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Exceptional Vast Pneumatization of Sinus of Sphenoid Bone: A Rare Anatomical Variation

Neumatización Extensa y Excepcional del Seno del Hueso Esfenoides: Una Variación Anatómica Poco Común

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ABOREGELA, A. M. Exceptional vast pneumatization of sinus of sphenoid bone: A rare anatomical variation. *Int. J. Morphol., 43(4)*:1429-1433, 2025.

SUMMARY: The wide variability of sphenoid sinus morphology and pneumatization attracted the attention of anatomists to identify and formulate updated descriptions and classifications. These assessments are essential in preventing the complications associated with the transsphenoidal surgery. Skull Computed Tomography images of a 30-year-old Saudi healthy female with a rare accidentally found anatomical variant of sphenoid sinus pneumatization were analyzed and morphometrically assessed. The sphenoid sinus was considered as combined presellar, sellar and postsellar types with pneumatization extensions in the anterior clinoid processes, pterygoid processes, greater wings and lesser wings of sphenoid. The maximum dimensions (width, length, and height) of the sinus were 6.88, 3.09, and 3.19 cm respectively with an average volume of the whole sphenoid sinus of 29.854 cm3. A detailed case-wise preoperative radiological evaluation as well as more screening studies are required to identify such rare cases.

KEY WORDS: Volumetry; Sella Turcica; Paranasal sinuses.

INTRODUCTION

Various aeration systems are placed in the human skull of which the sphenoid sinus, an irregular double air-filled space within the sphenoid bone (Yilmaz *et al*., 2016). Great variabilities were reported in the location, shape, size, and extension of sphenoid sinuses aeration (Açar *et al*., 2024). In the sagittal plane, the extension of pneumatized sphenoid sinuses is classified into five groups in relation to the sella turcica, apneumatized (agenesis), conchal, presellar, sellar, and postsellar (Tavakoli *et al*., 2023). Regarding the coronal extension, pneumatization was found either in the greater wing of the sphenoid, pterygoid process, or the anterior clinoid process (El-Anwar *et al*., 2020). It was reported that the average vertical height of the adult sphenoid sinus is 2 cm, transverse breadth is 1.8 cm, and anteroposterior depth is 2.1 cm (Standring, 2021). The cavity of the sphenoid sinus is irregularly divided into right and left parts by a thin bony septum (Oliveira *et al*., 2017). Volumetric studies mentioned that the mean volume of each sinus cavity reaches 7.820 cm^3 in adults with average total volume of both cavities 13 cm^3 (Anusha *et al*., 2015). Patient wise careful evaluation of the sphenoid sinuses size and pneumatization extension is crucial for the surgeon to achieve a better surgical result, and maximize the patient's safety (Stokovic *et al*., 2016). The aim of this study is to spotlight a very rare previously unreported (to the author's knowledge) pattern of sphenoid sinus pneumatization that was detected accidentally in a healthy female.

MATERIAL AND METHOD

Anonymous CT scan files -Digital Imaging and Communications in Medicine- (DICOM) corresponding to the patient were retrieved from the radiology department in King Abdullah hospital based on the conjoint cooperation agreement with the College of Medicine, University of Bisha, Saudi Arabia. Also, a very brief description of the case was achieved from the records to confirm the general health status. Ethical approval and patient consent were not imposed as the study did not gain confidential data of the patient or require direct contact with her. The CT images were achieved using a Gold Seal Discovery CT750 HD with 64 channels, 64 slice per rotation, 128i overlap reconstruction and ASiR dose reduction technology ((Japan Industries Association of Radiological Systems). The following parameters were applied: exposure 120 kV, 149 mA, rotation time 0.35 s, slice thicknesses 0.6-, 1.5-, and 3-mm. Images were

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acquired in the three planes, coronal, sagittal and transverse. Morphometric assessment of the size, volume, and the extension of the sphenoid sinus pneumatization was performed considering the whole sinus as one cavity. Three-dimensional (3D) reconstruction and measurements were performed using the tools provided in RadiAnt DICOM viewer 2024.1(64-bit) software. Manual segmentation, volumetric analysis and 3D reconstruction were performed using ITK/SNAP software (Oliveira *et al*., 2017). This open-source software allows the total manual or semiautomatic mapping of the studied structure, automatic volumetric analysis of the labeled structure and 3D surface rendering with interactive manipulation (Cevidanes *et al*., 2015). Visualization and delineation adopted the sagittal section and then complemented axially and coronally. Assessments were performed in triplicates by the same trained investigator (anatomist) with a period of 15 days intervals. Measurements were conducted in centimeters (cm) and the volume of the structure was in cm^3. Means and standard deviations (SD) of different values were calculated to overcome intra-rater discrepancies.

Ethical statement. This study was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its amendments or comparable ethical standards. Based on this, ethical approval and patient consent were not mandatory as the researcher had neither directly contacted the patient nor gained any confidential data.

CASE PRESENTATION

A 30-year-old Saudi female patient arrived at the general physician outpatient clinic in King Abdullah hospital in Bisha, Saudi Arabia. The patient was complaining of infrequent minor attacks of atypical vertigo (headache and nausea). On questioning, the patient has no other current complaint with negative present history of chronic disease or medications, no evident medical or surgical history, and to the patient's knowledge there were no similar cases in the family. General evaluation of the patient revealed no abnormality. The patient was referred to the neurologist who in turn requested brain computed tomography (CT) scan. No abnormalities were reported in brain CT scans other than wide sphenoid sinus pneumatization. Some supplementary medications were prescribed, and the patient was given a follow-up appointment.

The examination of the CT in the axial plane revealed that the sphenoid sinus is formed of two wide cavities separated by a thin bony septum and extending far lateral more on the right side. The cavities appeared with irregular outlines and dehiscence of the carotid canal. The coronal section showed marked extension of sphenoid pneumatization in the greater wing, lesser wing and pterygoid processes more on the right side with dehiscence of both optic canals. Moreover, the sagittal section expressed combining presellar, sellar and postsellar types of pneumatization with extension in the anterior clinoid process and partially absence of spheno-ethmoidal septum. Presentative cuts from the three planes are shown in Figure 1. 3D reconstruction and morphometry by RadiAnt software elaborated that the maximum coronal diameter (width) of the sinus is 6.88 cm, sagittal diameter (length) is 3.09 cm and craniocaudal diameter (height) is 3.19 cm as presented in Figure 2. Irrespective of the sphenoid septum, manual segmentation and volumetric assessment by ITK/SNAP software exhibited an average volume ± SD of the whole sphenoid sinus 29.854 ± 0.509 cm^3 as displayed in Figures 3 and 4.

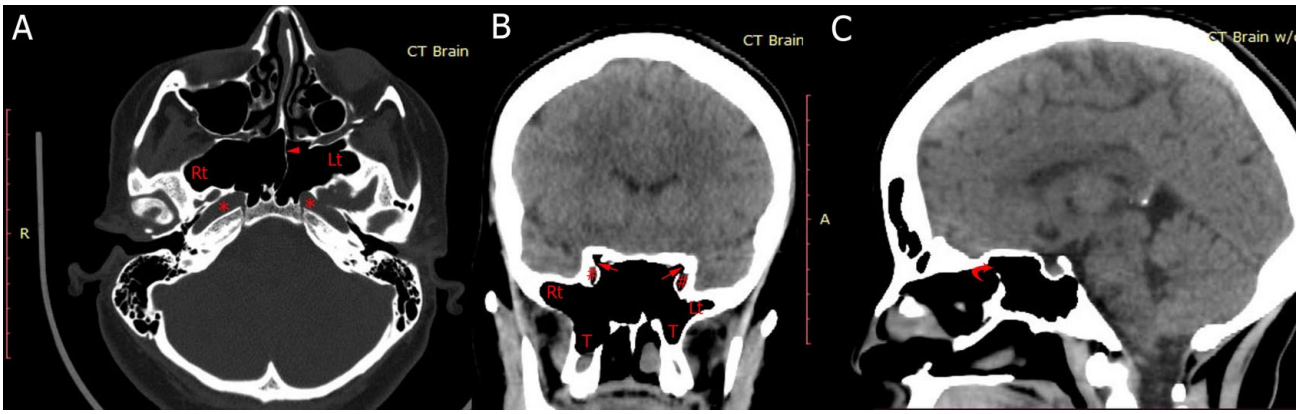

Fig. 1. Sample of CT scan cuts demonstrating the extension of sphenoid sinus pneumatization in A: Axial, B: Coronal, and C: Sagittal planes. Rt: right, Lt: left, *: carotid canal, arrowhead: sphenoid septum, #: optic canal, arrow: pneumatized lesser wing, T: pneumatized pterygoid process, curved arrow: partially absent spheno-ethmoidal septum.

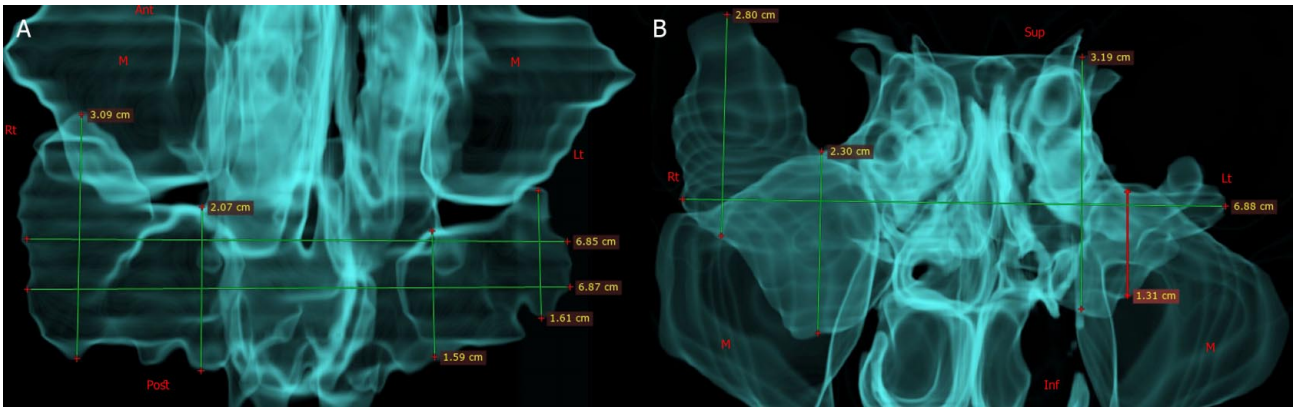

Fig. 2. Samples of the RadiAnt software 3D reconstruction air view showing several measured diameters in different planes. A: Superior view and B: Anterior view. Rt: right, Lt: left, Sup: superior, Inf: inferior, Ant: anterior, Post: posterior, M: maxillary sinus.

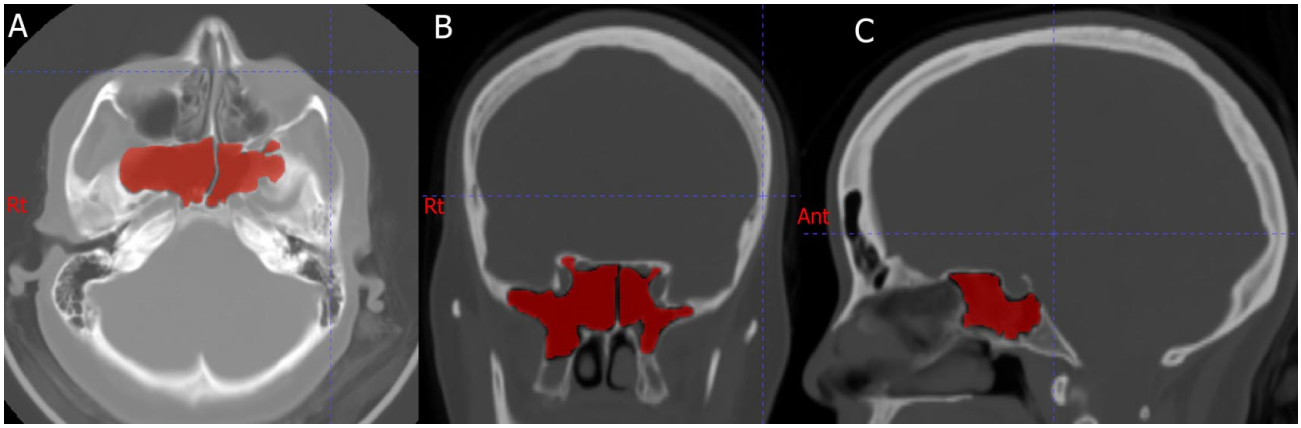

Fig. 3. CT images illustrating the strategy of manual mapping of the sphenoid sinus using the ITK/SNAP software in different planes. A: Axial, B: Coronal, and C: Sagittal. Rt: right, Ant: anterior.

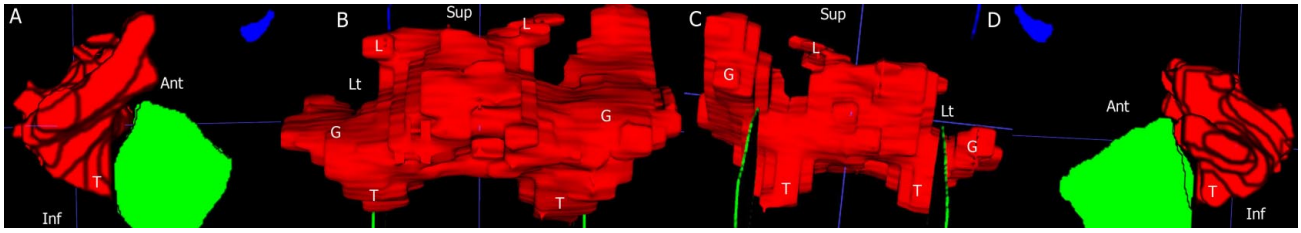

Fig. 4. Sample views of the 3D surface rendered interactive sphenoid sinus created by ITK/SNAP software. A: Right, B: Posterior, C: Anterior, and D: Left views. Lt: left, Sup: superior, Inf: inferior, Ant: anterior, G: greater wing, L: lesser wing, T: pterygoid process.

DISCUSSION

Realization of the anatomical variations in the type, size, extension, and shape of the sphenoid sinus pneumatization is of great practical importance in the surgical approaching of the pituitary gland and other structures in the skull base (Tavakoli *et al*., 2023). Sphenoid CT scan was reported as the best approach for identifying the anatomy and diversity of this region (Kumar & Selvi, 2020). Although the sphenoid sinus has usually two dissimilar cavities with one septum in between (Jaworek-Troc *et al*., 2018), it is conceived as a single cavity because the septum is being removed during surgery (Stokovic *et al*., 2016). Based on this, morphometrical analysis of the current case in the CT images considered the sphenoid sinus as a single cavity. Several studies including samples from different geographical locations described the vast diversity in the extension of sphenoid sinus pneumatization and the frequency of different patterns with consensus that the most common type is sellar and the most frequent extensions of

pneumatization are either anterior clinoid process, pterygoid process or greater wing of sphenoid (Tesfaye *et al*., 2021). In accordance with that, the current reported case resembled the sellar type with pre- and post-sellar expansion. Meanwhile, as not previously reported to the knowledge of the author, the pneumatization of the sphenoid sinus combined extensions in the anterior clinoid process, pterygoid process, greater wings and lesser wings of sphenoid. Considering the dimensions of the sphenoid sinus, the maximum reported length, width, and height were 3.45 cm, 3.5 cm, and 3.25 cm respectively (Stokovic *et al*., 2016). Interestingly, the sphenoid sinus in the current case recorded an exceptionally different dimension, especially in the width which was 6.88 cm with length of 3.09 cm and height of 3.19 cm. These measurements motivated the author to assess the volume of this sphenoid sinus. Previous volumetric studies revealed that the average size of sphenoid sinuses ± SD was 10.005 ± 5.101 cm^3 in males and 7.920 ± 3.176 cm^3 in females (Gibelli *et al*., 2018). The volume of sphenoid sinus was previously correlated with different parameters as sex, race, and the type of the sinus (Anusha *et al*., 2015; Oliveira *et al*., 2017; Cohen *et al*., 2018; Gibelli *et al*., 2018; Pirinc *et al*., 2019; Cellina *et al*., 2020). The maximum recorded size of the right sphenoid sinus was 11.993 cm^3 and that of the left one was 11.456 cm^3 so that the maximum total volume might reach 23.449 cm^3 collectively if considered for the same person (Oliveira *et al*., 2017). In the current case, the average total volume ± SD of the sphenoid sinus was 29.854 ± 0.509 cm^3 which exceeded all the previously reported in relation to sex, race, or type. This extensive expansion of the sphenoid sinus can facilitate the trans-sphenoidal endoscopic surgical approaches, however it might increase the risk of nerve lesions, intracranial hematoma, CSF leakage, and bony erosion (Tesfaye *et al*., 2021).

CONCLUSION

Considering the great variability of the sphenoid sinus anatomy and different reported classifications and correlations, a detailed patient-wise preoperative radiological evaluation is crucial. Also, more screening studies are required to identify rare cases which can help surgeons and hence update the recent classifications.

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ABOREGELA, A.M. Neumatización extensa y excepcional de l seno del hueso esfenoides: Una variación anatómica poco común. *Int. J. Morphol., 43(4)*:1429-1433, 2025.

RESUMEN: La amplia variabilidad de la morfología y la neumatización del seno del hueso esfenoides han atraído la atención de los anatomistas, quienes han buscado identificar y formular descripciones y clasificaciones actualizadas. Estas evaluaciones son esenciales para prevenir las complicaciones asociadas con la cirugía transesfenoidal. Se analizaron y evaluaron morfométricamente imágenes de tomografía computarizada craneal de una mujer saudí sana de 30 años, con una variante anatómica poco común de neumatización del seno esfenoidal, encontrado accidentalmente. El seno esfenoidal se identificó como una combinación de tipos preselar, selar y postselar, con extensiones de neumatización en los procesos clinoides anteriores, los procesos pterigoideas y las alas mayores y menores del hueso esfenoides. Las dimensiones máximas (ancho, largo y alto) del seno esfenoidal fueron de 6,88, 3,09 y 3,19 cm, respectivamente, con un volumen promedio del seno esfenoidal completo de 29,854 cm^3. Se requiere una evaluación radiológica preoperatoria detallada de cada caso, así como más estudios de cribado, para identificar estos casos poco frecuentes.

PALABRAS CLAVE: Volumetría; Silla turca; Senos paranasales.

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