eleven antra, F — females, M — males, F% — the percentage of females, M% — the percentage of males.



1 — 1/2 (21.96%), 2 — 2/3 (22.97%), 3 — 3/4 (32.09%), 4 — 4/5 (9.8%), 5 — 5/6 (7.09%), 6 — 6/7 (1.69%), 7 — 7/8 (3.04%), 8 — 8/9 (1.01%), 9 — 9/10 (0.34%), 10 — 10/11 (0.34%).

Fig. 3. The frequency of the presence of the total number of septa and antra in the total number of the patients.

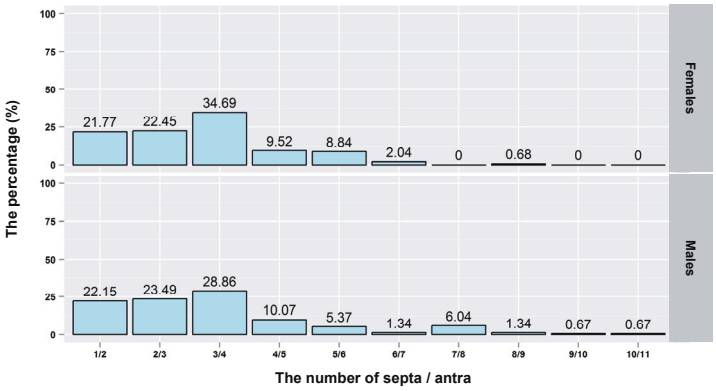


Fig. 4. The percentage distribution of the total number of septa and antra in females and males.

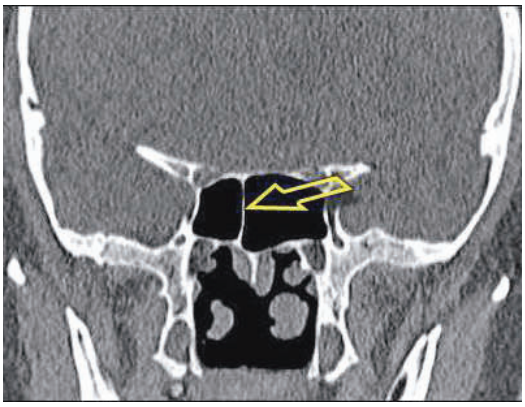


Fig. 5. CT scan of the paranasal sinuses, frontal plane. Total number of septa — 1, total number of antra in the sphenoid sinuses — 2 (1/2).

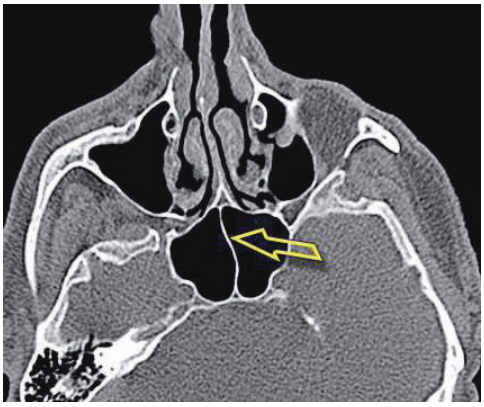


Fig. 6. CT scan of the paranasal sinuses, transverse plane. Total number of septa — 1, total number of antra in the sphenoid sinuses — 2 (1/2).

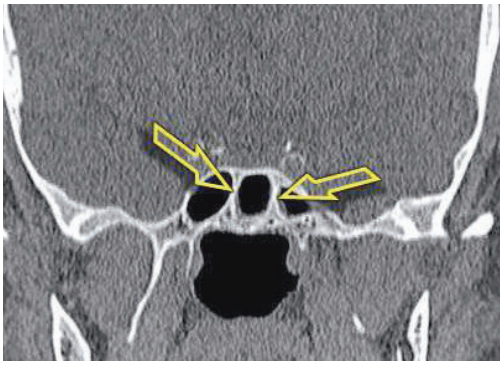


Fig. 7. CT scan of the paranasal sinuses, frontal plane. Total number of septa — 2, total number of antra in the sphenoid sinuses — 3 (2/3).

Fig. 8. CT scan of the paranasal sinuses, transverse plane. Total number of septa — 2, total number of antra in the sphenoid sinuses — 3 (2/3).

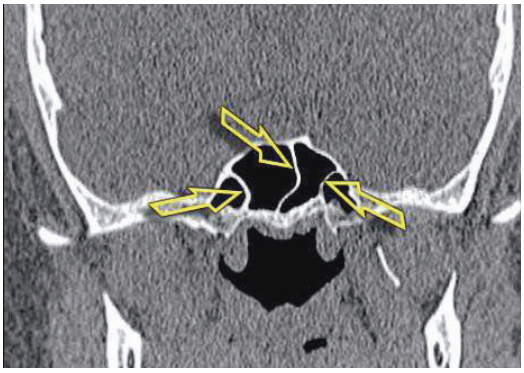


Fig. 9. CT scan of the paranasal sinuses, frontal plane. Total number of septa — 3, total number of antra in the sphenoid sinuses — 4 (3/4).

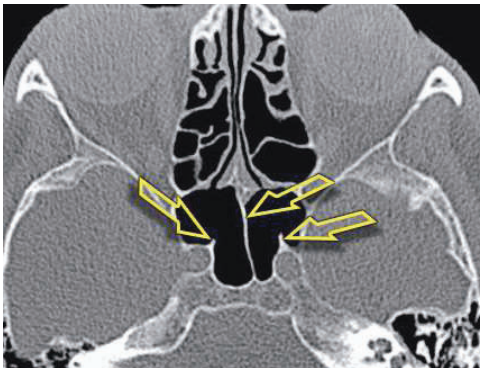


Fig. 10. CT scan of the paranasal sinuses, transverse plane. Total number of septa — 3, total number of antra in the sphenoid sinuses — 4 (3/4).

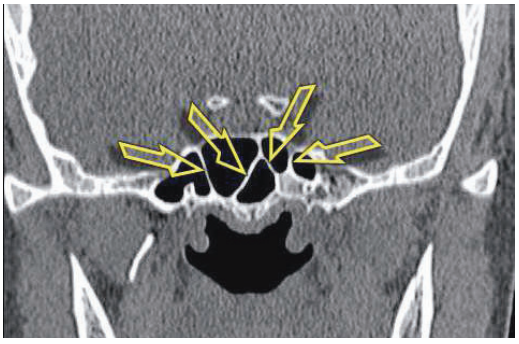


Fig. 11. CT scan of the paranasal sinuses, frontal plane. Total number of septa — 4, total number of antra in the sphenoid sinuses — 5 (4/5).

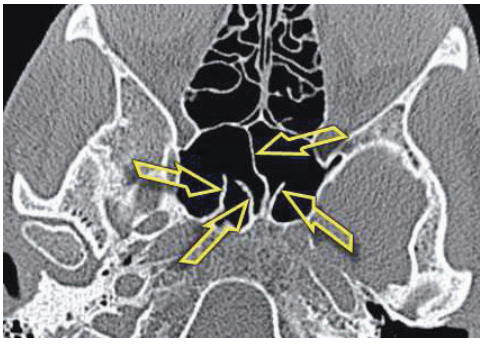


Fig. 12. CT scan of the paranasal sinuses, transverse plane. Total number of septa — 4, total number of antra in the sphenoid sinuses — 5 (4/5).

Fig. 13. CT scan of the paranasal sinuses, frontal plane. Total number of septa — 5, total number of antra in the sphenoid sinuses — 6 (5/6).

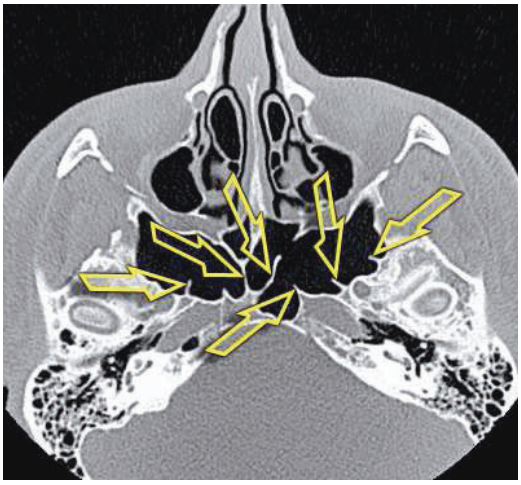


Fig. 14. CT scan of the paranasal sinuses, transverse plane. Total number of septa — 6, total number of antra in the sphenoid sinuses — 7 (6/7).

Discussion

At least one septum in the sphenoid sinuses was present in 296 patients (98.67%). 21.96% had only one septum (the MS), that divided the sphenoid sinus into two sphenoid antra. More than one sphenoid septum in the posterior part of the sphenoid sinuses was found in 231 patients (78.04%), which means that the AS were present. The most common were two AS 32.09% (altogether, three septa that divided the sinus into four antra). One AS was also very prevalent (22.97%, altogether two septa dividing the sinus into three antra). The presence of more than two AS was found with the following frequency: three AS in 9.8% of cases (altogether four septa dividing the sinus into five antra), four AS in 7.09% of cases (altogether, five septa dividing the sinus into six antra), five AS in 1.69% of cases (altogether, six septa dividing the sinus into seven antra), six AS in 3.04% (altogether, seven septa dividing the sinus into eight antra) and seven AS in 1.01% (altogether, eight septa dividing the sinus into nine antra). The least common variation was the presence of eight and nine AS, which were both prevalent in 0.34% of cases (respectively: altogether, nine septa dividing the sinus into ten antra and ten septa dividing the sinus into eleven antra). In the researched material, there were not any sphenoid sinuses identified that would have more than nine AS (altogether, more than ten septa dividing the sinus into more than eleven antra).

Abdullah *et al.* present a similar frequency of finding two septa — 25.71% of patients (18/70), three septa — 30% of patients (21/70), five septa — 5.71%

of patients (4/70) and six septa — 1.43% of patients (1/70) in the frontal planes. However, their remaining results are different: in their research, one septum was present in 14.29% of cases (10/70), and four septa in 24.29% of cases (17/70); they did not find sphenoid sinuses with more than six septa [5]. The single septum was present in 20% of patients in Sareen *et al.* (a cadaveric study). They also noticed that 80% of the patients had a greater number of the septa, but they did not specify the exact amount of the AS [14]. These results are similar to the others obtained previously, in which multiple septa were reported as follows: 76% of patients [1], 68% of patients [19] and 69.56% of patients [12]. The obtained results are also akin to the ones of other scientists who have analysed the presence of the septa on CT scans: the presence of a single septum in 28.1% of cases (18/64) and more than one septum in 71.9% of cases (46/64) [20]. Similar results were obtained by Tan and Ong in anatomical and endoscopic research carried out on 48 cadavers: single septum in 29.2% cases, one AS (altogether two septa) in 65.6% of cases and two AS (altogether three septa) in 5.2% of cases. The aforementioned researchers did not find more than two AS in their research material, which may relate to the small number of sinuses studied, the method of interpretation (cadaver endoscopy) and ethnic group (Asian) [21].

A greater frequency of the single septum was found by Awadalla *et al.*, whom provided results for two research groups: group A — anatomical study of 25 skulls (a single MS in 32% of cases) and group B — radiological study (CT and/or MRI) of 364 patients (a single MS in 35% of cases). At the same time, these researches present the following frequencies of the AS: for the group A — a single AS was present in 12% of cases and multiple septa were found in 28% of cases. As for the group B — a single AS was present in 7% of cases and multiple septa in 5.4% of cases [22]. Differences in the results may come from the fact that the study was carried on a different ethnic group (the Egyptians), methods with which the septa were assessed (MRI) or the chosen criteria of the presence of the AS (which is not stated in the work).

Dissimilar results are given by Haetinger *et al.*, whom mention that 27% of patients have the AS in the sphenoid sinuses [7]. Such discrepancy between the results may have its explanation in the inclusion criteria set by the authors — Haetinger *et al.* state the number of the septa only for the patients with the pneumatisation of the sphenoid sinuses behind the sella turcica. Moreover, Kinnman presents a lower frequency for the presence of the AS (without stating their numbers): 18.75% of cases (15/80). The dichotomy in the data may result from the imaging method (conventional RTG) and the method of choosing patients (the ones suffering from acromegaly) [23]. Similar discrepancy in the number of the septa in the sinuses was noticed by Hamid *et al.*, whom found a single septum (MS) in 71.6% of cases (212/296), presence of one AS in 10.8% of cases (32/296) and multiple septa in 6.8% of cases (20/296). It may be

associated with the study inclusion criteria (all the patients had pituitary adenoma) and the researched ethnic group (all patients were Egyptians) [24]. A lower frequency of AS was also noted in Serbian population (one septum 72%, two septa 17%, three septa 7%, four septa 4%) [25], in Korean — 52% (52/100) [26] and Romanian — 42% [27].

In the research carried out on 54 cases (27 patients in CTA imaging and 27 cadavers in endoscopic and CT imaging), Fernandez-Miranda *et al.* state twofold higher frequency of the presence of a single septum (MS) — 48.2%, twofold higher frequency of the presence of two septa (MS and one AS) — 40.7% and threefold lower frequency of the presence of three septa (MS and two AS) — 11.1%. These researchers did not find more than three septa in the sinuses — probably due to the scarce number of cadavers studied [28]. Similar results were obtained by the Turkish researchers, whom in the researched material (48 skulls), noticed the presence of only one septum in 46% of cases (22/48) and two AS in 52% of cases (25/48) [29]. Furthermore, Nitinavakarn *et al.* also presents the prevalence of a single septum in 47.7% of cases in the Taiwanese population [30].

Battal *et al.* state the presence of a single septum in 64.3%, two septa in 20.1% and greater numbers of septa in 14% (without stating the exact number of the AS) [31]. Similar results were given by ElKammash *et al.*: a single septum — 59.89%, two septa — 7.14%, multiple septa — 5.49% [32]. The researchers were studying 182 CT and MRI scans in a group of Egyptian patients. Similarly, Anusha *et al.* describe the prevalence of a single septum as 53.7% and multiple septa as 46.3% (using a head CT scan of 300 Malaysian patients) [33]. Furthermore, Idowu *et al.* state the presence of multiple septa in 48.33% of cases [34]. Stokovic *et al.* provide the prevalence of AS as 27.5% of cases (one AS in 17.6%, two AS in 7.84%, four AS in 1.96%). The study was carried out on 51 skulls with the cone beam CT (CBCT) [35].

The highest frequency of a single septum is given by Dundar *et al.* — 90.7% (198/218). These scientists noticed the presence of two septa in 6.8% of cases (15/218), dividing this group into two smaller subgroups: with two complete septa — 4.1% (9/218) and one complete and one incomplete septum — 2.7% (6/218). However, they did not find any greater number of AS [36]. Such big discrepancies may be a product of the ethnic group used in the study (the Turks) or the inclusion criteria of the presence of AS (not stated in the work). Shokri *et al.* found the frequency of the presence of septa in the sphenoid sinuses to be 74% of cases (74/100), but in their study they do not distinguish between the MS and AS [37]. The presence of AS was also found by Hammer and Radberg, whom say that they can run medially, frontally, sagittally or laterally (but they do not give the exact amount and frequency of their prevalence — they only say the lateral septa were present in 44% of cases) [38]. Sethi *et al.* present the AS in 30% of cases [39], whereas Tomovic *et al.* in 43.5% of cases [40] (Table 3).

Table 3. The frequency of the prevalence of septa in the sphenoid sinuses (S — septum).

Author (materials and methods)	1 S	>1 S	2 S	3 S	4 S	5 S	6 S	7 S	8 S	9 S	10 S
	%										
Abdullah *et al.* (70 CT)	14.29	87.14	25.71	30.00	24.29	5.71	1.43	–	–	–	–
Sareen *et al.* (20 skulls, dissection study)	20.00	80.00	–	–	–	–	–	–	–	–	–
Elwany *et al.* 1983 (100 RTG, 100 RTG skulls, 50 skulls — dissection study)	–	76.00	–	–	–	–	–	–	–	–	–
Elwany *et al.* 1999 (93 skulls, endoscopic and dissection study)	–	68.00	–	–	–	–	–	–	–	–	–
Mutlu *et al.* (69 HRCT)	–	69.56	–	–	–	–	–	–	–	–	–
Seddighi (64 CT and MRI)	28.10	71.90	–	–	–	–	–	–	–	–	–
Tan and Ong (48 skulls, endoscopic and dissection study)	29.20	70.08	65.60	5.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Awadalla *et al.* Gr. A (25 skulls, dissection study)	32.00	40.00	12.00	–	–	–	–	–	–	–	–
Awadalla *et al.* Gr. B (364 CT and/or MRI)	35.00	12.40	7.00	–	–	–	–	–	–	–	–
Haetinger *et al.* (25 skulls — dissection study, 50 CT of skulls, 750 CT)	–	27.00	–	–	–	–	–	–	–	–	–
Kinnman (80 skulls, dissection study)	–	18.75	–	–	–	–	–	–	–	–	–
Hamid *et al.* (296 CT and MRI)	71.60	17.60	10.80	–	–	–	–	–	–	–	–
Kapur *et al.* (200 CT)	72.00	28.00	17.00	7.00	4.00	–	–	–	–	–	–
Lee *et al.* (100 CT)	–	52.00	–	–	–	–	–	–	–	–	–
Lupascu *et al.* (200 CT)	–	47.00	–	–	–	–	–	–	–	–	–
Fernandez-Miranda *et al.* (27 angiography CT, 27 skulls — endoscopic and HRCT study)	48.20	51.80	40.70	11.10	–	–	–	–	–	–	–

Table 3. Cont.

Author (materials and methods)	1 S	>1 S	2 S	3 S	4 S	5 S	6 S	7 S	8 S	9 S	10 S
	%										
Kayalioglu *et al.* (180 MRI, 77 skulls — dissection study)	46.00	52.00	–	–	–	–	–	–	–	–	–
Nitinavakarn *et al.* (88 CT)	47.70	52.30	–	–	–	–	–	–	–	–	–
Dundar *et al.* (218 CT)	90.70	6.80	6.80	–	–	–	–	–	–	–	–
Battal *et al.* (314 angiography CT)	64.30	34.10	20.10	14.00							
ELKammash *et al.* (182 CT and MRI)	59.89	12.63	7.14	5.49							
Anusha *et al.* (300 CT)	53.70	46.30	–	–	–	–	–	–	–	–	–
Idowu *et al.* (60 CT)	–	48.33	–	–	–	–	–	–	–	–	–
Stokovic *et al.* (51 CBCT of skulls)	72.50	27.50	17.60	7.84	0.00	1.96	0.00	0.00	0.00	0.00	
Hammer and Radberg (120 skulls — RTG and TK, and 103 RTG)	?										
Sethi *et al.* (30 skulls, dissection study)	70.00	30.00									
Tomovic *et al.* (170 HRCT)	56.50	43.50									
Jaworek-Troć *et al.* (296 CT)	21.96	78.04	22.97	32.09	9.80	7.09	1.69	3.04	1.01	0.34	0.34

In this study, the AS (single or multiple) were located in each case in the posterior part of the sphenoid sinuses. It remains in accordance with other scientific reports [2, 28, 36].

Conclusions

1. The majority of patients have more than one septum in the sphenoid sinuses (most commonly two AS).
2. The majority of patients have more than two antra in the sphenoid sinuses (most commonly three antra).
3. The paranasal sinuses are greatly varied anatomically, hence conducting a CT scan is advisable in all patients requiring a surgical intervention, in furtherance to avoid potential complications that may arise due to the high prevalence of anatomical variations in the aforementioned sinuses.

Conflict of interest

None declared.

References

1. *Elwany S., Yacout Y.M., Talaat M., El-Nahass M., Gunied A., Talaat M.*: Surgical anatomy of the sphenoid sinus. The Journal of Laryngology and Otology. 1983; 97: 227–241.
2. *Vidic B.*: The postnatal development of the sphenoidal sinus and its spread into the dorsum sellae and posterior clinoid processes. Am J Roentgenal Radium The Nucl Med. 1968; 104 (1): 177–183.
3. *Degirmenci B., Haktanir A., Acar M., Albayrak R., Yucel A.*: Agenesis of sphenoid sinus: three cases. 2005. Published online.
4. *Yonetsu K., Watanabe M., Nakamura T.*: Age-related expansion and reduction in aeration of the sphenoid sinus: Volume assessment by helical CT scanning. AJNR Am J Neuroradiol. 2000; 21: 179–182.
5. *Abdullah B.J., Arasaratnam A., Kumar G., Gopala K.*: The sphenoid sinuses: computed tomographic assessment of septation, relationship to the internal carotid arteries and sidewall thickness in the Malaysian population. J HK Coll Radiol. 2001; 4: 185–188.
6. *Eryilmaz A., Ozeri C., Bayiz U., Samim E., Gocmen H., Akmansu H., Safak M.A., Dursun E.*: Functional endoscopic sinus surgery (FESS). Turk J Med Res. 1993; 11 (5): 221–223.
7. *Haetinger R.G., Navarro J.A.C., Liberti E.A.*: Basilar expansion of the human sphenoidal sinus: an integrated anatomical and computerized tomography study. Eur Radiol. 2006; 16: 2092–2099.
8. *Kantarci M., Karasen R.M., Alper F., Onbas O., Okur A., Karaman A.*: Remarkable anatomic variations in paranasal sinus region and their clinical importance. European Journal of Radiology. 2004; 50: 296–302.
9. *Kazkayasi M., Karadeniz Y., Arikan O.K.*: Anatomic variations of the sphenoid sinus on computed tomography. Rhinology. 2005; 43: 109–114.
10. *Keast A., Yelavich S., Dawes P., Lyons B.*: Anatomical variations of the paranasal sinuses in Polynesian and New Zealand European computerized tomography scans. Otolaryngology-Head and Neck Surgery. 2008; 139: 216–221.

11. *Mafee M.F., Chow J.M., Meyers R.*: Functional endoscopic sinus surgery: anatomy, CT screening, indications and complications. AJR. 1993; 160: 735–744.
12. *Mutlu C., Unlu H.H., Goktan C., Tarhan S., Egrilmez M.*: Radiologic anatomy of the sphenoid sinus for intranasal surgery. Rhinology. 2001; 39: 128–132.
13. *Perez-Pinas I., Sabate J., Carmona A., Catalina-Herrera C.J., Jimenez-Castellanos J.*: Anatomical variations in the human paransal sinus region studied by CT. J Anat. 2000; 197: 221–227.
14. *Sareen D., Agarwail A.K., Kaul J.M., Sethi A.*: Study of sphenoid sinus anatomy in relation to endoscopic surgery. Int J Morphol. 2005; 23 (3): 261–266.
15. *Terra E.R., Guedes F.R., Manzi F.R., Boscolo F.N.*: Pneumatization of the sphenoid sinus. Dentomaxillofacial Radiology. 2006; 35: 47–49.
16. *Becker D.G.*: The minimally invasive, endoscopic approach to sinus surgery. Journal of Long-Term Effects of Medical Implants. 2003; 13 (3): 207–221.
17. *Bogusławska R.*: Badanie zatok przynosowych metoda tomografii komputerowej dla celów chirurgii endoskopowej. Warszawa 1995.
18. *Krzeski A., Osuch-Wójcikiewicz E., Szwedowicz P., Tuszyńska A.*: Chirurgia endoskopowa w leczeniu guzów jam nosa i zatok przynosowych. Mag ORL. 2004; 3 (3): 79–84.
19. *Elwany S., Elsaeid I., Thabet H.*: Endoscopic anatomy of the sphenoid sinus. The Journal of Laryngology and Otology. 1999; 113: 122–126.
20. *Seddighi A., Seddighi A.S., Mellati O., Ghorbani J., Raad N., Soleimani M.M.*: Sphenoid sinus: anatomic variations and their importance in trans-sphenoid surgery. International Clinical Neuroscience Journal. 2014; 1 (1): 31–34.
21. *Tan H.K.K., Ong Y.K.*: Sphenoid sinus: an anatomic and endoscopic study in Asian cadavers. Clinical Anatomy. 2007; 20: 745–750.
22. *Awadalla A.M., Hussein Y., ElKammash T.H.*: Anatomical and radiological parameters of the sphenoida sinus among Egyptians and its impact on sellar region surgery. Egyptian Journal of Neurosurgery. 2015; 30 (1): 1–12.
23. *Kinnman J.*: Surgical aspects of the anatomy of the sphenoidal sinuses and the sella turcica. J Anat. 1977; 124 (3): 541–553.
24. *Hamid O., El Fiky L., Hassan O., Kotb A., El Fiky S.*: Anatomic variations of the sphenoid sinus and their impact on trans-sphenoid pituitary surgery. Skull Base. 2008; 18 (1): 9–15.
25. *Kapur E., Kapidzic A., Kulenovic A., Sarajlic L., Sahinovic A., Sahinovic M.*: Septation of the sphenoid sinus and its clinical significance. International Journal of Collaborative Research on Internal Medicine & Public Health. 2012; 4 (10): 1793–1802.
26. *Lee J.-Ch., Chuo P.-I., Hsiung M.-W.*: Ischemic optic neuropathy after endoscopic sinus surgery: a case report. Eur Arch Otorhinolaryngol. 2003; 260: 429–431.
27. *Lupascu M., Comsa Gh., Zainea V.*: Anatomical variations of the sphenoid sinus — a study of 200 cases. ARS Medica Tomitana. 2014; 2 (77): 57–62.
28. *Fernandez-Miranda J.C., Prevedello D.M., Madhok R., et al.*: Sphenoid septations and their relationship with internal carotid arteries: anatomical and radiological study. Laryngoscope. 2009; 119: 1893–1896.
29. *Kayalioglu G., Erturk M., Varol T.*: Variations in sphenoid sinus anatomy with special emphasis on pneumatization and endoscopic anatomic distances. Neurosciences. 2005; 10 (1): 79–84.
30. *Nitinavakarn B., Thanaviratananich S., Sangsilp N.*: Anatomical variation of the lateral nasal wall and paranasal sinuses: a CT study for endoscopic sinus surgery (ESS) in Thai patients. J Med Assoc Thai. 2005; 88 (6): 763–768.
31. *Battal B., Akay S., Karaman B., et al.*: The relationship between the variations of sphenoid sinus and nasal septum. Gulhane Tip Derg. 2014; 56: 232–237.
32. *ElKammash T.H., Enaba M.M., Awadalla A.M.*: Variability in sphenoid sinus pneumatization and its impact upon reduction of complications following sellar region surgeries. The Egyptian Journal of Radiology and Nuclear Medicine. 2014; 45: 705–714.

33. *Anusha B., Baharudin A., Philip R., Harvinder S., Mohd Shaffie B., Ramiza R.R.*: Anatomical variants of surgically important landmarks in the sphenoid sinus: a radiologic study in Southeast Asian patients. Surg Radiol Anat. 2015; 37: 1182–1190.
34. *Idowu O.E., Balogun B.O., Okoli C.A.*: Dimensions, septation, and pattern of pneumatization of the sphenoidal sinus. Folia Morphol. 2009; 68 (4): 228–232.
35. *Stokovic N., Trkulja V., Dumic-Cule I., Cukovic-Bagic I., Lauc T., Vukicevic S., Grgurevic L.*: Sphenoid sinus types, dimensions and relationship with surrounding structures. Ann Anat. 2016; 203: 69–76.
36. *Dundar R., Kulduk E., Soy F.K., Aslan M., Kilavuz A.E., Sakarya E.U., Yazici H., Eren A.*: Radiological evaluation of septal bone variations in the sphenoid sinus. J Med Updates. 2014; 4 (1): 6–10.
37. *Shokri A., Mortazavi H., Baharvand M., Falah-Kooshki S., Ostovarrad F., Karimi A.*: Prevalence of incidental findings in paranasal sinuses using CBCT. Dent Med Probl. 2014; 51 (4): 431–438.
38. *Hammer G., Radberg C.*: The sphenoidal sinus. Acta Radiologica. 1961; 56 (6): 401–422.
39. *Sethi D.S., Stanley R.E., Pillay P.K.*: Endoscopic anatomy of the sphenoid sinus and sella turcica. The Journal of Laryngology and Otology. 1995; 109: 951–955.
40. *Tomovic S., Esmaeili A., Chan N.J., Shukla P.A., Choudhry O.J., Liu J.K., Eloy J.A.*: High-resolution computed tomography analysis of variations of the sphenoid sinus. J Neurol Surg B. 2013; 74: 82–90.