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Anatomical variations of the sphenoid sinus on multislice computed tomography and the clinical significance

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Abstract— : Sphenoid sinus is a cavity filled with air, located in the body of the sphenoid bone. A thin bone lamella divides it in two parts, the right and the left, which are usually unequal in size. MSCT is the most precise method of evaluating the sphenoid sinus and provides the best visualization of detailed sinus anatomy, its relationship with surrounding neurovascular structures and bone cavities. The aim of this paper is to establish the variations of pneumatization of the sphenoid sinus and the existence of multiple septa. A retrospective-prospective study was conducted at the Clinic for Radiology of the Clinical Center of the University of Sarajevo in the period from January 2017 to the end of 2018, where major bone variations of paranasal sinuses were analyzed and interpreted in 200 patients who performed a MSCT scan of paranasal sinuses for suspected disease. Pneumatization is most commonly present in the greater wing of the sphenoid bone, most commonly bilaterally (103 or 51%), then in pterygoid processes, also most commonly bilaterally (43 or 22% of cases), and least in the anterior clinoid processes, also most commonly bilaterally (44 or 22% of cases). Pneumatization only on the right side is most commonly noted in the pterygoid process (21 or 10% of cases), then in the anterior clinoid process (19 or 10% of cases), and the most rarely in the greater wing of the sphenoid bone (8 or 4% of cases). Pneumatization on the left side only is most often noted in the greater wings of the sphenoid bone (24 or 12% of cases), then in the pterygoid process (22 or 11% of cases), and the most rarely in the anterior clinoid process (17 or 8% of cases). An analysis of the septum of the sphenoid sinus shows that a main septum (174 or 87%) was noted in the majority of patients, and the main septum was absent in 26 or 13% of patients. MSCT is a method of choice in the representation the variations of pneumatization of the sphenoid sinus and the existence of multiple septa, with their immediate anatomical environment.

Index Terms— multislice computed tomography (MSCT), sphenoid sinus, pneumatization, anatomical variations, neurovascular.

1 Introduction

Sphenoid sinus is a pneumatic space located in the body of sphenoid bone. It is divided by a thinbone lamella, septum sinuum sphenoidalium, in two parts, the right and the left, which are usually unequal in size. The body of the sphenoid bone is cube shaped and on it we describe the the upper, lower, front and back side. The back side is visible only on the separated bone. It is linked to the pars basilaris ossis occipitalis by the cartilage until the age of 18, after which the ossification occurs and a unique bone is formed called os basilare(1). On the lateral sides, a groove called sulcus caroticus is observed, it lodges the internal carotid artery, followed by the internal carotid plexus and internal carotid venous plexus. The lesser wings of the sphenoid bone, alae minores, are separated from the front-top corner of the lateral side of the sphenoid body with two roots, which form the optical canal, the canalis opticus, through which optic nerve and ophthalmic artery pass. The greater wings, alae majores, depart from the lateral side of the trunk with three roots: front, middle and back. Between the front and the middle root there is a round opening, the foramen rotundum, through which themaxillary nerve comes out of the skull. Between the middle and back root there is an oval opening, aforamen ovale, through which the mandibular nerve exits the skull. The winged attachments, processus pterygoidei, depart from the lower side of the greater wings with two roots, forming the canal between, canalis pterygoideus, through which artery and nervus canalis pterygoidei pass (2). Ancient anatomists initially distinguished only the body and the larger wings of the sphenoid bone, comparing them with the wings of a bat or bird (3). Sinus drainage takes place through the aperture of sphenoid sinus, located in small bone plates called sphenoidal conchae. The sinus estuaries are placed on both sides of the cristae sphenoidalis (on the front of the body of the bone, along the midline), through which the sinus communicates with the sphenoethmoidal recess of the nasal cavity (4, 5). Non-enhanced multi-slice computed tomography (MSCT) of the paranasal sinus and facial lobes represents the gold standard for a wide range of indications. Especially, the extent and severity of inflammatory sinus disease can be determined, thus adding valuable information to the clinical diagnosis of rhinosinusitis [1-5]. Important information regarding bones, surgically relevant anatomical

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variants and soft tissue can be provided with high spatial resolution and contrast (6). MSCT is the most precise method for evaluating the paranasal sinuses. Multi-slice scanning in different planes in very thin layers (1-5 mm) provides the best visualization of detailed sinus anatomy, their relationship with surrounding neurovascular structures and bone cavities (7). The aim of this paper is to establish the variations of the sphenoid sinus pneumatization and the existence of multiple septa.

2 MATERIALS AND METHODS

A retrospective-prospective study was conducted at the Clinic of Radiology at the Clinical Center of the University of Sarajevo in the time period from January 2017 to the end of 2018, where major bone variations of paranasal sinuses were analyzed and interpreted. The study included 200 patients who performed MSCT of paranasal sinuses conducting the usual procedures, due to suspicion of paranasal sinus disease. All acquired data as well as work with the patients was in line with the rules and principles of the Ethical Committee of the Clinical Center of the University of Sarajevo. The study included patients aged 15-75 years, 134 male and 66 female. MSCT images were acquired on one of two MSCT scanners: CT OPTIMA 660 GE and TOSHIBA Aquilion prime 160 slice, 1.25-3 mm layer thickness (increment 1 mm). 23 axial scans with coronal and sagittal reconstructions, with a bone window (2300-2500 HU) and a window for soft tissues (300-500 HU) were made. During the analysis of the images, multiplanar reconstructions were used, which allow one image to be viewed in the axial, coronal, sagittal, and, if necessary, oblique planes. Criteria for inclusion in the study: patients older than 15 and younger than 75 years of age, patients who underwent MSCT of paranasal sinuses in the specified period according to the appropriate protocol.

Criteria for non-inclusion in the study: patients younger than 15 and over 75, patients with benign or malignant tumors of paranasal sinuses, patients in whom surgery of paranasal cavities or nasal cavity was performed, patients with traumatic lesions of paranasal sinuses and nasal cavity. Statistical analysis The results of the study were processed using descriptive statistical analysis, through the tables (database), through an absolute number of cases, percent, arithmetic mean, median, standard errors, and standard deviations. In testing the difference between sexual and age distribution, a hi-square ($\chi 2$) test was used, with Yates correction for a small number of cases in individual cells (under 5), and Fisher's exact test for 2x2 tables. Spearman's linear correlation test was used to test statistically significant correlations between individual variables. The results of all statistical tests with $p < 0.05$ or at a confidence level of 95% were considered statistically significant. Statistical analysis and results display were performed using Microsoft Excel 2012 and the IBM SPSS v19.0 statistical statistics (Chicago, Illinois, USA).

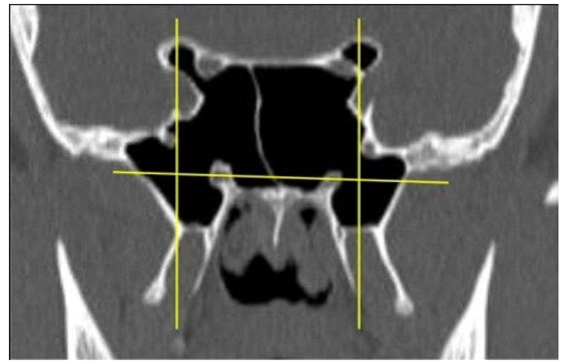
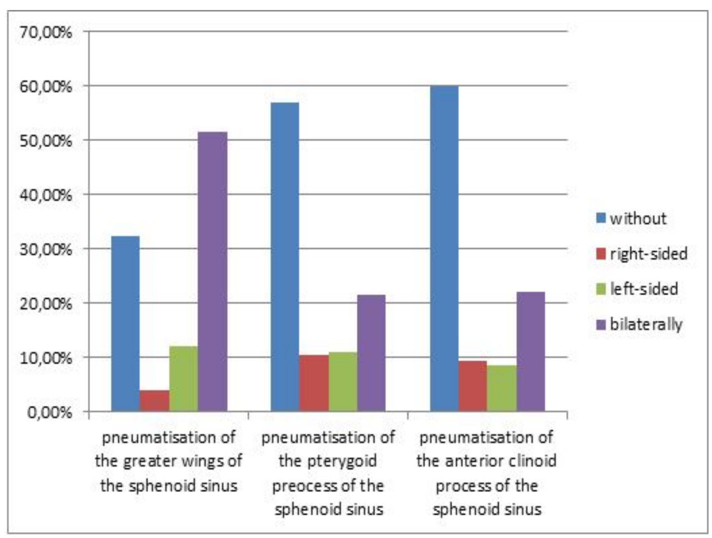


Fig 1. Pneumatization GWS, PP and ACP bilaterally

3 RESULTS

A total of 200 patients were included in the study, 134 or 67% male and 66 or 33% female, aged 15-75 years (mean age 40.1 ± 17.2 years). In the analysis of anatomical variations of the sphenoid sinus, pneumatization of the greater wings, pneumatization of the pterygoid process and pneumatization of the anterior clinoid process were analyzed (Fig. 1, Chart 1). Pneumatization of the greater wing of the sphenoid bone-GSW was present in 135 or 67% of patients. 103 or 52% of patients had bilateral pneumatization of greater wings was, while one-sided, left or right was present in 24 or 12%, or 8 or 4% of cases. In females, it was noted that bilateral and right-sided pneumatization of greater wings was more frequent, while male patients had unilateral pneumatization more often on the left.

CHART 1
Overview of the pneumatization of the sphenoid sinus structures.



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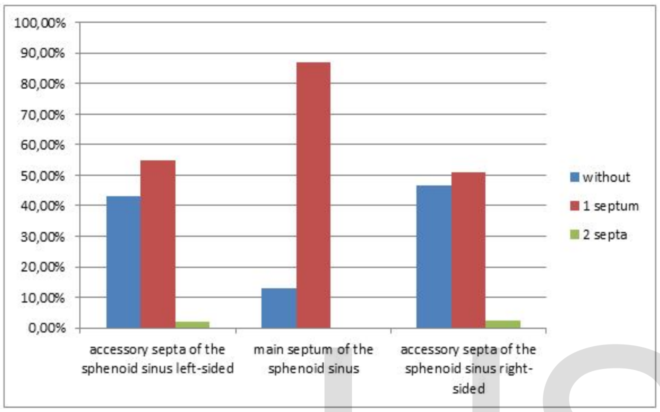
There was no statistically significant difference in the pneumatization of greater wings with respect to gender. Pneumatization of pterigoid process of the clinoid bone-PP was present in 86 or 43% of patients. In patients with pneumatization of pterygoid process, it was found that pneumatization was most commonly present on both sides (43 or 22% of cases), then left (22 or 11% of cases), and the least on the right side (21 or 10% of cases).

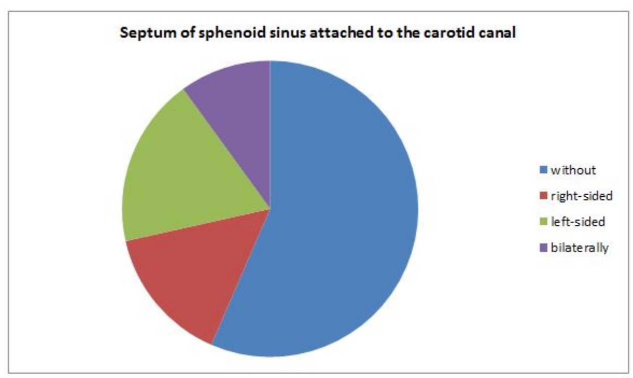
CHART 2.
Presentation of the septum of the sphenoid sinus, by number and localization



By analyzing the pneumatization of pterigoid process of the clinoid bone-PP, according to sex, we observed that in both sexes the pneumatization was present bilaterally most common, with no statistically significant difference between the sexes (p> 0.05), whereas when observed unilateral pneumatization of the pterigoid process, in men the pneumatization was more frequent on the right side and in women on the left side. The analysis shows that the pneumatization of the anterior clinoid process of the sphenoid bone-ACP was present in 80 or 40% of cases. As in the cases of pneumatization of greater wings and pterygoid process, pneumatization of the anterior clinoid process was most commonly present bilaterally (44 or 22% of cases), then on the right side (19 or 9%), and the least on the left side (17 or 9% of cases). In relation to gender, we observed that most patients have bilateral pneumatization, with no statistically significant difference between genders (p> 0.05). Unilateraly, pneumatization of the anterior clinoids in both sexes was more frequent on the right side. The presence of the main septum of the sphenoid sinus, the presence and number of accessory septa left and right as well as septa of the sphenoid sinus that are related to the carotid canal were analyzed (Chart 2). MSCT scanning revealed the presence of the main septum of the sphenoid sinus in 174 or 87% of cases. In contrast, the main septum deficiency was noted in 26 or 13% of patients.

Accessory septa were not present left in 86% or 43% of patients, one was reported in 110 or 55% of cases, and two septa in only 4 or 2% of patients. Accessory septa were not present right in 93% or 46% of patients, one was noted in 102 or 51%, and two in 5 or 3% of patients. An analysis of the septum of the sphenoid sinus shows that a main septum (174 or 87%) was present in the majority of patients, and the main septum was absent in 26 or 13% of patients. Accessory septa left were not present in 86 or 43% of patients, one was noted in 110 or 55%, and two septa only in 4 or 2% of patients. Accessory septa were not present on the right side in 93% or 46% of patients, one was noted in 102 or 51%, and two in 5 or 3% of patients. Main or so-called intersphenoid septum was present in 115 or 86% of cases in men, or 59 or 89% of female patients, with no statistically significant difference between them (p> 0.05). The existence of an accessory septum was verified in 66 or 49% of male patients and 36 or 54% of female patients. There were patients who did not have an accessory septum, 64 or 48% male and 29 or 44% female, and the rarest cases were the presence of two septa right (4 or 3% male and 1 or 2% female). There was no statistically significant difference in gender. We analyzed the presence and representation of the accessory septa of the sphenoid sinus left, according to gender. The analysis of the accessory septum of the sphenoid sinus left shows that the majority of patients had an accessory septum (76 or 57% of male patients and 34 or 52% female patients), followed by the number of patients who did not have an accessory septum (57 or 43% male and 29 or 44% female), and the rarest cases were the presence of two septa left (1 or 1% male and 3 or 5% female). We have not recorded a statistically significant gender difference (p> 0.05). In addition to the analysis of the number of septa, in this paper a special emphasis is placed on their insertion, primarily in relation to the channel of the internal carotid artery on the posterolateral wall of the sphenoid sinus (Chart 3).

CHART 3.
The depiction of the septum of the sphenoid sinus that is attached to the carotid canal



A review of the septum of the sphenoid sinus associated with the carotid canal shows that it was present in 87 or 43.5% of patients, it was most often present on the left (37 or 19% of cases), then right (30 or 15% of cases) and on both sides (20 or 10% of cases). An analysis of the septum of the sphenoid sinus that is linked to the carotid canal in relation to gender shows that in both sexes most often the septum is absent. In patients in whom we visualized the existence of a septum with insertion on the wall of the carotid canal, a more frequent presence on the left was found in both sexes. There was no statistically significant difference in sex (p> 0.05)..

4 DISCUSSION

Knowing the anatomical variations of the sphenoid sinus in the broadest sense of the word, as well as the knowledge of its relationship with surrounding structures such as the optic nerve, internal carotid artery, cavernous sinus and pituitary gland, using multidetector devices of computerized tomography is of great importance in preoperative analysis, whether it is endoscopic procedures on the sinus itself or microsurgical transsphenoid approach to the sellar or parasellar region; it shortens operative procedure time, reduces the number of complications during and after surgery. Likewise, a good knowledge of anatomical variations of the sphenoid sinus contributes to a better understanding of the possible spread of any inflammatory or any tumor processes of the sphenoid sinus to the surrounding structures and influences the choice and duration of the therapeutic procedure (8, 9). A large number of anatomical variations of the sphenoid sinus can lead to an increased risk of injury to important neurovascular and glandular structures. Extensive hyperpneumatization of the sphenoid bone with consecutive pneumatization of the anterior clinoid processes can lead to an injury to the optic nerve. Prominence of the internal carotid artery into lumen of the sinus can also lead to its injury in endoscopic surgical procedures, especially in cases of variations in the position, number, and insertion of the septum within the sinus (10).

A pneumatization summary review shows that pneumatization was most commonly present in the greater wings of the sphenoid bone-GWS, most commonly bilaterally (103 or 51%), followed by pterygoid processes-PP, also most commonly bilaterally (43 or 22%), while it was rarest in the anterior clinoid processes-ACP, also most commonly bilaterally (44 or 22% of cases). Pneumatization only on the right side was most commonly observed in pterygoid process-PP (21 or 10% of cases), then in the anterior clinoid process-ACP (19 or 10% of cases), while it was rarest in the greater wings of the sphenoid bone-GWS (8 or 4% of cases) .Pneumatization on the left side only is most commonly found in the greater wings of the sphenoid bone-GWS (24 or 12% of cases), then in the pterygoid process-PP (22 or 11% of cases), while it was rarest in the anterior clinoid process-ACP (17 or 8% of cases). Hewaidi et al. (11) analyzed the variation of paranasal sinuses in 300 Libyan patients and they found pneumatization of the greater wing of the sphenoid bone in 60 patients (20%). Possible reasons forthis great deviation of our results in comparison with the results of the Libyan authors are different diagnostic criteria, as well as the different technical parameters used during the recording, above all the thickness of the layers of 4 mm, and the scanning in the coronal plane. Another possible reason for this deviation is the different ethnicity of the human patients.

In his doctoral dissertation, Dobec Meić also analyzed the pneumatization of greater wings of the sphenoid bone in 122 patients, and penumatization was present in 33.5% of patients (12). When it comes to pneumatization of pterigoid processes-PP in our study, pneumatization was present in 86 or 43% of human patients. Pneumatisation was bilaterally present in 43 or 22% of human patients, right-sided at 21 or 10%, while left-sided was found in 22 or 11% of patients. In available worldwide studies, the pneumatization of pterygoid processes ranges from 29-43% (12). Major deviations were noted while comparing our results with the results of the Libyan authors, Hewaidi et al. which found pneumatization of the anterior clinoid processes in 15.3% of their patients (11).

Egyptian authors, Ossama Hamid et al. (13) examined the septum of the sphenoid sinus using computerized tomography in 296 patients, where in 71% of the patients the presence of a septum was found, in 10.8% of the patients the septum was absent, and 10.8% of the patients had accessory septum. In their work, they also examined septa attached to carotid canal, where they found that septum was attached to the carotid canal in 4.7% of patients. In her study, Dobec Meic also examined the septum of the sphenoid sinus, where she found the existence of the main septum in 97.5% of the patients. One septum on each side was found in 29.5% of patients, and in 9.8% of patients she found two septa on the right side, while two septa were found on the left with 7.3% of patients. Absence of the main septum was established in 2.4% of patients (12). Sareen et al. (14) investigated bony septa of sphenoid sinuses in 20 cadavers, they found that there were multiple septa in 80% of cadavers examined, while 20% had only one septum.

5 CONCLUSION

Computerized tomography is a method of choice in evaluating the variations of pneumatization of the sphenoid sinus and the existence of multiple septa whose presence increases the risk of intraoperative and postoperative complications. The combination of axial and coronal cross sections gives an insight into the whole interaction of sphenoid sinus with its surrounding neurovascular structures and bone cavities, which facilitates the understanding of pathological processes, their development and spread, and suggests and helps in the planning and realization of surgical, primarily endoscopic procedures.

6 CONFLICT OF INTERESTE

None

REFERENCES

[1] De Lano MC, Fun FY, Zinreich SJ. Relations of the optic nerve to the posterior paranasal sinuses: a CT anatomic study. Am J Neuroradiol 1996;17(4):669-675.

[2] Dilberović F, Kapur E. Osteologija. Štamaprija Fojnica, Sarajevo 2004; 13- 16,21-27, 48-52.

[3] An entire universe of the Roman world's architecture found in the human skull. Turliuc D, Turliuc □, Cucu

A, Dumitrescu G, Costea C J Hist Neurosci. 2017 Jan-Mar; 26(1):88-100.

[4] Takahashi M, Tamakawa Y, Shindo M, Konno S, Konno A. Computed tomography of the paranasal sinuses and their adjacent structures. Computerized tomography 1977;1(4):295 311.

[5] Scuderi AJ, Harnsberger HR, Boyer RS. Pneumatization of the paranasal sinuses: normal features to the acurate interpretation of CT scans and MR images. Am J Roentgenol 1993;160:1101-1104.

[6] Aksoy EA, Özden SU, Karaarslan E, Ünal ÖF, Tanyeri H. Reliability of high-pitch ultra-low-dose paranasal sinus computed tomography for evaluating paranasal sinus anatomy and sinus disease. J Craniofac Surg. 2014;25: 1801–1804.

[7] Meyers RM, Valvassori G. Interpretation of anatomic variations of computed tomography scans of the sinuses. A surgeons perspective. Laryngoscope 1998; 108(3):422-5.

[8] Vidić B. The postnatal development of the sphenoid sinus and its spread into the dorsum sellae and posterior clinoid process, Am J Roentgenol 1968; 104:177-183.

[9] Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991 Jan;101(1):56-64.

[10] Hudgins PA. Complications of endoscopic sinus surgery. Radiol Clin North Am 1993; 31:21-32.

[11] Hewaidi GH, Omami GM. Anatomic Variation of Sphenoid Sinus and Related Structures in Libyan Population: CT Scan Study. Libyan J Med 2007;AOP: 128-133.

[12] Dobec-Meić B. Prikaz anatomskih varijacija sfenoidnog sinusa kompjutoriziranom tomografijom.Zagreb,Hrvatska:Medicinski fakultet sveučilišta u Zagrebu; 2011: Doktorska disertacija.

[13] Ossama Hamid, Lobna El Fiky, Ossama Hassan, Ali Kotb, Sahar El Fiky. Anatomic Variations of the Sphenoid Sinus and Their Impact on Transsphenoid Pituitary Surgery. Skull Base 2008;18(1):9–15.

[14] Sareen D, Agarwal AK, Kaul JM, Sethi A. Study of sphenoid sinus anatomy in relation to endoscopic surgery. Int J Morphol 2005; 23(3):261- 266.