www.surgicalneurologyint.com

ScientificScholar® Knowledge is power
Publisher of Scientific Journals

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Professor of Clinical Neurosurgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neuroanatomy and Neurophysiology

Editor
Seyed Ali Khonsary, MD
University of California at Los Angeles, Los Angeles, CA, USA

SNI® Open Access

Review Article

Morphometric analysis of transsphenoidal surgery in Peruvian population

Christian Alexander Yataco-Wilcas, Bruno Eduardo Diaz-Llanes, Yosimar Salomon Coasaca-Tito, Luis Alberto Lengua-Vega, Cristian Eugenio Salazar-Campos

Department of Neurosurgery, Neurozone 3D Research Center, Lima, Peru.

E-mail: Christian Alexander Yataco-Wilcas - christian.yataco.15@gmail.com; Bruno Eduardo Diaz-Llanes - brunodiazllanes@gmail.com; Yosimar Salomon Coasaca-Tito - yosimar.coasaca@unmsm.edu.pe; Luis Alberto Lengua-Vega - dr.luisalberto@gmail.com; *Cristian Eugenio Salazar-Campos - cristiansc92@gmail.com

***Corresponding author:**
Cristian Eugenio Salazar-Campos,
Department of Neurosurgery,
Neurozone 3D Research Center,
Lima, Peru.

cristiansc92@gmail.com

Received: 31 March 2024
Accepted: 16 April 2024
Published: 10 May 2024

DOI
10.25259/SNI_239_2024

Quick Response Code:

ABSTRACT

Background: Transsphenoidal surgery has become a key element in the approach to skull base pathologies. The objective of the study was to explore the morphometry of the sphenoidal region in the Peruvian population, with an emphasis on understanding its specific anatomical characteristics and providing quantitative data for the planning of transsphenoidal surgery.

Methods: A cross-sectional study included a random sample of 81 cases of healthy individuals who presented to the Radiology Department of a Private Hospital Center in Peru over 1 year. Skull computed tomography scans without contrast were performed, and a detailed morphometric analysis was conducted by an expert neurosurgeon, including measurements of four parameters to evaluate the anatomy of the craniofacial region.

Results: Most participants exhibited complete sellar pneumatization, followed by incomplete sellar pneumatization, while conchal pneumatization was rare. Significant differences were found between men and women in the distance from the nasal opening to the dorsum of the sella turcica. No significant gender differences were observed in other anatomical measurements or significant changes with age in anatomical measurements.

Conclusion: Morphometric analysis provides crucial data for the precise customization of surgical interventions in the Peruvian population, especially in transsphenoidal surgery. The results highlight the importance of considering individual anatomical differences and gender variability during surgical planning. Morphometry emerges as a valuable tool to enhance the quality and safety of transsphenoidal surgery by adapting surgical strategies to the specific anatomical dimensions of each patient.

Keywords: Morphometry, Sellar anatomy, Sphenoidal pneumatisation, Transsphenoidal surgery, Anatomical measurements

INTRODUCTION

Transsphenoidal surgery has become a key element in the approach to sellar pathologies, especially in the treatment of pituitary adenomas and other conditions related to the pituitary gland.[3] This technique, characterized by its minimally invasive nature, revolutionizes surgical intervention using the nasal route to access the sella turcica without compromising the cranial structures.[12]

Through the implementation of endoscopes and micro-instruments, detailed visualization is achieved for precise excision of skull base lesions, thus minimizing the risk of damage to adjacent tissues.[18] The precise selection of surgical instruments plays a crucial role in the complete extraction of sellar lesions during transsphenoidal interventions, with it being essential to consider the individual anatomical characteristics of each patient to achieve optimal results and minimal risks.[12,36] Thus, the evolution of transsphenoidal surgery has been accompanied by significant advances in technology and instrumentation design, offering neurosurgeons various options to address lesions in the sellar region accurately.[10,16]

At present, the philosophy of “safe surgery” has become an essential paradigm in the field of surgical interventions, emphasizing the importance of detailed planning supported by precise anatomical measurements, not only to increase patient safety but also to improve surgical outcomes.[31] The use of quantitative data and the application of planned protocols not only provide a framework for clinical decision-making but also actively contribute to risk reduction and complication prevention.[17]

Preoperative morphometric analysis of the sellar region in the Peruvian population emerges as an essential tool in planning transsphenoidal surgery, adding a crucial dimension to the precision and personalization of this neurosurgical approach. By meticulously evaluating the anatomical characteristics of the sella turcica and surrounding structures through tomographic imaging techniques, neurosurgeons can obtain specific and quantitative information about each patient’s anatomical variability.[13] This information guides surgical strategy, improving instrument selection and anatomical approach, thereby contributing to more precise extraction and minimizing potential complications.[20,35] The objective of this study is to explore the morphometry of the sellar region in the Peruvian population, delving into the understanding of its specific anatomical characteristics and providing valuable information with direct implications in the planning and execution of surgical procedures.

METHODS

Study participants

We conducted a cross-sectional study involving 81 randomly selected cases. These individuals, deemed healthy, were chosen from those who visited the Radiology Department of a Private Hospital Center in Peru between January 2023 and January 2024. The research protocol underwent review and approval by the Medical Ethics Committee of the same private hospital.

Image acquisition

Every patient underwent non-contrast computed tomography (CT) scans of their skull, and only images displaying morphometric features without alterations were used. These images were acquired using the equipment and techniques available in the Radiology Department of the Private Hospital Center. To take measurements on bone window images, we utilized a lightweight, fast, and intuitive medical image viewer, such as RadiAnt DICOM Viewer (Medixant, Poznan, Poland), ensuring optimal viewing conditions.

Image analysis

A meticulous morphometric analysis of the images was conducted, led by an experienced neurosurgeon and neuroradiologist. The main objective was to identify types of pneumatization of the sphenoid sinus, classifying them into conchal, complete sellar, and incomplete sellar [Figure 1].

In addition, specific measurements of four key parameters to evaluate the anatomy of the craniofacial region were carried out. First, the distance from the nasal opening to the sphenoid sinus was measured. Second, the assessment of the distance between the anterior and posterior edges of the sphenoid sinus. Third, the distance from the anterior skull base to the sphenoidal ostium, the opening of the sphenoid sinus. Finally, the evaluation of the distance from the floor of the sphenoid sinus to the sphenoidal ostium [Figure 2].

It is relevant to note that, in cases of conchal pneumatization, measurements from the skull base to the sphenoidal ostium and from the floor of the sphenoid sinus to the sphenoidal ostium were omitted, based on the fact that the conchal type does not have a sphenoidal ostium.

Statistical analysis

The collected information was transferred to a database and subjected to analysis using STATA software version 15. Initially, the frequency distribution of the selected variables in the sample was conducted. Subsequently, measurements of quantitative variables were represented in a normal distribution curve and tabulated, including the mean and standard deviation. To assess the statistical significance of the results, parametric statistical tests were applied. Independent samples *t*-test and analysis of variance test were used to compare means between two or more groups, respectively. In addition, the Kruskal–Wallis test was included to evaluate the significance of variables with non-normal distribution. A level of statistical significance was established at $P \leq 0.05$, considering results meeting this criterion as significant.

RESULTS

The results reveal that the majority of participants were in the age groups of 20–29 years and 30–39 years, with 32 and 18 participants, respectively. Gender distribution was balanced, with 43 male and 38 female participants totaling 81 participants

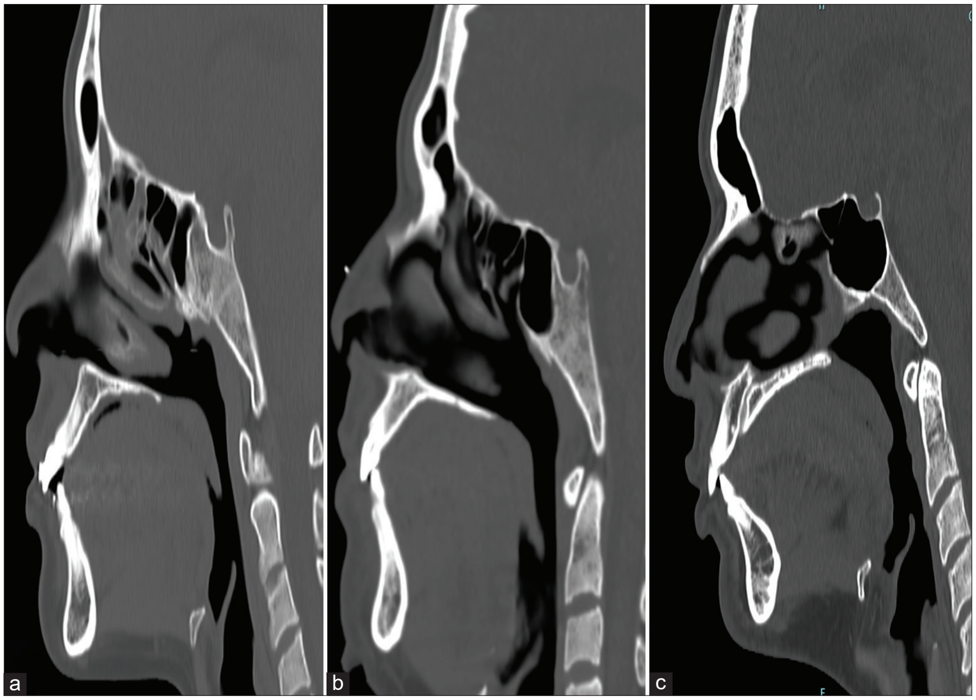

Figure 1: Types of pneumatization of the sphenoid sinus in the Peruvian population. (a) Conchal pneumatization, (b) complete sellar pneumatization, and (c) incomplete sellar pneumatization.

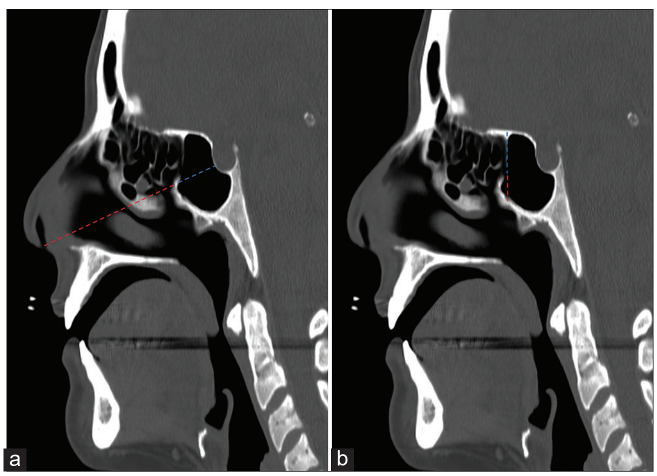

Figure 2: Measurements of the sphenoid sinus in the Peruvian population. (a) The dashed red line measured the distance from the nasal opening to the sphenoid sinus. The blue line measured the distance between the anterior and posterior borders of the sphenoid sinus. (b) The dashed blue line measures the distance from the anterior skull base to the sphenoid ostium, and the dashed red line measures the distance from the floor of the sphenoid sinus to the sphenoid ostium.

[Table 1]. Concerning the sphenoid sinus pneumatization, the majority displayed complete sellar pneumatization (64.20%), with incomplete sellar pneumatization observed in 34.57% of cases. Conchal pneumatization was evident in only one individual (1.23%) [Table 2].

Table 1: Distribution of participants by age and gender.

Group	Age	M	F	Total
1	20–29	20	12	32
2	30–39	8	10	18
3	40–49	8	7	15
4	50–59	5	5	10
5	≥60	2	4	6
	Total	43	38	81

M: Male, F: Female

The results in Table 3 indicate that conchal pneumatization was observed in only one individual in the female group, while incomplete and complete sellar pneumatization was more common in both men and women, with a slightly higher percentage in the male group.

Table 4 presents the comparison of morphometric measurements between men and women in the studied population. Statistically significant differences were found in the distance from the nasal opening to the dorsum of the sella turcica, being greater in men (mean: 91.14 mm, standard deviation [SD]: 3.64) compared to women (mean: 83.81 mm, SD: 4.52) ($P = 0.0000$). This finding indicates significant variability in this measurement between genders.

Regarding the distance between the anterior and posterior walls of the sphenoid sinus, no significant differences were observed between men (mean: 18.29 mm, SD: 2.97) and women (mean: 17.03 mm, SD: 3.00) ($P = 0.0613$). In addition, no significant differences were found in measurements from the base of the skull to the sphenoidal ostium and from the floor of the sphenoid sinus to the sphenoidal ostium between genders.

Table 5 presents the anatomical measurements of the sphenoid sinus in different age and gender groups. In the case of men, no significant changes with age were evident in the distance from the nasal opening to the dorsum of the sella turcica ($P = 0.0659$), nor measurements of the anterior and posterior walls of the sphenoid sinus, the base of the skull to the sphenoidal ostium, and the floor of the sphenoid sinus to the sphenoidal ostium. As for women, the distance from the nasal opening to the dorsum of the sella turcica and measurements between the anterior and posterior walls of the sphenoid sinus did not present statistically significant differences across ages ($P = 0.6342$ and 0.9707, respectively). The relationship between the base of the skull and the sphenoidal ostium remains constant ($P = 0.7491$), as does the distance from the floor of the sphenoid sinus to the sphenoidal ostium ($P = 0.1711$).

Table 2: Distribution of types of sphenoid sinus pneumatization.

Type	Number of individuals	Percentage
Conchal	1	1.23
Sellar incomplete	28	34.57
Sellar complete	52	64.20
Total	81	100%

Table 3: Distribution of types of sphenoid sinus pneumatization by gender and age.

	Conchal	Sellar incomplete	Sellar complete	Total
Total (%)	1	28	52	81
Male (%)	0	15 (18.52)	28 (34.75)	43
Female (%)	1 (1.23)	13 (16.05)	24 (29.35)	38
Age				
20–29	1	13	18	32
30–39	0	8	10	18
40–49	0	3	12	15
50–59	0	3	7	10
≥60	0	1	5	6

DISCUSSION

Morphometry plays an essential role in providing detailed quantitative information about the anatomy of a specific population. Previous Peruvian studies have been published on the morphometry of the foramen magnum [34]. Therefore, detailed information about the anatomy of the sphenoidal region and sella turcica is necessary. Our morphometric analysis of the sphenoid sinus not only allows for precise customization of surgical interventions, adapting strategies to the specific dimensions of the Peruvian population, but also significantly contributes to risk reduction and complication reduction by guiding the choice of instruments and surgical techniques.[9,30] A recent study conducted among the Jordanian population indicated that there were no significant variations observed in the sella turcica measurements among different genders or age groups. In addition, the predominant form of sphenoid sinus pneumatization was identified to be primarily sellar, a discovery that closely resembles our outcomes.[1] Regarding the optimization of postoperative outcomes, the application of morphometry plays a crucial role in increasing the likelihood of precise removal of sellar lesions.[21,25] As a result, this resource provides concrete and quantifiable criteria that enhance the safety and general excellence of neurosurgical interventions, thus affirming the principle of "safe surgery."[31]

Surgical planning not only customizes the intervention according to individual characteristics but also reduces risks and improves surgical outcomes by anticipating potential challenges in the operating room.[23] Analyzing preoperative imaging studies, including magnetic resonance imaging and CT scans, assists in gaining a comprehensive understanding of the complex anatomy around the sellar and parasellar regions, as well as determining the size and characteristics of the lesion requiring treatment.[36] In addition, employing triplanar radiological images and neuronavigation methods empowers neurosurgeons to navigate through anatomical structures in real-time, aiding in the prevention of inadvertent harm to critical neurovascular structures

Table 4: Comparison of morphometric measurements in millimeters of the sphenoid sinus by gender.

	Male			Female			*P*-value
	Range	Media	SD	Range	Media	SD	
Nasal opening - Dorsum of sella turcica	83.34–98.18	91.14	3.64	74.43–94.51	83.81	4.52	0.0000
Anterior wall of sphenoid sinus - Posterior wall of sphenoid sinus	14.46–25.18	18.29	2.97	10.85–22.45	17.03	3.00	0.0613
The base of the skull - Sphenoid ostium	5.26–13.59	9.56	2.00	5.77–17.11	9.53	2.15	0.9617
Floor of sphenoid sinus - Sphenoid ostium	6.36–13.82	9.6	1.74	5.35–14.74	9.30	1.95	0.4690

SD: Standard deviation

Table 5: Morphometric measurements in millimeters of the sphenoid sinus in male and female populations by age groups.

	20–29 years			30–39 years			40–49 years			50–59 years			≥60 years			*P*-value
	Range	Media	SD	Range	Media	SD	Range	Media	SD	Range	Media	SD	Range	Media	SD	
Male																
Nasal opening - Dorsum of Sella Turcica	83.34–98.18	90.74	3.35	86.49–97.82	93.11	4.23	84.19–95.22	88.74	3.14	90.45–96.39	93.68	2.54	88.25–92.77	90.51	3.20	0.0659
Anterior wall of sphenoid sinus - Posterior wall of sphenoid sinus	14.52–23.15	17.78	2.74	14.75–25.18	19.05	4.12	14.46–23.38	18.67	2.91	15.81–22.98	19.26	2.61	15.9–16.95	16.43	0.74	0.6616
The base of the skull - Sphenoid ostium	5.26–12.88	9.08	1.95	6.57–13.59	9.97	2.08	8.17–12.7	10.37	1.69	7.65–12.1	10.37	2.12	6.38–8.38	7.38	1.41	0.2134
Floor of sphenoid sinus - Sphenoid ostium	6.36–13.82	9.65	2.07	7.12–10.4	8.84	0.97	7.98–12.42	9.66	1.70	8.58–11.99	10.49	1.40	8.63–10.92	9.78	1.62	0.5357
Female																
Nasal opening - Dorsum of Sella Turcica	75.03–87.16	82.39	3.68	79.33–90.97	84.96	3.80	78.18–94.51	84.62	5.52	78.07–87.42	84.10	4.14	74.43–92.78	83.46	7.79	0.6342
Anterior wall of sphenoid sinus - Posterior wall of sphenoid sinus	10.85–22.45	16.94	3.70	12.63–22.16	17.07	3.14	11.94–19.65	16.41	2.78	13.86–21.28	17.70	2.64	15.59–19.83	17.43	2.15	0.9707
Base of skull - Sphenoid ostium	6.28–17.11	9.53	2.93	5.77–10.89	9.57	1.57	8.24–11.83	9.47	1.38	8.42–15.13	10.38	2.80	6.32–10.43	8.52	1.70	0.7491
Floor of sphenoid sinus - Sphenoid ostium	5.35–11.38	8.49	1.81	7.06–12.37	9.29	1.74	7.96–10.4	9.03	0.88	7.1–14.74	9.79	3.02	9.22–13.07	11.45	1.63	0.1711

SD: Standard deviation

during the surgical intervention.[11] In addition, multiplanar reconstructions and neuronavigation protocols deliver a detailed portrayal of tumor expansion, bone modifications, and anatomical divergences, all of which are vital for meticulous and successful surgical planning.[22] Similarly, 3D models for surgical planning have become valuable tools in planning endoscopic endonasal transsphenoidal surgery as they allow for simulating the specific surgical approach for each patient, aiding in better understanding the anatomy and avoiding intraoperative complications.[28] As a result, meticulous surgical planning is paramount for the effective management of patients with pituitary adenomas, particularly in an environment where surgical, medical, and radiological treatments have significantly progressed.[8,14] Moreover, the selection of instruments for delicate and precise manipulation of neuroanatomy aims for optimal outcomes and minimizing complications; in other words, shorter hospital stays.[4,33] Furthermore, additional studies are needed to validate these findings and determine the impact on postoperative outcomes of patients with pituitary tumors in the Peruvian population.

The frequency of the open sphenoid ostium in Peruvian anatomy raises significant questions about the suitability of the transsphenoidal approach in surgeries for pituitary tumors. This anatomical finding suggests that the transsphenoidal approach could be a viable option due to the high accessibility of the sphenoid ostium in most Peruvians, facilitating access to the sellar region without the need for additional sinus opening procedures.[27,32] However, further studies are required to confirm the efficacy and safety of this surgical approach in this specific population, emphasizing the importance of individualized evaluation of each case to optimize surgical outcomes and minimize complications.

Considering the distance and choosing the right instruments for a transsphenoidal approach is crucial for surgical planning.[5] This optimal distance between the nasal opening and the sella turcica is vital for ensuring precise and safe surgery.[19] Careful selection of surgical instruments that fit within this specific range is sought,[5] enabling efficient access and minimizing potential complications associated with anatomical variations.[15,37] This precise guidance helps customize the surgery, ensuring that both the distance and instruments used match each individual's anatomy, ultimately improving the effectiveness and safety of the procedure.

The frequent pneumatization of the sphenoid sinus in the Peruvian population is a crucial factor in surgical planning for transsphenoidal procedures. Sphenoid sinus pneumatization, characterized by air cavities, directly influences surgical strategies.[9,29] This anatomical consideration emphasizes the need for thorough preoperative assessment to anticipate and address the complexities associated with pneumatization.[24] Consistency in this feature among Peruvians allows for more precise surgical adaptation, ensuring effective management of individual anatomical variations and enhancing the safety and success of transsphenoidal surgeries.

The fact that most Peruvians have a fully pneumatized sphenoid sinus emphasizes that the transsphenoidal approach could be a feasible option for treating sellar region conditions. With this prevalent pneumatization pattern, this surgical method, known for being minimally invasive, appears effective and suitable for Peruvian patients.[6,7,26] This alignment between common anatomy and surgical technique supports the practicality and success of the transsphenoidal approach in Peru, providing a reliable basis for clinical decisions and underlining its importance in managing sellar conditions in this specific population. However, it is essential to recognize that sphenoid sinus anatomy varies widely, so morphometric data should only guide surgical planning, not replace thorough preoperative imaging assessment and intraoperative observations for each patient.[2]

CONCLUSION

The morphometric analysis highlights that complete sellar pneumatization is the most common in the Peruvian population. This study holds significant relevance for transsphenoidal surgery in Peru as it provides detailed quantitative insights into the individual anatomy of the sella turcica and surrounding structures. Moreover, the variation in the distance from the nasal opening to the dorsum of the sella turcica between males and females underscores the role of morphometry in tailoring surgical approaches precisely, thereby mitigating risks and complications by adjusting strategies according to each patient's unique anatomical characteristics.

Morphometry, akin to an artist's precise brush strokes, enables surgeons to delineate interventions meticulously, considering individual anatomical nuances and guiding instrument selection with precision. This artistry not only enhances the customization of surgical procedures but also enhances overall procedural safety by anticipating anatomical variations that influence the efficacy of transsphenoidal surgery. Thus, the fusion of morphometric analysis with surgical expertise results in a tailored and personalized approach that enhances the quality and safety of transsphenoidal surgery, specifically within the Peruvian population.

Ethical approval

The research protocol underwent review and approval by the Medical Ethics Committee of Private Hospital Center. The approval number 05-012024-115 Date 17/01/2024.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Al-Dwairy S, Al-Mousa A, Fataftah J, Tarifi AA, Al-Ani SO, Badran KH, *et al*. Morphometric analysis of the sella turcica and sphenoid sinus: A retrospective cross-sectional study. Int J Morphol 2023;41:858-62.
2. Azab WA, Abdelnabi EA, Mostafa KH, Burhamah TA, Alhaj AK, Khalil AM, *et al*. Effect of sphenoid sinus pneumatization on the surgical windows for extended endoscopic endonasal transsphenoidal surgery. World Neurosurg 2020;133:e695-701.
3. Buchfelder M, Schlaffer SM, Zhao Y. The optimal surgical techniques for pituitary tumors. Best Pract Res Clin Endocrinol Metab 2019;33:101299.
4. Cappabianca P, Cavallo LM, Esposito F, de Divitiis E. Endoscopic endonasal transsphenoidal surgery: Procedure, endoscopic equipment and instrumentation. Childs Nerv Syst 2004;20:796-801.
5. Chumnanvej S, Pillai BM, Chalongwongse S, Suthakorn J. Endonasal endoscopic transsphenoidal approach robot prototype: A cadaveric trial. Asian J Surg 2021;44:345-51.
6. Dogan ME, Kotanlı S, Yavuz Y, Wahjuningrum DA, Pawar AM. Computed tomography-based assessment of sphenoid sinus and sella turcica pneumatization analysis: A retrospective study. PeerJ 2023;11:e16623.
7. ELKammash TH, Enaba MM, Awadalla AM. Variability in sphenoid sinus pneumatization and its impact upon reduction of complications following sellar region surgeries. Egypt J Radiol Nucl Med 2014;45:705-14.
8. Enkaoua A, Islam M, Ramalhinho J, Dowrick T, Booker J, Khan DZ, *et al*. Image-guidance in endoscopic pituitary surgery: An *in-silico* study of errors involved in tracker-based techniques. Front Surg 2023;10:1222859.
9. Famurewa OC, Ibitoye BO, Ameye SA, Asaleye CM, Ayoola OO, Onigbinde OS. Sphenoid sinus pneumatization, septation, and the internal carotid artery: A computed tomography study. Niger Med J 2018;59:7-13.
10. Gandhi CD, Christiano LD, Eloy JA, Prestigiacomo CJ, Post KD. The historical evolution of transsphenoidal surgery: Facilitation by technological advances. Neurosurg Focus 2009;27:E8.
11. García-Garrigós E, Arenas-Jiménez JJ, Monjas-Cánovas I, Abarca-Olivas J, Cortés-Vela JJ, De La Hoz-Rosa J, *et al*. Transsphenoidal approach in endoscopic endonasal surgery for skull base lesions: What radiologists and surgeons need to know. RadioGraphics 2015;35:1170-85.
12. Hanson M, Li H, Geer E, Karimi S, Tabar V, Cohen MA. Perioperative management of endoscopic transsphenoidal pituitary surgery. World J Otorhinolaryngol Head Neck Surg 2020;6:84-93.
13. Iskra T, Stachera B, Możdżeń K, Murawska A, Ostrowski P,

Bonczar M, *et al*. Morphology of the sella turcica: A meta-analysis based on the results of 18,364 patients. Brain Sci 2023;13:1208.
14. Khan DZ, Hanrahan JG, Baldeweg SE, Dorward NL, Stoyanov D, Marcus HJ. Current and future advances in surgical therapy for pituitary adenoma. Endocr Rev 2023;44:947-59.
15. Van Lindert EJ, Ingels K, Mylanus E, Grotenhuis JA. Variations of endonasal anatomy: Relevance for the endoscopic endonasal transsphenoidal approach. Acta Neurochir (Wien) 2010;152:1015-20.
16. Liu JK, Das K, Weiss MH, Laws ER Jr., Couldwell WT. The history and evolution of transsphenoidal surgery. J Neurosurg 2001;95:1083-96.
17. Lobatto DJ, de Vries F, Zamanipoor Najafabadi AH, Pereira AM, Peul WC, Vliet Vlieland TP, *et al*. Preoperative risk factors for postoperative complications in endoscopic pituitary surgery: A systematic review. Pituitary 2018;21:84-97.
18. Louis RG, Eisenberg A, Barkhoudarian G, Griffiths C, Kelly DF. Evolution of minimally invasive approaches to the sella and parasellar region. Int Arch Otorhinolaryngol 2014;18:S136-48.
19. Luzzi S, Giotta Lucifero A, Rabski J, Kadri PA, Al-Mefty O. The party wall: Redefining the indications of transcranial approaches for giant pituitary adenomas in endoscopic era. Cancers 2023;15:2235.
20. Elhadi AM, Hardesty DA, Zaidi HA, Kalani MY, Nakaji P, White W, *et al*. Evaluation of surgical freedom for microscopic and endoscopic transsphenoidal approaches to the sella. Neurosurgery 2015;11 (Suppl 2):69-78; discussion 78-9.
21. Maia R, Miranda A, Geraldo AF, Sampaio L, Ramaglia A, Tortora D, *et al*. Neuroimaging of pediatric tumors of the sellar region-A review in light of the 2021 WHO classification of tumors of the central nervous system. Front Pediatr 2023;11:1162654.
22. Orringer DA, Golby A, Jolesz F. Neuronavigation in the surgical management of brain tumors: Current and future trends. Expert Rev Med Devices 2012;9:491-500.
23. Raappana A, Koivukangas J, Pirilä T. 3D modeling-based surgical planning in transsphenoidal pituitary surgery - preliminary results. Acta Otolaryngol (Stockh) 2008;128:1011-8.
24. Raseman J, Guryildirim M, Beer-Furlan A, Jhaveri M, Tajudeen BA, Byrne RW, *et al*. Preoperative computed tomography imaging of the sphenoid sinus: Striving towards safe transsphenoidal surgery. J Neurol Surg Part B Skull Base 2020;81:251-62.
25. Sari S, Sari E, Akgun V, Ozcan E, Ince S, Saldir M, *et al*. Measures of pituitary gland and stalk: From neonate to adolescence. J Pediatr Endocrinol Metab 2014;27:1071-6.
26. Sevinc O, Is M, Barut C, Erdogan A. Anatomic variations of sphenoid sinus pneumatization in a sample of Turkish population: MRI study. Int J Morphol 2014;32:1140-3.
27. Shin JH, Kang SG, Hong YK, Jeun SS, Kim SW, Kim SW, *et al*. Role of the superior turbinate when performing endoscopic endonasal transsphenoidal approach. Folia Morphol 2014;73:73-8.
28. Shinomiya A, Shindo A, Kawanishi M, Miyake K, Nakamura T, Matsubara S, *et al*. Usefulness of the 3D virtual visualization surgical planning simulation and 3D model for endoscopic endonasal transsphenoidal surgery of pituitary adenoma: Technical report and review of literature. Interdiscip Neurosurg 2018;13:13-9.
29. Şimşek S, İşlek A. Pneumatization of the sphenoid sinus is the major factor determining the variations of adjacent vital structures. Egypt J Otolaryngol 2024;40:2.
30. Štoković N, Trkulja V, Dumić-Čule I, Čuković-Bagić I, Lauc T, Vukičević S, *et al*. Sphenoid sinus types, dimensions and relationship with surrounding structures. Ann Anat 2016;203:69-76.
31. Venneri F, Brown LB, Cammelli F, Haut ER. Safe surgery saves lives. In: Donaldson L, Ricciardi W, Sheridan S, Tartaglia R, editors. Textbook of patient safety and clinical risk management. Cham: Springer International Publishing; 2021. p. 177-88.
32. Wei LF, Zhang J, Chen HJ, Wang R. Value of anatomical landmarks in single-nostril endonasal transnasal-sphenoidal surgery. Exp Ther Med 2013;5:1057-62.
33. Yan JL, Chang CN, Chen PY. Endoscopic transsphenoidal surgery for resection of pituitary macroadenoma: A retrospective study. PLoS One 2021;16:e0255599.
34. Yataco-Wilcas CA, Salazar-Ascurra A, Diaz-Llanes BE, Coasaca-Tito YS, Lengua-Vega LA, Salazar-Campos CE. Morphometric analysis of the foramen magnum in the Peruvian population. Surg Neurol Int 2024;15:9.
35. Zada G, Agarwalla PK, Mukundan S Jr., Dunn I, Golby AJ, Laws E Jr. The neurosurgical anatomy of the sphenoid sinus and sellar floor in endoscopic transsphenoidal surgery. J Neurosurg 2011;114:1319-30.
36. Zada G, Woodmansee WW, Iuliano S, Laws ER. Perioperative management of patients undergoing transsphenoidal pituitary surgery. Asian J Neurosurg 2010;5:1-6.
37. Zhan G, Guo S, Hu H, Liao J, Dang R, Yang Y. Expanded endoscopic endonasal transsphenoidal approach to determine morphological characteristics and clinical considerations of the cavernous sinus venous spaces. Sci Rep 2022;12:16794.

How to cite this article: Yataco-Wilcas CA, Diaz-Llanes BE, Coasaca-Tito YS, Lengua-Vega LA, Salazar-Campos CE. Morphometric analysis of transsphenoidal surgery in Peruvian population. Surg Neurol Int. 2024;15:156. doi: 10.25259/SNI_239_2024