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## Incorporation of the sphenoid sinuses' septum / septa in the carotid canal — evaluation before the FESS

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**Abstract:** The purpose of the research was to define the frequency prevalence of the incorporation of sphenoid sinuses' septum / septa in the carotid canal of the adult population.

**Materials and Methods:** 296 computed tomography (CT) scans of the patients (147 females, 149 males), who did not present any pathology in the sphenoid sinuses, were evaluated in this retrospective analysis. Spiral CT scanner — Siemens Somatom Sensation 16 — was used to glean the medical images. Standard procedure applied in the option Siemens CARE Dose 4D. No contrast medium was administered. Multiplans reconstruction (MPR) tool was used in order to obtain frontal and sagittal planes from the transverse planes previously received.

**Results:** Bilateral incorporation of the main septum (MS) in the carotid canal was not present in any of the patients, whereas unilateral incorporation was noticed in 21.96% of the patients (17.68% females, 26.17% males). On the right side it occurred in 11.82% of cases (10.88% females, 12.75% males), and on the left side in 10.14% of cases (6.8% females, 13.42% males). Bilateral incorporation of the additional septum (AS) was found in 8.45% of the patients (4.08% females, 12.75% males), whereas unilateral incorporation was noted in 28.37% of the patients. It was seen on the right side in 11.82% of cases (12.93% females, 10.74% males), and on the left side in 16.55% cases (15.65% females, 17.45% males). The most common variant was the incorporation of only one of the septa (either the MS or the AS) in the wall of the carotid canal unilaterally. Such situation took place in 30.07% of the patients (29.25% females, 30.87% males).

Incorporation of two septa on the same side was noticed in 4.39% of cases (4.08% females, 4.7% males), and incorporation of three septa in 0.34% of cases (0.7% males).

**C o n c l u s i o n s:** The anatomy of the paranasal sinuses is varied to a great extent, hence performing a CT scan is crucial before the scheduled surgery, as it may lessen the unforeseeable surgical complications, that may result from the high prevalence of variants in the sinuses.

**Keywords:** sphenoid sinuses, main septum, additional septum, carotid canal, FESS.

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## Introduction

Within the sphenoid bone, one can find pneumatic spaces filled with air, lined with mucous membrane that are recognised as sphenoid sinuses. They are known to have a very varied morphology. The discrepancies between them include: their size, shape, the number of septa present, and the degree to which they are filled with air [1–3].

The anatomical structure of the sphenoid sinuses is of dire importance to surgeons carrying out medical interventions in this region, especially since the sinuses adjoin important neurovascular structures that lie next to their wall. In order to diminish the surgical risks and avoid iatrogenic complications during a surgery (including endoscopy), medical professionals should evaluate the anatomical parameters of the sinuses before commencing such procedure [4–14].

Computed tomography (CT) scan is regarded as one of the most accurate methods of gleaning the medical images of the paranasal sinuses, as it allows to pinpoint a clear-cut representation of the osseous structures and identify anatomical variations.

Functional endoscopic sinus surgery (FESS) has become an increasingly popular surgical method carried out in the paranasal sinuses these days [15, 16]. The minimally invasive endoscopic techniques allowed to decrease the number of extensive classical surgical interventions performed in this region.

Since the beginning of the 1990s, the FESS is regarded as a method of choice while treating the chronic inflammatory conditions in the paranasal sinuses. The advantages of the endoscopic techniques over the extensive classical surgeries include: access to the hardly attainable places, smaller number of iatrogenic injuries and shorter recovery period following the procedure [5, 17].

## Materials and Methods

296 patients (147 females, 149 males) were referred to the Department of Medical Imaging of the University Hospital in Kraków to undergo a CT scan, which was then included in this retrospective analysis. In order to participate in this study, the patients had to be over eighteen years old and present no pathologies in the sphenoid sinuses.

Patients who had suffered from a head trauma or had undergone nasal, orbital or cranial basis surgery prior to the research, were not included in the following analysis.

Standard procedure applied in the option Siemens CARE Dose 4D while obtaining the CT scans via spiral CT scanner Siemens Somatom Sensation 16. Contrast medium was not administered to any of the patients. Multiplans reconstruction (MPR) tool was used in order to reconstruct the frontal and sagittal planes, after the CT scans in the transverse planes were gleaned in the first instance. Diagnostic station Siemens Volume Wizard was applied in order to evaluate the medical imaging data.

The analysis of the obtained images involved the presence of the incorporation of a septum (or septa) in the wall of the carotid canal — including the type of the septum that underwent the incorporation (either the main septum — the MS or the additional septum — the AS). Bilateral and unilateral arrangements were further noted.

## Results

Bilateral incorporation of the MS in the wall of the carotid canal was not noticed in any of the patients, whereas unilaterally it was present in 65 patients (26 females, 39 males). In 35 cases (16 females, 19 males) it took place on the right side, and on the left side in 30 cases (10 females, 20 males).

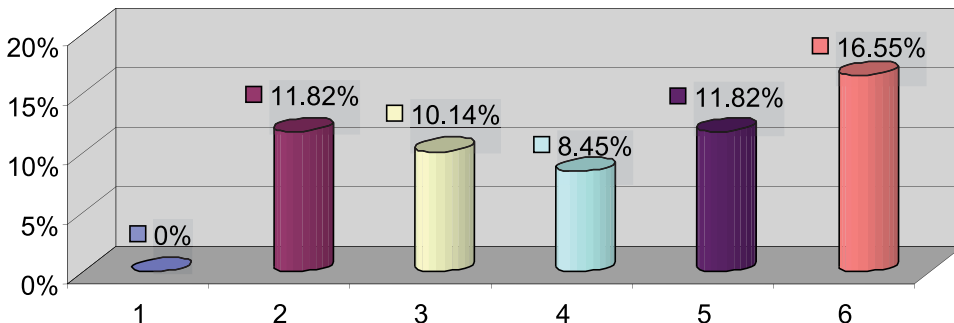
Bilateral incorporation of the AS in the wall of the carotid canal was found in 25 patients (6 females, 19 males), whereas unilaterally it was noted in 84 patients. On the right side it was present in 35 cases (19 females, 16 males), and on the left side in 49 cases (23 females, 26 males) (Table 1, Fig. 1).

**Table 1.** The frequency prevalence of the incorporation of the MS / AS in the wall of the carotid canal — the type of the incorporated septum.

CC	F	F%	M	M%	F + M	F + M%
MS R + L	0	0%	0	0%	0	0%
MS R	16	10.88%	19	12.75%	35	11.82%
MS L	10	6.8%	20	13.42%	30	10.14%
AS R + L	6	4.08%	19	12.75%	25	8.45%
AS R	19	12.93%	16	10.74%	35	11.82%
AS L	23	<b>15.65%</b>	26	<b>17.45%</b>	49	<b>16.55%</b>
None	73	<b>49.66%</b>	49	<b>32.89%</b>	122	<b>41.22%</b>

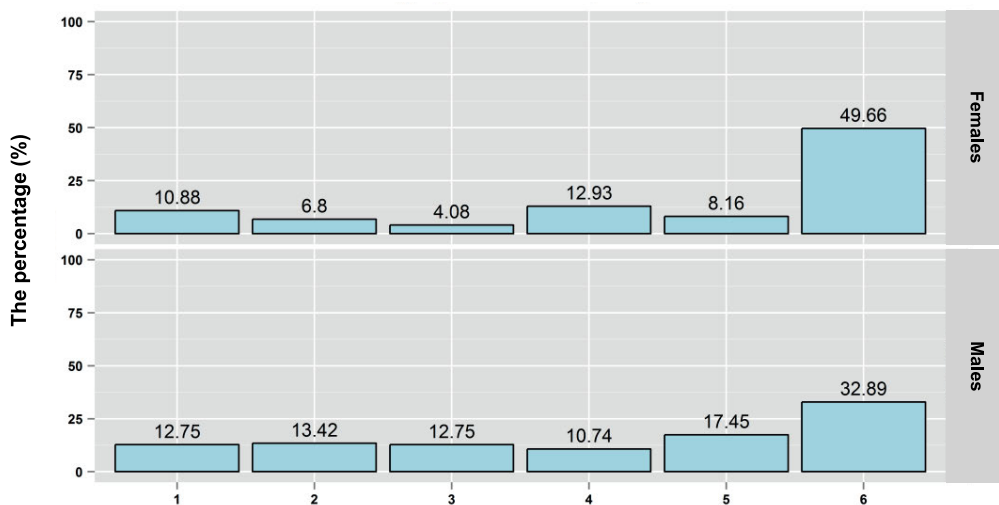
CC — carotid canal, MS — main septum, AS — additional septum, R + L — bilaterally, R — on the right side, L — on the left side, F — females, F% — the percentage of females, M — males, M% — the percentage of males.

CC — carotid canal, MS — main septum, AS — additional septum, R + L — bilaterally, R — on the right side, L — on the left side, F — females, F% — the percentage of females, M — males, M% — the percentage of males.

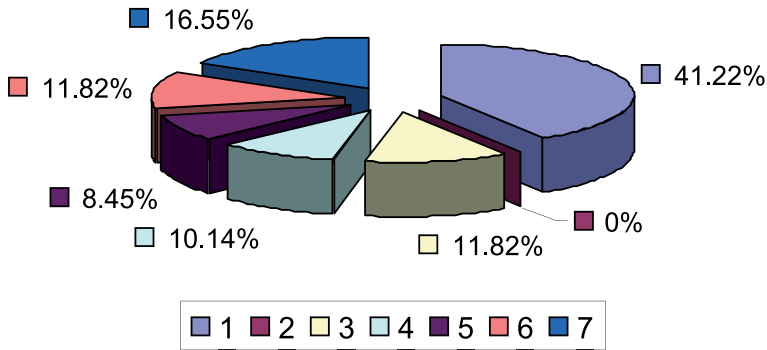


**Fig. 1.** The frequency prevalence of the incorporation of the MS / AS in the wall of the carotid canal in the total research group — the type of the incorporated septum.  
 1 — bilateral incorporation of the MS (0%), 2 — incorporation of the MS on the right side (11.82%), 3 — incorporation of the MS on the left side (10.14%), 4 — bilateral incorporation of the AS (8.45%), 5 — incorporation of the AS on the right side (11.82%), 6 — incorporation of the AS on the left side (16.55%).

A statistically significant relation was found between the type of the incorporated septum (or its absence) and gender ( $p = 0.008$ ,  $\chi^2$  test). The MS R + L variant was not included in the analysis due to the lack of those cases. Basing on the results it may be concluded that the MS L and AS R + L types definitely predominate in males in 20/30 cases (66.7%) and 19/25 cases (76%) respectively. The remaining types are more or less evenly distributed in both females and males, but none of the groups is dominating (Fig. 2 and 3).



**Fig. 2.** The percentage distribution of the frequency prevalence of the incorporation of the septum (or its absence) in the wall of the carotid canal in females and males.



**Fig. 3.** The frequency prevalence of the incorporation of the MS / AS in the wall of the carotid canal in the total research group — the type of the incorporated septum — collective data. 1 — absence of the incorporation (41%), 2 — bilateral incorporation of the MS (0%), 3 — incorporation of the MS on the right side (11.82%), 4 — incorporation of the MS on the left side (10.14%), 5 — bilateral incorporation of the AS (8.45%), 6 — incorporation of the AS on the right side (11.82%), 7 — incorporation of the AS on the left side (16.55%).

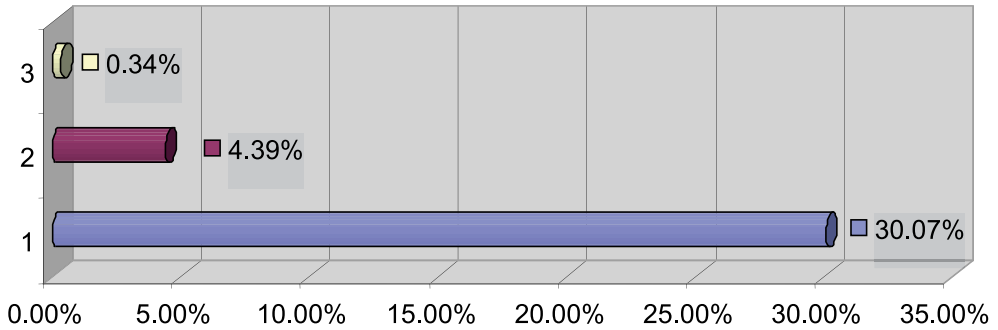
Unilateral incorporation of only one septum in the wall of the carotid canal was the most prevalent type. It occurred in 89 patients (43 females, 46 males). Unilateral incorporation of two septa in the wall of the carotid canal on the same side took place in 13 patients (6 females, 7 males), whereas three septa were incorporated in 1 patient (male). In the whole research material there were not found any sphenoid sinuses in which more than three septa would be incorporated in the wall of the carotid canal on the same side.

No statistically significant discrepancies between the distribution of the number of septa in females and males were found ( $p = 0.563$ , Mann-Whitney's test). The percentage distribution of the number of the incorporated septa in females and males is approximately equal. The vast majority of both genders (around 65%) did not have any incorporated septum. Approximately 30% of females and males had only one septum incorporated, around 4% two septa, and only one male had 3 incorporated septa (Table 2, Fig. 4–14).

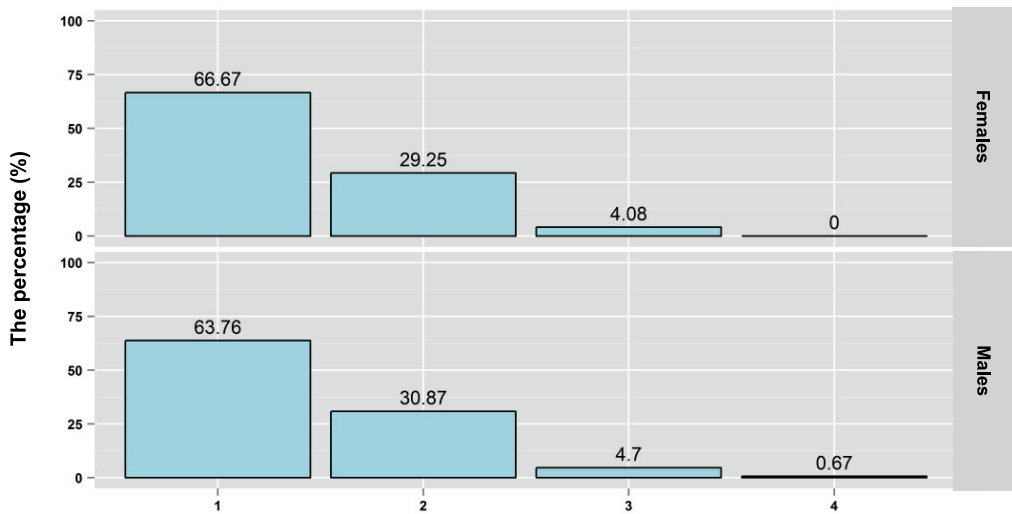
**Table 2.** The frequency prevalence of the incorporation of a septum / septa in the wall of the carotid canal — the total number of incorporated septa.

NS	F	F%	M	M%	F + M	F + M%
0	98	66.67%	95	63.73%	193	65.2%
1	43	29.25%	46	30.87%	89	30.07%
2	6	4.08%	7	4.7%	13	4.39%
3	0	0%	1	0.07%	1	0.34%

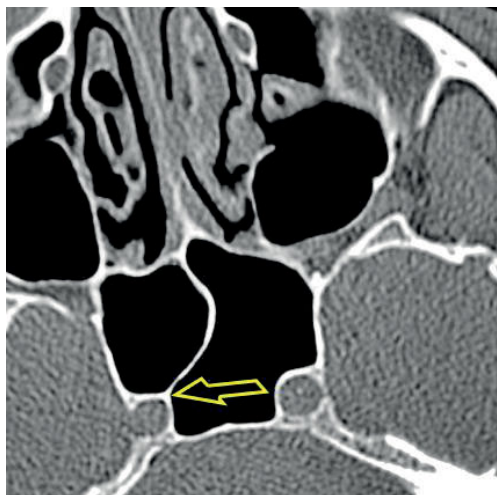
NS — the number of septa, F — females, F% — the percentage of females, M — males, M% — the percentage of males.



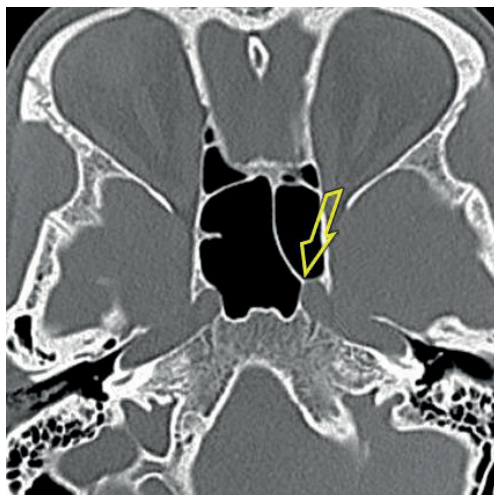
**Fig. 4.** The frequency prevalence of the incorporation of a septum / septa in the wall of the carotid canal — the number of incorporated septa in the total research group. 1 — one incorporated septum (30.07%), 2 — two incorporated septa (4.39%), 3 — three incorporated septa (0.34%).



**Fig. 5.** The percentage distribution of the number of the incorporated septa in the wall of the carotid canal in females and males.



**Fig. 6.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of the MS in the wall of the carotid canal on the right side.



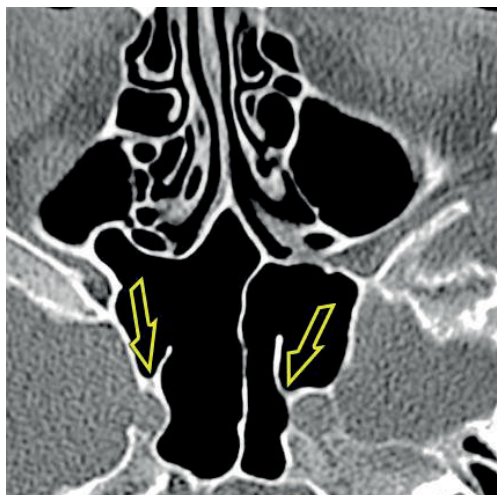
**Fig. 7.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of the MS in the wall of the carotid canal on the left side.



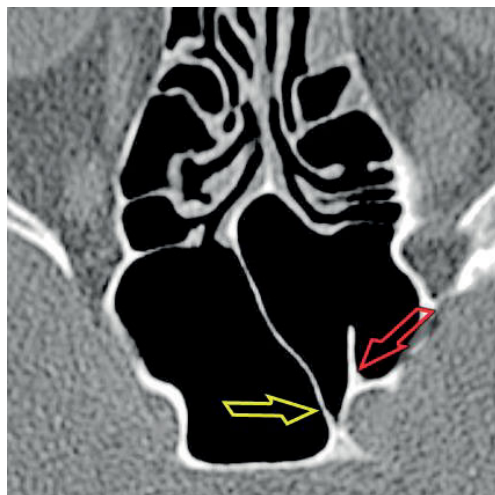
**Fig. 8.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of the AS in the wall of the carotid canal on the right side.



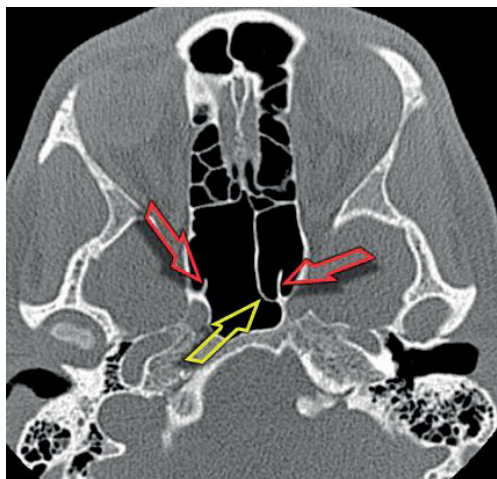
**Fig. 9.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of the AS in the wall of the carotid canal on the left side.



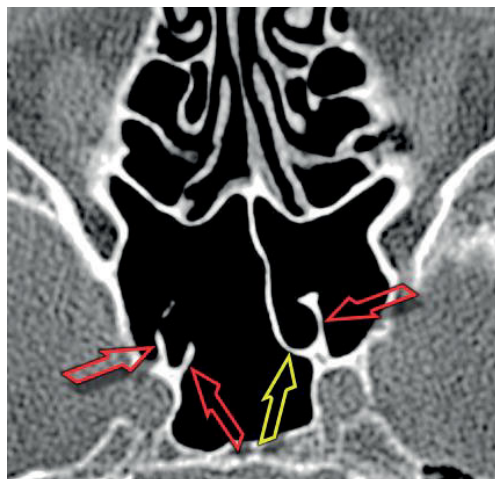
**Fig. 10.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of the AS in the wall of the carotid canal on both right and left sides (bilateral).



**Fig. 11.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of two septa (the MS and the AS) in the wall of the carotid canal on the left side.

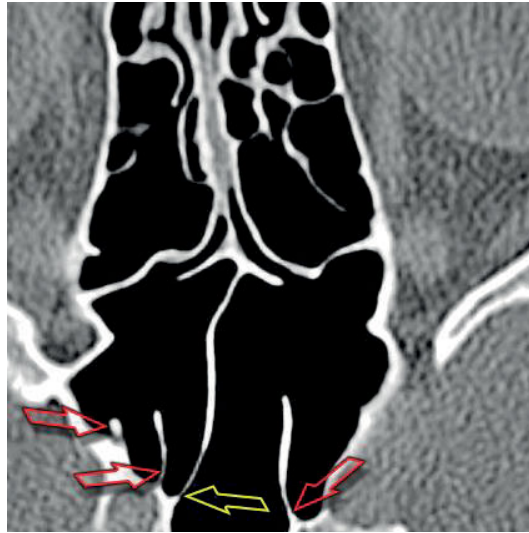


**Fig. 12.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of two septa (the MS and the AS) in the wall of the carotid canal on the left side and incorporation of the AS in the wall of the carotid canal on the right side.



**Fig. 13.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of two septa (the MS and the AS) in the wall of the carotid canal on the left side and incorporation of two AS in the wall of the carotid canal on the right side.





**Fig. 14.** A CT scan of the paranasal sinuses, transverse plane. Incorporation of one AS in the wall of the carotid canal on the left side and incorporation of three septa (the MS and two AS) in the wall of the carotid canal on the right side.

## Discussion

Bilateral incorporation of the MS in the wall of the carotid canal was not found in any of the patients. Unilateral incorporation of the MS was noticed in 21.96% of the patients (17.68% females, 26.17% males). It was present on the right side in 11.82% of cases (10.88% females, 12.75% males) and on the left side in 10.14% of cases (6.8% females, 13.42% males).

On the other side, bilateral incorporation of the AS in the wall of the carotid canal was prevalent in 8.45% of the patients (4.08% females, 12.75% males), and unilateral in 28.37% of the patients (28.58% females, 28.19% males). On the right side it was noted in 16.55% of cases (12.93% females, 10.74% males) and on the left side in 16.55% of cases (15.65% females, 17.45% males).

Similar results were obtained by Kapur *et al.* who report this variant as 23.5% [18].

High frequency of the incorporation of a septum or septa was given by Fernandez-Miranda *et al.*, who evaluate the incorporation of at least one septum in the wall of the carotid canal as 87%, whereas its absence as 13% [19]. Sethi *et al.* present a twofold higher frequency prevalence of this MS variant — 40% [20].

Abdullah *et al.* state the frequency prevalence of the septum connected with the carotid canal on the right side as 18.57% (13 patients), and on the left side as 12.86% (9 patients) in the total research group of 70 patients. Nonetheless, the aforementioned scientists do not provide the type of the incorporated septum [4]. Other

researchers evaluate this variant to be present in: 32% [20] (but giving the result cumulatively with the incorporation of the septum into the optic canal), 14.5% for the MS and 13.04% for the AS (0.6% unilaterally and 0.7% bilaterally) [19] and 27.7% [21, 22].

Elwany *et al.* provide a definitely lower frequency prevalence of the incorporated septum, and estimate it as 12.9% (but they do not state the side, type or the number of the incorporated septa). The discrepancy between the data may result from the research method (cadaveric endoscopic study), as well as the number of the sinuses studied (93 cadavers) [23]. Similarly, Nitinavakarn *et al.* evaluate this prevalence as 13.6%. The dissimilar results may come from the ethnic group studied (Thai population) and the small number of the patients studied (88 patients).

Anusha *et al.* provide the following frequency prevalence of the incorporation of the septum in the carotid canal: single septum — 5% (1.67% on the right side, 3.33% on the left side) and in case of multiple septa — 9.67% (1.67% on the right side, 3.33% on the left side, 4.67% bilaterally) [24]. Those researchers evaluated 300 Malaysian people.

The lowest prevalence of the incorporated MS in the wall of the carotid canal is given by Hamid *et al.*, stating it as 4.7% (2.69% on the right side, 2.01% on the left side) [25]. One of the reasons behind these results may be the research group's inclusion criteria (all patients had pituitary adenoma), as well as the ethnic group studied (all patients had Egyptian origins). Furthermore, Stokovic *et al.* also present a low frequency prevalence of this variant — in their study the MS was incorporated in the wall of the carotid canal in 3.9% of cases, and the AS in 17.65% of cases [26]. It may come down to the fact of evaluating a small research group (51 skulls), the inclusion criteria (only the canals with a present protrusion into the sphenoid sinuses' lumen) and the research method (CBCT).

Tan and Chong mention that the septum may have connection with the wall of the carotid canal, but they do not provide any information about the frequency prevalence of this variant [27] (Table 3).

The most common variant was the unilateral incorporation of only one septum in the wall of the carotid canal. Such situation took place in 30.07% of the patients (29.25% females, 30.87% males). The incorporation of two septa in the wall of the carotid canal on the same side occurred in 4.39% of the patients (4.08% females, 4.7% males), and three septa were incorporated in 0.34% of the patients (0.67% males). There were not found any sphenoid sinuses that would have more than three septa incorporated in the wall of the carotid canal unilaterally.

Lower frequency of the incorporation of the septa in the wall of the carotid canal was given by Kapur *et al.* — single septum in 2%, two septa — 9%, three septa — 5%, four septa — 4% [13]. The aforementioned study (200 CT scans) was conducted on the Serbian population.

**Table 3.** The frequency prevalence of the incorporation of the septa in the carotid canal — the type of the septum.

Author (material and methods)	MS uni-laterally	AS uni-laterally	MS on the right	AS on the right	MS on the left	AS on the left	MS bilaterally	AS bilaterally
	%							
Kapur <i>et al.</i> (200 CT scans)	19		11		8		0	
Fernandez-Miranda <i>et al.</i> (27 angiography CT, 27 skulls — endoscopic and HRCT study)	87							
Sethi <i>et al.</i> (30 skulls, dissection study)	40							
Abdullah <i>et al.</i> (70 CT scans)	31.43		18.57		12.86		—	
Lupascu <i>et al.</i> (200 CT scans)	32							
Mutlu <i>et al.</i> (69 HRCT)	14.5	0.6	—	—	—	—	—	0.7
Bademci and Unal (45 CT scans)	27.7							
Elwany <i>et al.</i> 1999 (93 skulls, endoscopic and dissection study)	12.9							
Nitinavakarn <i>et al.</i> (88 CT scans)	13.6							
Anusha <i>et al.</i> (300 CT scans)	5	5	1.67	1.67	3.33	3.33	0	4.67
Hamid <i>et al.</i> (296 CT and MRI scans)	4.7	—	2.69	—	2.01	—	—	—
Stokovic <i>et al.</i> (51 skulls, CBCT study)	3.9	17.65	—	—	—	—	—	—
Tan and Chong (-)	?							
Jaworek-Troć <i>et al.</i> (296 CT scans)	21.96	28.37	11.82	16.55	10.14	16.55	0	8.45

Abdullah *et al.* evaluate the number of the incorporated septa as follows: 1 septum (2.86% on the right and 2.86% on the left side), 2 septa (8.57% on the right and 5.71% on the left side), 3 septa (5.71% on the right and 2.86% on the left side) and 4 septa (1.43% on the right and 1.43% on the left side) [4]. The discrepancies in the results may be related to the number of the sinuses studied (70 patients).

Fernandez-Miranda *et al.* provide an undoubtedly higher frequency prevalence of the incorporation of the septa, evaluating the incorporation of at least one septum in the wall of the carotid canal as 87% and incorporation of two or more septa as 44% [19] (Table 4).

**Table 4.** The frequency prevalence of the incorporation of the septa in the wall of the carotid canal — the number of septa.

Author (materials and methods)	1	2	3	4
Kapur <i>et al.</i> (200 CT scans)	2%	9%	5%	4%
Abdullah <i>et al.</i> (70 CT scans)	5.72%	14.28%	8.57%	2.86%
Fernandez-Miranda <i>et al.</i> (27 angiography CT scans, 27 skulls — endoscopic and HRCT study)	87%		44%	
Jaworek-Troć <i>et al.</i> (296 CT scans)	30.07%	4.39%	0.34%	0%

## Conclusions

1. In the majority of the patients, neither the MS nor AS are incorporated in the wall of the carotid canal.

2. In case of the incorporation of a septum in the wall of the carotid canal, the left AS was found to do so the most often.

3. When a septum is incorporated in the wall of the carotid canal, it is usually a single septum (either the MS or AS).

4. Since there is a high prevalence of the anatomical variants [28, 29] surrounding the paranasal sinuses, it is prudent to conduct a CT scan before the scheduled surgical intervention. Doing so will help diminish potential complications that may appear during the procedure, arising from the perplexing structure of the paranasal sinuses.

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