Sphenoid sinus symmetry and differences between sexes*

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SUMMARY

Objectives: *To evaluate the anatomic variations of neurovascular structures adjacent to the sphenoid sinus and their agreement between right and left sides as well as differences between sexes.*

Methods: *Forty-five cadavers were dissected (24 men, and differences between sexes and agreement of anatomic variations of the sphenoid sinus between sides were analyzed.*

Results: *The mean distance from the sphenoid sinus ostium to the anterior nasal spine was greater in males than in females by an average of 3.0 mm ($p = 0.001$) while the mean difference of distances between the right and left side was -1.1 ± 3.1 mm. Female cadavers had a greater frequency of optic-carotid recess ($p = 0.04$) and dehiscence over the maxillary nerve ($p = 0.02$), as well as greater relative risk of optic nerve protrusion ($p < 0.001$), and dehiscence over the internal carotid artery (ICA) ($p = 0.002$). In male cadavers the intersinus septum was inserted on the course of the ICA 3.5 times more often than in female ($p = 0.02$). Agreement of anatomic variations between sides ranged from moderate to almost perfect depending on the structures evaluated.*

Conclusions: *There are anatomic differences of the sphenoid sinus between sexes and between right and left sides, and these differences should be taken into consideration during surgery.*

Key words: sphenoid sinus, anatomy, endoscopy, symmetry, cadaver

INTRODUCTION

The sphenoid sinus (SS) is the most posterior paranasal sinus, and is located in the center of the skull base. Sinus surgery is particularly difficult because of the extremely important anatomic relationships with vital structures, such as the internal carotid artery, the optic nerve, the pituitary and the cavernous sinus as well as wide anatomic variation [1,2]. Accidental injuries of the internal carotid artery (ICA) and the optic nerve (ON), for example, have catastrophic consequences. Therefore, familiarity with possible anatomic variations is fundamental when operating on the sinus itself or on adjacent structures. However, no studies about this topic were published before the 1990s [3,4].

Despite the importance and complexity of the sphenoid sinus anatomy, few studies focused their investigations on this sinus. There is also scarce data about the agreement between sides or the differences between sexes in the Brazilian medical literature.

Therefore, this study used endoscopic cadaver dissection to evaluate the agreement between the right and left side and the differences between sexes of the anatomic variations of the neurovascular structures adjacent to the sphenoid sinus, more specifically the internal carotid artery and the optic, maxillary and vidian nerves.

MATERIALS AND METHODS

This study was approved by the Ethics Committee for the Analysis of Research Projects (Comissão de Ética para Análise de Projetos de Pesquisa, CAPPesq) of Hospital de Clínicas, School of Medicine, Universidade de São Paulo, Brazil, under protocol no. 113/04 on March 13, 2004, and by the board of directors of the São Paulo Death Certification Service (Serviço de Verificação de Óbitos da Capital, SVOC) of Universidade de São Paulo.

Cadavers

Cadavers were selected according to the following criteria: death in the previous 24 hours; age greater than 30 years; any cause of death. Exclusion criteria were: (1) signs of craniofacial trauma, (2) nasal and sinus disease (polyposis, rhinosinusitis), (3) history or signs of any surgery or previous nose or skull base dissection. Forty-eight cadavers were examined from April to December 2004 in the São Paulo Death Certification Service (Serviço de Verificação de Óbitos da Capital) of

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Universidade de São Paulo (SVOC-USP). Two cadavers were excluded from the study due to signs of chronic sinusitis and nasal sinus polyposis, and another due to signs of previous nasal sinus surgery. Of the 45 cadavers in the sample, 24 (53.3%) were male.

Table 1 shows anthropometric and ethnic data and age at death. Mean weight and height of male cadavers were significantly greater than those of female cadavers ($p = 0.03$ and $p < 0.001$). There were no statistically significant differences in age between sexes.

- Degree of sinus pneumatization, classified as conchal, presellar and sellar, according to Hammer and Radberg [5];
- Position and shape of the sinus ostium;
- Presence of Onodi cells, defined by Stamberger [6] as a posterior ethmoid cell with pneumatization cranial and/or lateral to the anterior wall of the sphenoid sinus, and located between the sphenoid sinus and the skull base (sphenoid plane);
- Presence of dehiscence or protrusions of the internal carotid artery and optic, maxillary, and vidian nerves;

Table 1. Anthropometric data, age at death, and ethnicity according to sex of 45 cadavers.

	Sex			
	Male (n = 24)	Female (n = 21)	P	Total (n = 45)
Height (cm)				
Mean ± standard deviation	174.8 ± 6.5	166.0 ± 5.4	< 0.001	170.7 ± 7.4
Range	160 / 180	160 / 175		160 / 180
Weight (kg)				
Mean ± standard deviation	68.3 ± 9.3	63.8 ± 14.8	0.03	66.1 ± 12.4
Range	50 / 96	45 / 120		45 / 120
Age (years)				
Mean ± standard deviation	59.2 ± 13.6	65.0 ± 12.8	0.2	61.9 ± 13.4
Range	30 / 80	39 / 83		30 / 83
Ethnicity[1]				
White	11 (45.8 %)	11 (52.4 %)	0.9	22 (48.9 %)
Mixed	8 (33.3 %)	6 (28.6 %)		14 (31.1 %)
Black	5 (20.8 %)	4 (19.0 %)		9 (20.0 %)

[1] Data described as n (%)

Procedures

All procedures were recorded with a system composed of a halogen light source, microcamera, video monitor and digital camera. The microcamera was connected to two 4-mm rigid endoscopes (Hopkins II Telescope, Karl Storz, Germany): a 0-degree one for straight viewing, and a 45-degree for angled viewing. Technicians from the SVOC-USP laboratory performed routine opening of the cranial cavity, removed the brain and exposed the skull base. The optic nerves, chiasma, pituitary and the cavernous segment of the internal carotid artery remained intact. All dissections were made by only one author and two assistants, and strictly followed the steps described below: The ostium of the sphenoid sinus on each side was located with the 4-mm 0-degree endoscope. The position of each ostium in relation to the posteroinferior end of the superior turbinate was recorded and classified as medial or lateral. The distances between the anterior nasal spine and the left and right ostia were measured with a caliper. The anterior wall of the sphenoid sinus was widely opened, and anterior and posterior ethmoidectomies were performed. The relationship between the location of the posterior ethmoid cells and the sphenoid sinus was recorded. All the mucosa in its interior was removed. The following variations were studied:

- Distance from its anterior wall to the anterior nasal spine;
- Presence of optic-carotid, pterygoid and lateral recesses;

A seeker (Karl Storz) and a 45-degree endoscope were used to examine the walls of the sphenoid sinus in a detailed way. Whenever protrusions of the neurovascular structures were not clearly identified, the bone walls of the sphenoid sinus over those structures were removed for confirmation.

Statistical analysis

Data were stored and analyzed using the SPSS for Windows 10.0 software (SPSS INC – Chicago, IL). The 95% confidence interval of findings was ± 5% for a sample of 45 cadavers. For each cadaver, the agreement of anatomic variations between sides was evaluated by calculation of kappa coefficients; the agreement of measurements and between sides was analyzed using the model described by Bland and Altman [7,8]. The criteria described by Landis and Koch [9] were used for the interpretation of kappa coefficients, as shown in Table 2. The chi-square and the Fisher exact tests were used to compare differences between sexes and the Mann-Whitney nonparametric U test, for continuous variables. In this analysis, the values of right and left sides were added, and, therefore, each cadaver contributed with 2 sides, which totaled 90 sides under study. Differences were classified as statistically significant when p was lower than 0.05 (level of significance of 5%).

Table 2. Interpretation of kappa coefficient values for categorical data.

Kappa Statistics	Strength of Agreement
<0.0	Poor
0.0 – 0.20	Slight
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Substantial
0.81 – 1.0	Almost Perfect

SOURCE: Landis, J R and Koch, GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33:159-74

Table 3. Prevalence of the anatomic variations of sphenoid sinus ostium of the 90 sides under study according to sex.

	Sex		
	Male (n = 48)	Female (n = 42)	p
Position in relation of superior turbinate			
Medial	43 (89.6 %)	34 (81.0 %)	0.24
Lateral	5 (10.4 %)	8 (19.0 %)	
Shape			
Circular	41 (85.4 %)	37 (88.1 %)	0.7
Elliptic	7 (14.6 %)	5 (11.9 %)	
Distance from ostium to ANS	69.4 ± 4.1	66.4 ± 4.6	0.001

ANS = anterior nasal spine.

RESULTS

Analysis of differences between sexes

The prevalence of anatomic variations of the ostium of the sphenoid sinus according to sex is shown in Table 3. The mean distance from the sphenoid sinus ostium to the anterior nasal spine was 3.0 mm greater in males ($p = 0.001$). The other differences in ostia between sexes were not statistically significant.

Figure 1 shows the percentages of types of pneumatization of the sphenoid sinus according to sex. Differences were not statistically significant.

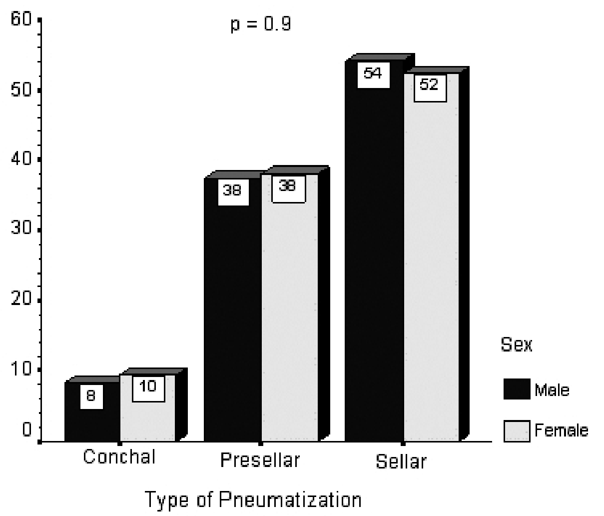

Figure 1. Prevalence of different types of pneumatization of the sphenoid sinus according to sex.

Table 4. Prevalence of the anatomic variations of sphenoid sinus ostium and presence of Onodi cell in the posterior ethmoid of the 90 sides under study according to sex.

	Sex		
	Male (n = 48)	Female (n = 42)	p
Crests	10 (20.8 %)	10 (23.8 %)	0.7
Septum insertion on the course of			
A. Internal carotid artery 1	12 (25.0 %)	3 (7.1 %)	0.02
Optic nerve 1	0 (0.0 %)	2 (4.8 %)	0.1
Recess			
Optic-carotid	16 (33.3 %)	23 (54.8 %)	0.04
Lateral	21 (43.8 %)	20 (47.6 %)	0.7
Pterygoid	22 (45.8 %)	21 (50.0 %)	0.7
Presence of Onodi cell	15 (31.3 %)	8 (19.0 %)	0.19

ANS = anterior nasal spine.

Table 5. Prevalence of dehiscence and protrusions of neurovascular structures adjacent to the sphenoid sinus in the 90 sides under study according to sex.

	Sex		
	Male (n = 48)	Female (n = 42)	p
PInternal carotid artery			
Protrusion	24 (50.0 %)	20 (47.6 %)	0.8
Dehiscence	8 (16.7 %)	20 (47.6 %)	0.002
Optic nerve			
Protrusion	8 (16.7 %)	24 (57.1 %)	< 0.001
Dehiscence	3 (6.3 %)	5 (11.9 %)	0.5
Maxillary nerve			
Protrusion	22 (45.8 %)	19 (45.2 %)	0.9
Dehiscence	0 (0.0 %)	5 (11.9 %)	0.02
Vidian nerve			
Protrusion	23 (47.9 %)	22 (52.4 %)	0.7
Dehiscence	8 (16.7 %)	14 (33.3 %)	0.07

Table 4 shows the prevalence of anatomic variations of the sphenoid sinus and the presence of Onodi cells in the posterior ethmoid according to sex. Female cadavers had a greater frequency of optic-carotid recesses (54.8 vs. 33.3%; p – 0.04), and male cadavers had a relative risk (RR) of insertion of the septum on the course of ICA 3.5 times greater (95% CI, 1.1 – 11.6). The other differences in measurements between sexes were not statistically significant.

The comparison of prevalence of dehiscence and protrusions of the neurovascular structures adjacent to the sphenoid sinus between sexes is shown in Table 5. Female cadavers had a RR for dehiscent ICA 1.9 times (95% CI, 1.4 – 5.8) greater than male cadavers ($p = 0.002$). Female cadavers also had 3.4 times (95% CI, 1.4 – 5.9) more frequent presence of optic nerve protrusion ($p < 0.001$). All the 5 sides with dehiscence over the maxillary nerve belonged to female cadavers ($p = 0.02$). Female sides also had a greater frequency of dehiscence over the vidian

Table 6. Analysis of agreement of the anatomic characteristics of the sphenoid sinus between right and left sides.

	Simple agreement	Kappa (± standard diviation)	p
Ostium			
Visible without removing ST	88.9 %	0.62 (± 0.17)	< 0.001
Position in relation to ST	91.1 %	0.55 (± 0.18)	< 0.001
Shape	75.6 %	0.52 (± 0.12)	< 0.001
Pneumatization	100 %	1.0 (± 0.0)	< 0.001
Crests	77.8 %	0.36 (± 0.16)	0.02
Presence of Onodi cell	80.0 %	0.48 (± 0.15)	0.001
Recess			
Optic-carotid	80.0 %	0.59 (± 0.12)	< 0.001
Lateral	75.5 %	0.51 (± 0.12)	< 0.001
Pterygoid	75.6 %	0.51 (± 0.13)	0.001
Protrusion of			
Internal carotid artery	86.6 %	0.73 (± 0.10)	< 0.001
Optic nerve	86.7 %	0.71 (± 0.11)	< 0.001
Maxillary nerve	75.5 %	0.51 (± 0.12)	< 0.001
Vidian nerve	71.2 %	0.42 (± 0.14)	0.005
Dehiscence over			
Internal carotid artery	73.4 %	0.39 (± 0.14)	0.006
Optic nerve	91.1 %	0.46 (± 0.23)	0.002
Maxillary nerve	97.7 %	0.79 (± 0.20)	< 0.001
Vidian nerve	68,9 %	0,17 (± 0,16)	0,3

ST = superior turbinate.

nerve, but this difference was not statistically significant (p = 0.07). The other differences in dehiscence and protrusions of neurovascular structures were not statistically significant.

Analysis of agreement between right and left sides

Table 6 shows the analysis of agreement between right and left sides and the corresponding kappa coefficients of the anatomic characteristics of the sphenoid sinus under study.

Agreement between the distance from the anterior nasal spine to the right and left sphenoid ostia are graphically represented according to the method described by Bland and Altman [8] in Figure 2. The mean difference between right and left sides was -1.1 mm ± 3.1 mm.

DISCUSSION

According to the latest demographic census in Brazil [10], the country had a population of 170 million inhabitants, 91 million classified as white (53.7%), 10 million as blacks (6.2%), 761 thousand as yellow (0.4%), 65 million as mixed race (38.4%), and 734 thousand as native Brazilians (0.4%). The Brazilian population, however, is the result of extensive miscegenation of native Brazilians, Europeans and Africans, and has one of the greatest ethnic variations in the world according to Pimenta et al. [11]. In their study with 756 individuals in São Paulo, they found that the classification into color categories, such as white, black or mixed, to identify races and ethnic groups was not genetically supported in Brazil. The use of kits for genomic analysis to estimate the role of African or European ancestors revealed extensive overlaps of the three race categories to define individual ethnicity. They concluded that there is significant dissociation between skin color and genetic inheritance for each individual in Brazil. Therefore, those authors suggested that the use of morphologic differences, such as skin color and hair texture, should not be used as parameters for clinical evaluations. Because of that, our study did not analyze differences between cadavers according to skin color.

The distance between ICA and the sphenoid sinus (SS) ostium was statistically greater in male cadavers. Male cadavers also had mean height and weight values greater than female cadavers. We believe that the difference in ostia between sexes is explained by the fact that human males tend to be physically larger.

Female cadavers had a significantly greater prevalence of dehiscence over the ICA and the maxillary nerve, and a greater, though not significant, presence of dehiscence over the vidian nerve, although their frequency of sellar pneumatization was similar to that found in male cadavers. This may be

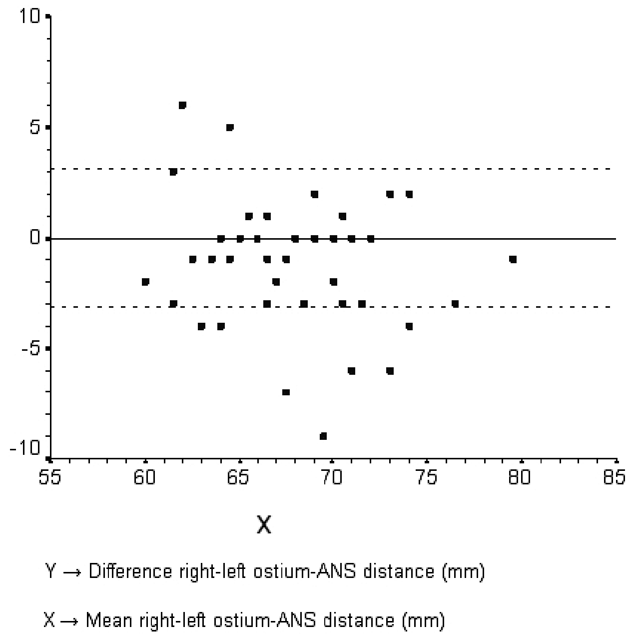

Figure 2. Agreement of distances from the ostium of the sphenoid sinus to the anterior nasal spine (ANS) in millimeters between right and left sides. In the y-axis, the continuous line indicates perfect agreement, and the interval between dotted lines indicates the ± 1 standard deviation interval of the mean difference between sides (± 3.1 mm).

explained by the fact that bone mass and density are lower in women because of lower hormone stimulation, which may also explain why the sphenoid bone is thinner.

No studies in the literature have analyzed the agreement of anatomic variation of the sphenoid sinus between sides. The analysis of symmetry of the distance from the ostium to the anterior nasal spine revealed that the smallest difference was 0 mm, and the largest, 9 mm, and that the difference between sides was ± 3.1 mm in 80% of the cases. According to our findings, there is substantial agreement (kappa – 0.62; $p \leq 0.001$) in visualization of the SS ostium without removal of the superior turbinate, which indicates the possibility of a faster surgical approach.

The greater the SS pneumatization, the easier the access to adjacent regions because drilling of thick bone walls is not necessary and vital structures are easily identified [12]. Therefore, knowledge of sinus symmetry may facilitate access to the contralateral sinus. We found perfect agreement (kappa = 1.0; $p \leq 0.001$) between sides in the analysis of pneumatization. Therefore, surgeons may approach the contralateral side more confidently. However, this agreement is not relevant in daily practice because preoperative CT scans may easily evaluate the degree of pneumatization of sinuses [13]. Our study found substantial agreement in the comparison of both optic nerve and ICA protrusions (kappa = 0.71 for both; $p \leq 0.001$), which should call attention to areas more likely to be injured, such as protrusions on the lateral wall of the sphenoid sinus, during contralateral approaches. However, the agreement in the comparison of presence of Onodi cells was only moderate, a fact that indicates that, during the opening of the sphenoid sinus, surgeons should approach it carefully and pay special attention to identifying Onodi cells to avoid injury to the optic nerve.

Although the vidian nerve was the one most frequently seen to protrude on the SS wall, only slight agreement was found when comparing the prevalence of nerve dehiscence (kappa = 0.17) between sides.

Female cadavers had statistically smaller dimensions than male cadavers and a greater prevalence of dehiscence of neurovascular structures adjacent to the sphenoid sinus. Agreement of anatomic variations between sides ranged from moderate to perfect according to the structures evaluated. Anatomic differences of the sphenoid sinus between sexes and sides were demonstrated in this study and should be taken into consideration during surgery.

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