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Tomographic classification proposal for safe endoscopic surgery of the sphenoid sinus

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Abstract

Introduction: *Sphenoidal sinus surgery and transsphenoidal approaches are commonly used by ENT surgeons and neurosurgeons to treat various pathologies. Radiological evaluation of this area is essential to identify neurovascular structures and their anatomical relationships.* **Objective:** *To propose a pre-surgical classification system for the sphenoid sinus, where risk groups are established in relation to neurovascular structures, with an alphanumeric code.* **Methods:** *Retrospective study, with simple computed tomography scans of the nose and paranasal sinuses of patients from the otolaryngology and head and neck surgery service of the General Hospital of Mexico. Classified according to the transverse diameter of the sphenoid sinus: I, < 29 mm; II, 29-39.9 mm; and III, > 40 mm. The lateralization of included elements is their light: L, left; R, right; and B, bilateral. Anatomical element involved: N, optic nerve; V, internal carotid artery; and O, another type of element.* **Results:** *200 imaging studies were analyzed. The average age of the population studied was 36.2 years. 49.5% were men (n = 99) and 50.5% (n = 101) women. Grade III presents a higher risk by compromising neurovascular structures in 90.6%. The general lateralization presented was 13.5% to the right side and 13% to the contralateral side. Isolated optic nerve protrusion occurred in 13.5% (n = 11), protruding internal carotid was found in 40% (n = 80), and in 7.5% (n = 15) both elements were found protruding towards the lumen of the sphenoid sinus.* **Conclusions:** *The proposed classification facilitates the transmission of information to the surgical team, prior to surgery, with a simple alphanumeric code, increasing the safety of the surgical procedure.*

Keywords: *Sphenoid sinus. Internal carotid artery. Ophthalmic nerve. Functional endoscopic sinus surgery.*

Introduction

The sphenoidal sinus is located q5 the center of the base of the skull, as a mucosa-lined, pneumatised, and unique cavity[1]. It has an approximate volume of 7.5 mm^3 in adults[2,3]. Inside, multiple structures can be observed that mark different anatomical regions: cavernous sinus, internal carotid artery, frontal lobe, central surface of the brainstem, cranial nerves III-VI, and pituitary gland[4,5].

The anatomical relations of the sphenoidal sinus begin with the optic nerve, which runs anterior to posteroinferior and lateral in relation to the sphenoidal sinus; the internal carotid artery ascends in its posterolateral portion; between these reliefs, the opticarotid recess or groove can be seen[4-7]. The optic nerve passes superior and lateral to the sphenoidal sinus. However, it can sometimes protrude into it[3]. This happens when there is excessive pneumatization of the

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sphenoid base and, therefore, the proximity of these neurovascular structures through a potentially thin bony separation, or even bony dehiscence, making these structures vulnerable to injuries during ethmoidectomy or sphenoidotomy[3,4,8].

Sphenoidal sinus surgery and transsphenoidal approaches are commonly used by ENT surgeons and neurosurgeons to treat various conditions[9,10]. Radiological evaluation of this area in the pre- and postoperative stages is crucial to identify neurovascular structures and their anatomical relationships and helps reduce possible complications during and after the intervention[9].

Computed tomography (CT) of the nasal cavities and paranasal sinuses has shown interest in categorizing patterns of pneumatization and anatomical variants, and is also the best method to evaluate the anatomy of the paranasal sinuses and the base of the skull[9,11-13].

There are different classifications that describe the pneumatization of sphenoidal sinus. One of the most widely used is the one proposed by Congdon in 1920, which considers 3 types of pneumatization with respect to the sella turcica, evaluating them in a sagittal plane: type I, conchal; type II, presellar; and type III, sellar[1,14].

The relation of the internal carotid artery focusing on the parasellar (coronal plane) and paraclival (axial plane) segments is classified considering the lateral and posterior spread of the sphenoidal sinus, where the following types can be found: no protrusion of the internal carotid artery, protrusion of the internal carotid artery (defined as > 50% protrusion of the structure into the sphenoidal sinus), and dehiscent[9].

Finally, another one of the most widely used classifications for radiological analysis is when there is or there is no septation within the sphenoidal sinus, analyzing the variants in the axial or coronal plane, and describing them with respect to their unique, multiple, or lateralized presence[9,15].

So far, there is no analysis in the literature of the patterns of sphenoidal sinus pneumatization in the Mexican population. Despite having various tomographic classifications of the different types of sphenoidal sinus pneumatization, these do not describe the neurovascular elements that pose surgical risk.

The objective of this study is to describe the prevalence of the different types of sphenoidal sinus pneumatization in the Mexican population and propose a new preoperative tomographic classification system to establish surgical risk groups in relation to neurovascular structures.

Method

We conducted a retrospective, observational, and cross-sectional study by analyzing 225 simple CT studies of the nasal cavities and paranasal sinuses performed in patients evaluated by the otorhinolaryngology and head and neck surgery service of Hospital General de Mexico, as part of the study protocol for nasal obstruction in our institution from May 1st, 2018 through November 31st, 2021.

The inclusion criteria were: simple CT images of the nasal cavities and paranasal sinuses, with 0.2 mm multiplanar views (axial, coronal, sagittal), bone window of Mexican patients of both sexes aged older than 18 years and younger than 85 years acquired by the radiology and imaging service of Hospital General de Mexico. Exclusion criteria were CT studies of patients with a history of sphenoidal sinus surgery or with presence of inflammatory, neoplastic, or traumatic lesions inside of it.

For the validity of the study, 5 independent reviewers made measurements of the diameters of the sphenoidal sinus and identified neurovascular structures and their relationship with the sphenoidal sinus. They were tomographically classified in the sagittal plane using Congdon classification[1], and subsequently, the proposed new classification was applied (Table 1) , and the examples represented (Figs. 1-5). By applying this scale, 2 types of sphenoidal sinuses can be tomographically stratified:

- Low risk: I, with or without involvement of anatomical elements.
- High risk: II or III, with or without involvement of anatomical elements

Results

A total of 225 simple CT scans were analyzed, 200 of which met the inclusion criteria and 25 were excluded based on the exclusion criteria (10 did not have multiplanar views, 3 did not have a bone window, 2 had a history of sphenoidal surgery, and 10 had sphenoidal lesions).

The mean age of the studied population was 36.2 years (range, 18-79); 49.5% were men (n = 99) and 50.5% (n = 101), women.

With respect to the previous Congdon classification, the studied population presented the following results: conchal 1.5% (n = 3), sellar 84.5% (n = 169), and presellar 14% (n = 28).

Applying the proposed new classification, the following data were found:

Table 1. Proposed classification

Grade of pneumatization of the sphenoidal sinus based on its widest transverse diameter in the coronal vs the axial view	
I	< 29 mm
II	29.1-39.9 mm
III	> 40 mm
Laterality (elements included inside the sinus lumen)	
L	Elements included on the left side
R	Elements included on the right side
B	Elements present bilaterally
Anatomical element involved, included inside the lumen of the sphenoidal sinus	
N	Neurological element (optic nerve)
V	Vascular element (internal carotid artery)
O	Other types of elements (meninges, brain tissue, cerebrospinal fluid, etc.)
Intersinus septum	
/	Intersinus septum inserted on the left side
\	Intersinus septum inserted on the right side
M	Multiple intersinus septa directed to both sides

- Degree of sphenoidal sinus pneumatization based on its widest transverse diameter in the coronal vs the axial plane, considering asymmetries and anatomical variants: 21.5% (n = 43) fell into classification I, and 16.2% of these (n = 7) had anatomical elements occupying space within the lumen of the sphenoidal sinus; 46.5% of the overall population (n = 93) fell into classification II, and 55.9% of these (n = 52) had anatomical elements observed within the sphenoidal sinus; and finally, 32% of the population (n = 64) fell within classification III, 90.6% of which (n = 58) had anatomical elements within the lumen of the sphenoidal sinus.
- Laterality: anatomical elements slightly predominated on the right (13.5%, n = 27) vs the left side (13%, n = 26). In 25% of the cases (n = 50), symmetry was found, with neurovascular elements on both sides.
- Anatomical Element: in 47% of cases (n = 94), no neurovascular elements were observed within the sphenoidal sinus; in 5.5% (n = 11), the isolated presence of the optic nerve was found within the sphenoidal lumen; 40% of cases (n = 80) showed their internal carotid artery within the sphenoidal sinus either partially or totally; and in 7.5% of cases (n = 15) both the internal carotid artery and the optic nerve were found within the lumen of the sphenoidal sinus.
- Intersinus septum: a total of 33% of cases (n = 66) exhibited an intersinus septum inserted in the bony wall surrounding the carotid artery. In 13.5% of these (n = 27), the intersinus septum was directed towards the right side, in 16% (n = 33) towards the left side, and in 3% (n = 6) to both sides.

Discussion

The sphenoidal sinus is surgically complex. With CT, we can have preoperative images that brings us closer to the real intraoperative view, aimed at reducing complications. However, there is still room for improvement, in which the nature of these studies can be leveraged by implementing a simple alphanumeric code that allows the surgeon to gather the most relevant information from the topographic study on the regions that might pose some risk to important vascular or neurological structures.

In this study, different types of sphenoidal sinus pneumatization are described, with the sellar type being the most frequent (84.9%), which is similar to the 98% rate reported by Prabu et al.[16]

Regarding the proposed classification, it is evident that, in terms of pneumatization, grade III poses a greater risk by involving anatomical structures in 90.6% of the analyzed studies. The slight presence of lateralization to the right side—with 13.5%, vs 13% on the contralateral side—is a notable finding too. The isolated protrusion of the optic nerve was reported in 5.5% of cases vs the 8% to 70% reported by the currently available scientific medical literature[17].

In this study, we found that the internal carotid artery is located within the lumen of the sphenoidal sinus in 40% of the cases, while Dal Secchi et al.[4] describe protrusion in 61%; however, this feature has been reported to vary from 26.1% up to 67%[16], which is consistent with our data. Additionally, the presence of dehiscent or thin bony coverage of the internal carotid

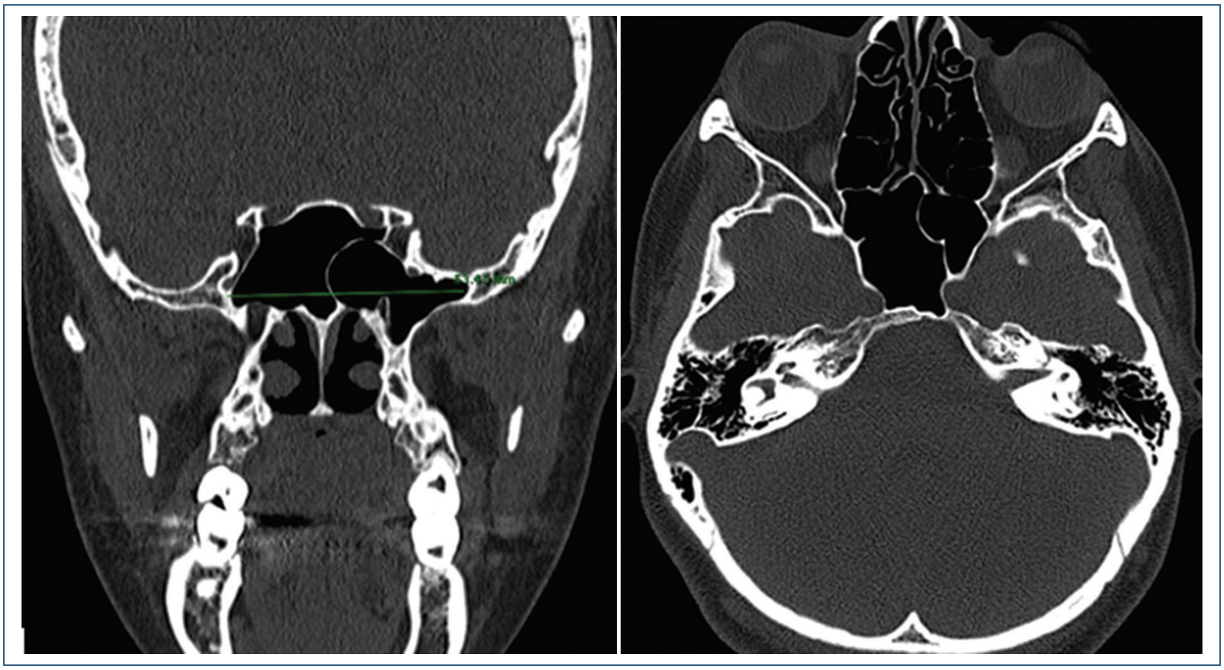

Figure 1. Simple computed tomography of the nose and paranasal sinuses in axial and coronal views detailing surgical risk III L V N/based on the proposed classification.

Figure 2. Simple computed tomography of the nose and paranasal sinuses in axial and coronal views detailing surgical risk II B V/based on the proposed classification.

artery has been reported in up to 4%, and in our study, it appeared in 8%, making it essential for the surgeon to be informed of these variants to avoid vital complications[18].

The protrusion of both neurovascular structures was present in 7.5% of all cases studied; in this group, 66.6% had these elements on both sides of the sphenoidal

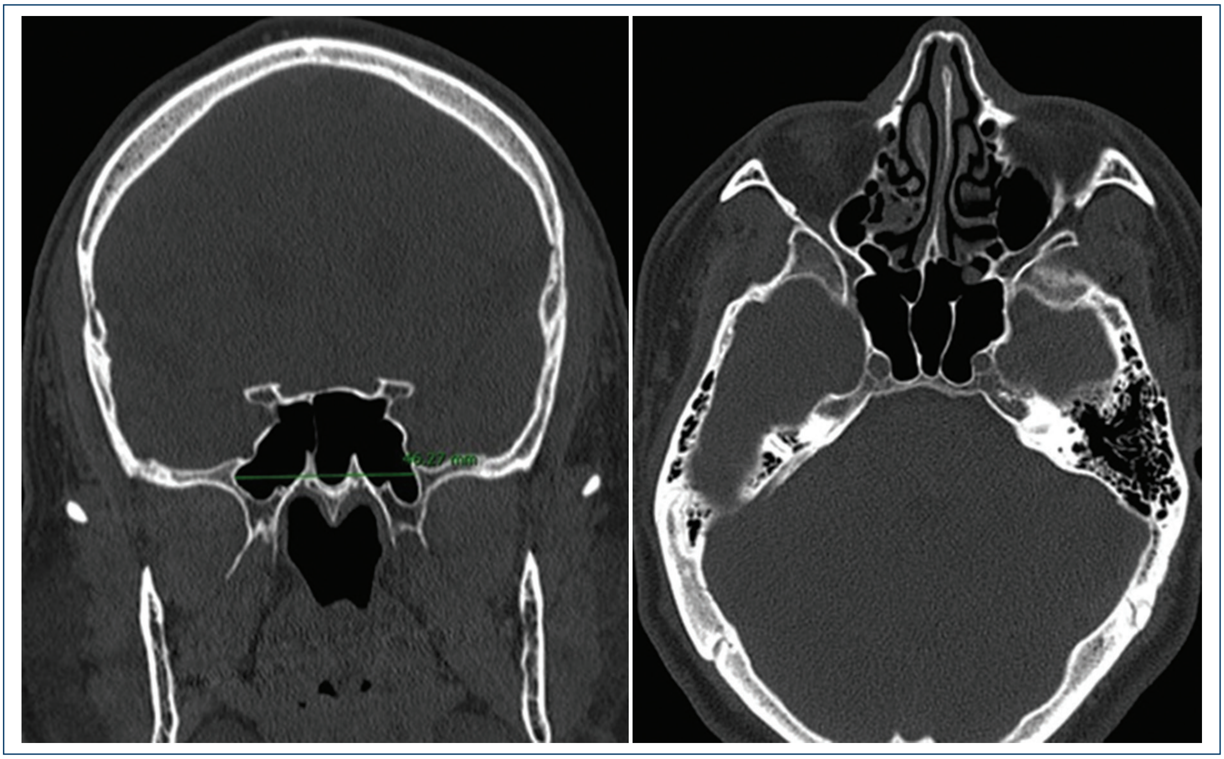

Figure 3. Simple computed tomography of the nose and paranasal sinuses in axial and coronal views detailing surgical risk III B V B N based on the proposed classification.

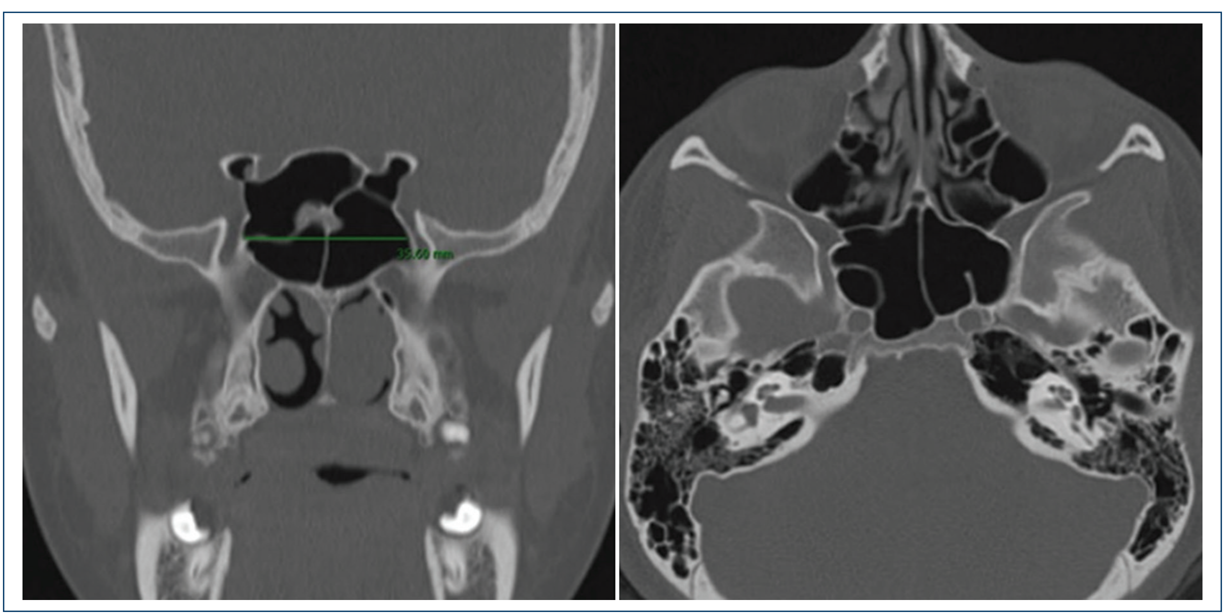

Figure 4. Simple computed tomography of the nose and paranasal sinuses in axial and coronal views detailing surgical risk III R V B N M based on the proposed classification.

sinus, which complicated the surgery and required advanced surgical skills from the surgeon.

Regarding the intersinus septum, 33% (n = 66) were inserted in neurovascular structures, predominantly on the left side in 16.5% (n = 33). It has been reported that during surgery, we should be extremely cautious before fracturing or removing these septa, as it is safer not to manipulate them unless strictly necessary[18].

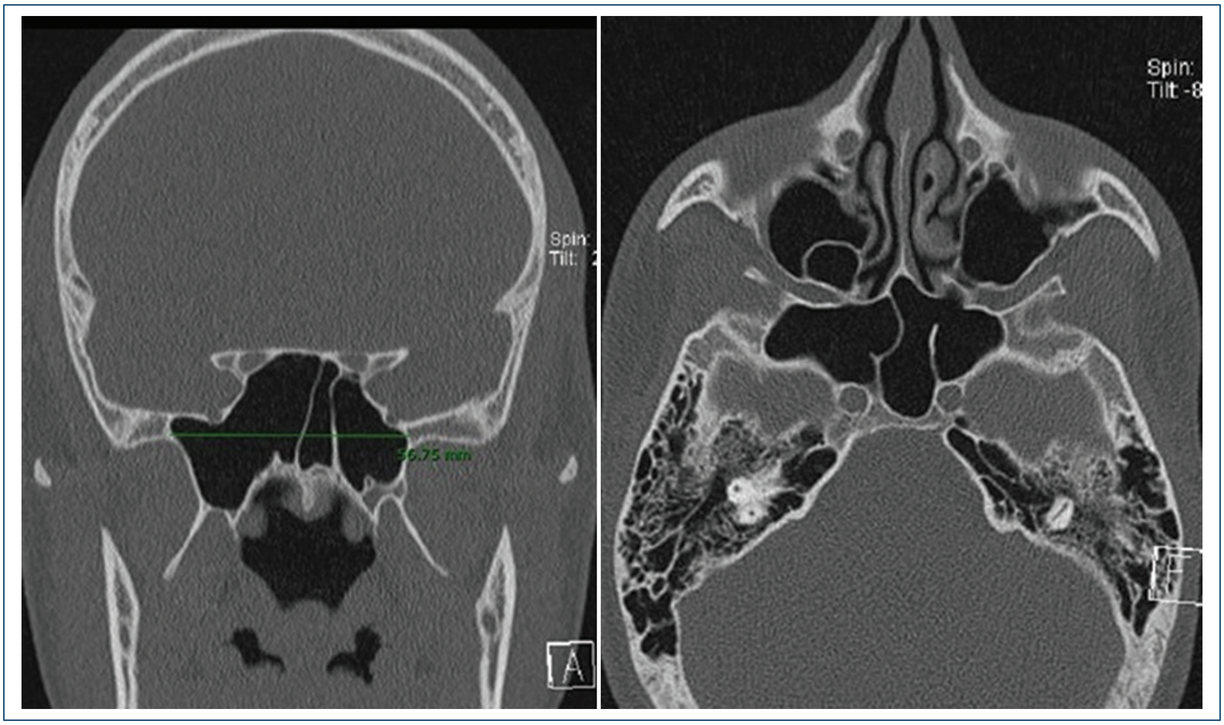

Figure 5. Simple computed tomography of the nose and paranasal sinuses in axial and coronal views detailing surgical risk III B V R N/based on the proposed classification.

The literature describes classifications similar to the one proposed here, such as DeLano et al.[19], who categorize the relationship of the optic nerve with the posterior paranasal sinuses into 4 subtypes:

- Type 1: The optic nerve runs adjacent to the sphenoidal sinus without indentation of the sinus wall.
- Type 2: The optic nerve runs adjacent to the sphenoidal sinus, causing indentation of the sinus wall.
- Type 3: The nerves run through the sphenoidal sinus.
- Type 4: The nerves pass immediately adjacent to the sphenoidal sinus and the posterior ethmoidal cell.

Our classification does not seek to replace DeLano's classification but rather be an add-on to it because it implicitly describes the involvement of both the optic nerve and the internal carotid artery with the sphenoidal sinus, as well as its degree of pneumatization, in a simple and relevant way.

The relevance of the new classification lies in facilitating the precise transmission of information to the surgical team and even patients. Taking, for example, patient #39 from our database, we can state that they have a high-risk classification: III L N V/ (Fig. 1). By becoming familiar with the classification, we would immediately have information about the patient and know that:

- The sphenoidal sinus measured in its transverse diameter is highly pneumatized, with > 40 mm (III).
- Anatomical elements are found on the left side of the sphenoidal sinus, being in this case the internal carotid artery and the optic nerve, which could lead to a potentially catastrophic outcome if not anticipated (L, N, V).
- There is an intersinus septum on the left side.

In this way, we ensure an adequate transmission of information to the surgical team, briefly and meaningfully, helping reduce possible complications during surgery in this region.

The limitations of our study are that in patients with deficient pneumatization, such as those younger than 12 years, this classification is not applicable. Additionally, for the measurement and evaluation of the structures to be studied, an adequate position of the patient during the tomographic study is required; in our institution, multiplanar reconstruction is performed to correct the position and thereby analyze the studies.

Certainly, although it is an easy-to-use scale due to its simple symbolism, it does not replace the surgeon's evaluation, skills, or experience; it is only an aid to reduce the probable risk during the inherently complicated surgical event.

Conclusions

With the advancement of technology, new protocols are created to improve patient care. CT scans are widely used in the clinical and surgical fields.

The anatomical description performed in the Mexican population presents variations, which are similar to those described in various international studies, so we consider that the external validity of this study has universal application.

The relevance of the proposed new classification lies in establishing a simple language for all surgeons who treat the sphenoidal sinus, increasing the safety of the surgical procedure, as well as the study and approach of the patient, facilitating the transmission of information with an alphanumeric code, whose premise is to serve as a prelude to creating better proposals in the future.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Confidentiality of data. The authors declare that no patient data appear in this article. Furthermore, they have acknowledged and followed the recommendations as per the SAGER guidelines depending on the type and nature of the study.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of images, graphics, tables, or their corresponding captions.

References

1. Ruiz-Aburto AA, Valenzuela CS, Yáñez LA, Lemp MM, Sanhueza ZA, Olivares SP. Radiologic anatomy of sphenoidal sinus, analysis of 120 surgically intervened patients. Rev Chil Neurocir. 2015;41:54-8.
2. Rahmati A, Ghafari R, Anjomshoa M. Normal variations of sphenoid sinus and the adjacent structures detected in cone beam computed tomography. J Dent. 2016;17:32-7.
3. Wang J, Bidari S, Inoue K, Yang H, Rhoton A. Extensions of the sphenoid sinus: a new classification. Neurosurgery. 2010;66:797-816.
4. Dal Secchi MM, Dolci RLL, Teixeira R, Lazarini PR. An analysis of anatomic variations of the sphenoid sinus and its relationship to the internal carotid artery. Int Arch Otorhinolaryngol. 2018;22:161-6.
5. García-Pastor C, Moreno-Jiménez S, Gómez-Llata Andrade S. Microanatomía de la región selar y paraclinoidea en especímenes mexicanos. Arch Neuroci. 2005;10:212-20.
6. Maza G, VanKoevering KK, Yanez-Siller JC, Baglam T, Otto BA, Prevedello DM, et al. Surgical simulation of a catastrophic internal carotid artery injury: a laser-sintered model. Int Forum Allergy Rhinol.2019;9:53-9.
7. Silva Méndez-Bengassi I, Vasallo García V, Cenjor Español C. Anatomía y embriología de la nariz y senos paranasales. Libr Virtual Form en ORL. 2017;(41):1-34.
8. Vaezi A, Cardenas E, Pinheiro-Neto C, Paluzzi A, Branstetter BF, Gardner PA, et al. Classification of sphenoid sinus pneumatization: relevance for endoscopic skull base surgery. Laryngoscope. 2015;125:577-81.
9. Lakhani M, Sadiq M, Mukhtar S. Sphenoid sinus anatomical relations and their implications in endoscopic sinus surgery. Int J Med Res Health Sci. 2017;6:162-6.
10. Malone A, Bruni M, Wong R, Tabor M, Boyev KP. Pneumatization patterns of the petrous apex and lateral sphenoid recess. J Neurol Surgery. 2017;78:441-6.
11. Yazici D. Evaluation of anatomical variations on paranasal sinus computed tomography. ENT Update. 2018;8:175-9.
12. Marino MJ, Weinstein JE, Riley CA, Levy JM, Emerson NA, Mccoul ED. Assessment of pneumatization of the paranasal sinuses: a comprehensive and validated metric. Int Forum Allergy Rhinol. 2016;6:429-36.
13. Ilków W, Waligóra M, Kunc M, Kucharzewski M. Pneumatization of the sphenoid sinus, dorsum sellae and posterior clinoid processes in computed tomography. Polish J Radiol. 2018;83:366-71.
14. Tomovic S, Esmaeili A, Chan NJ, Shukla PA, Choudhry OJ, Liu JK, et al. High-resolution computed tomography analysis of variations of the sphenoid sinus. J Neurol Surgery. 2013;74:82-90.
15. Awadalla AM, Hussein Y, ElKammash TH. Anatomical and radiological parameters of the sphenoid sinus among Egyptians and its impact on sellar region. Egypt J Neurosurg. 2015;30:1-12.
16. Prabu SS, Veerapandian R, Prgadhees R, Pradeep S, Rajendran M. Neurovascular variations of sphenoid sinus: impact on transsphenoidal surgery. Int J Sci Study. 2018;6:5-9.
17. Fasunla AJ, Ameye SA, Adebola OS, Ogbole G, Adeleye AO, Adekanmi AJ. Anatomical variations of the sphenoid sinus and nearby neurovascular structures seen on computed tomography of black Africans. East Cent African J Surg. 2012;17:57-64.
18. Kang YJ, Lee IH, Kim SW, Kim DH. Surgical and radiological differences in intersphenoid sinus septation and the prevalence of Onodi cells with the endoscopic endonasal transsphenoidal approach. Medicina (Kaunas). 2022;58:1479.
19. DeLano MC, Fun FY, Zinreich SJ. Relationship of the optic nerve to the posterior paranasal sinuses: a CT anatomic study. AJNR Am J Neuroradiol. 1996;17:669-75.