

Anatomical Variability of the Sphenoid Sinus in Côte d'Ivoire and Its Relevance to Transsphenoidal Surgery: A Descriptive and Analytical Morphometric CT Study

Soress Dongo^{1,2*}, Louis Derou^{1,2}, Landry Teti^{1,2}, Bernard Fionko^{1,2}, Jean-Baptiste Keke^{1,2}, Jean Jacques Kouassi¹, Espérance Broalet^{2,3}

¹Department of Neurosurgery, Bouaké University Hospital, Bouaké, Côte d'Ivoire

²Faculty of Medical Sciences, Alassane Ouattara University of Bouaké, Bouaké, Côte d'Ivoire

³Department of Neurosurgery, Saint Joseph Moscati Hospital, Yamoussoukro, Côte d'Ivoire

Email: *dongosoress0723@gmail.com

How to cite this paper: Dongo, S., Derou, L., Teti, L., Fionko, B., Keke, J.-B., Kouassi, J.J. and Broalet, E. (2026) Anatomical Variability of the Sphenoid Sinus in Côte d'Ivoire and Its Relevance to Transsphenoidal Surgery: A Descriptive and Analytical Morphometric CT Study. *World Journal of Neuroscience*, 16, 298-312.

<https://doi.org/10.4236/wjns.2026.164019>

Received: June 23, 2026

Accepted: October 24, 2026

Published: October 27, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Background: The sphenoid sinus is highly variable, which conditions the safety of the transsphenoidal approach, yet morphometric data remain scarce in sub-Saharan Africa. **Objective:** To describe the morphological and morphometric characteristics of the sphenoid sinus in an Ivorian population and to investigate the associations between the type of pneumatization and demographic and anatomical parameters. **Methods:** Retrospective descriptive and analytical study of the cranial CT scans of 150 Ivorian adults aged 20 years or over, selected consecutively from 184 examinations performed at the Radiology Department of the Bouaké Regional Hospital Center between March and June 2026. Pneumatization was classified according to Hammer and Radberg and the sella turcica according to Axelsson; each scan was read in consensus by a neurosurgeon and a radiologist using predefined criteria for protrusion and dehiscence. Associations were tested with chi-square or exact tests, distances were compared between sexes (Welch t test, with Mann-Whitney U test as sensitivity analysis) and correlated with age (Spearman), and effect estimates are given with 95% confidence intervals (CI). **Results:** Mean age was 39.3 ± 13.9 years (sex ratio 1.83). Sellar (40.0%) and postsellar (36.7%) pneumatization predominated (together 76.7%), followed by the presellar (21.3%) and conchal (2.0%) types. A septation was present in 96.0% of patients and internal carotid artery (ICA) and/or optic nerve variants in 44 (29.3%). ICA protrusion occurred only in sellar (6.7%) and postsellar (20.0%) sinuses, a risk difference of 13.0 percentage points (95% CI 2.0 to 20.4) compared with the presellar and conchal types ($p = 0.012$); this association did not withstand cor-

rection for multiple testing. The nasal orifice-sphenoid sinus distance was longer in men (mean difference 5.6 mm, 95% CI 4.0 to 7.3) and the sinus superior edge-ostium distance longer in women (1.1 mm, 95% CI 0.3 to 2.0); a smaller difference in sinus depth (1.2 mm, 95% CI 0.1 to 2.3) did not withstand correction for multiple testing. No distance was correlated with age (all $|\rho| < 0.12$). **Conclusion:** In this series, most sphenoid sinuses showed sellar or postsellar pneumatization, which offers a potentially favorable bony corridor for the transsphenoidal approach; postsellar sinuses, however, concentrated ICA protrusion. These single-center data provide a local imaging reference and do not replace a patient-specific preoperative CT assessment.

Keywords

Sphenoid Sinus, Pneumatization, Morphometry, Computed Tomography, Transsphenoidal Surgery, Côte d'Ivoire

1. Introduction

The sphenoid sinus is an air-filled cavity hollowed out within the body of the sphenoid bone, the posterior extension of the paranasal sinuses [1]. Unlike the other facial sinuses, its pneumatization begins late and generally becomes complete only at the end of adolescence [2]. This pneumatization, which varies greatly from one individual to another, determines the volume of the sinus and the thinning of its walls, bringing them into direct contact with major neurovascular structures: the sella turcica, the internal carotid arteries and the optic nerves [3].

The endonasal transsphenoidal approach is today the reference approach for most lesions of the sellar region, owing to its minimally traumatic nature, the absence of cerebral retraction and the quality of visualization it provides [3]. The extent and type of pneumatization largely determine the feasibility and safety of this approach [2] [3]. Reported complication rates range from 10% to 26.3%, with mortality between 0% and 0.68% [4]-[6], underscoring the value of precise morphometric planning [7].

The sphenoid sinus is considered the most variable of the paranasal sinuses, both in the degree and type of its pneumatization and in the number and position of its septa or its relationships with neighboring structures [8] [9]. Several classifications have been proposed, notably those of Hamberger *et al.* [10], Hammer and Radberg [11], Cho *et al.* [12] and Güldner *et al.* [13], all based on the relationship between the aerated cavity and the sellar floor.

Beyond morphological description, identifying factors—demographic or anatomical—statistically associated with the type of pneumatization would allow better anticipation of at-risk configurations before the surgical approach [2]. While variations of the sphenoid sinus remain documented in several African populations [14], studies combining a descriptive and analytical approach remain rare in French-speaking sub-Saharan Africa.

The aim of this work was to describe the morphological and morphometric characteristics of the sphenoid sinus in the Ivorian population of Bouaké and to investigate the associations between the type of pneumatization and sex, age, septation, variants of the internal carotid artery and the optic nerve, the morphology of the sella turcica and the measured sphenoid distances.

2. Materials and Methods

2.1. Setting, Type and Period of Study

This was a retrospective descriptive and analytical study, conducted at the Radiology Department of the Bouaké Regional Hospital Center (CHR), over a four-month period from March to June 2026.

2.2. Population and Sampling

The study covered the cranial CT images of 150 Ivorian patients of both sexes, aged 20 years or over in order to ensure complete sphenoid pneumatization. A non-probability exhaustive (consecutive) sampling method was used: all images obtained during the period and meeting the criteria below were included, without random selection or prior sample-size calculation. Of the 184 cranial CT examinations assessed for eligibility during the study period, 34 were not included: 15 patients younger than 20 years, 7 examinations with slice thickness greater than 3 mm, 5 with low resolution or artifacts in the study area, 4 with the sphenoid sinus not or poorly visualized, and 3 in patients with a history of sphenoid surgery; 150 examinations were retained for analysis (Figure 1).

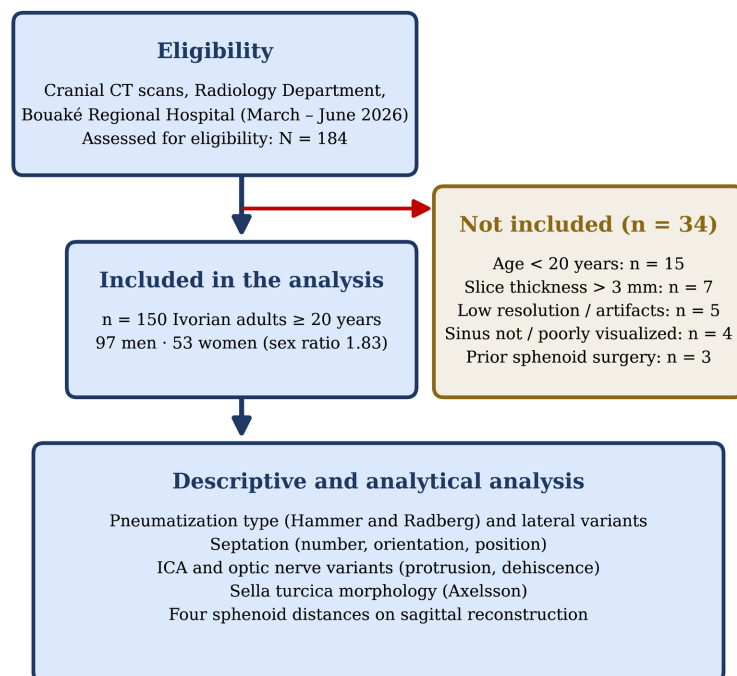


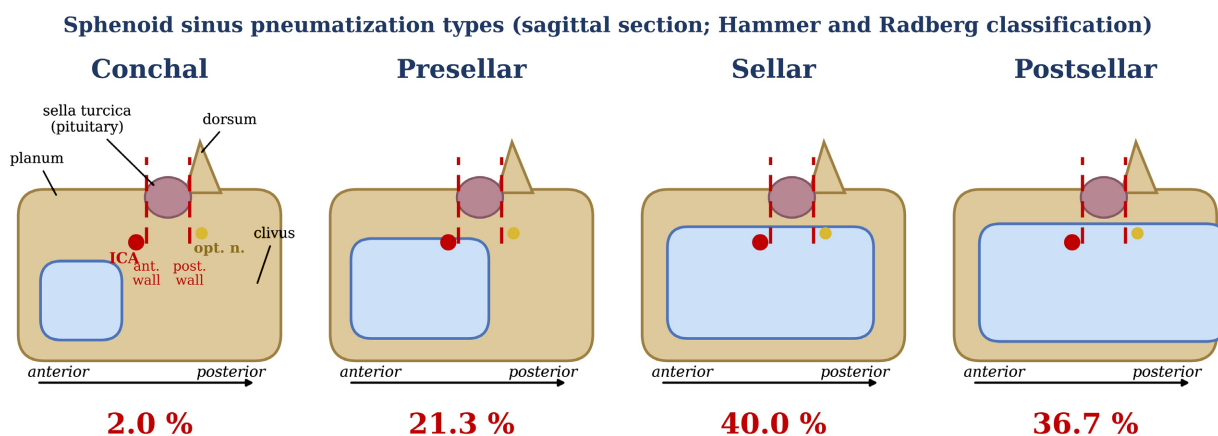
Figure 1. Study flow diagram: 184 CT examinations assessed for eligibility, 34 not included (by criterion) and 150 retained for analysis.

Inclusion criteria: Ivorian patients of both sexes, aged 20 years or over, who had undergone a cranial CT scan with bone window (with or without contrast injection), and presenting images of usable morphometric quality.

Non-inclusion criteria: slice thickness greater than 3 mm, low-resolution images or those with artifacts in the study area, sphenoid sinus not visualized or poorly visualized, history of sphenoid sinus surgery.

2.3. Image Acquisition and Analysis

Images were acquired on a General Electric 64-slice scanner (140 kV, 144 mAs), with 1.5- to 3-mm slices in the axial plane, reconstructed in the coronal and sagittal planes, then processed with AW Volume Share 7 software and analyzed in bone window. Each examination was reviewed jointly by a neurosurgeon and a radiologist, who recorded a single consensus rating at the time of reading; the scans were not rated independently beforehand, so inter-observer agreement could not be estimated. The type of pneumatization was classified according to the Hammer and Radberg system [11], supplemented by the sellar/postsellar distinction of later classifications [12] [13] (Figure 2), and the morphology of the sella turcica according to the Axelsson classification [15].



Air cavity (blue) expanding from anterior to posterior. ICA = internal carotid artery (red); opt. n. = optic nerve (yellow); red dashed lines = anterior and posterior sellar walls.

Figure 2. Types of sphenoid sinus pneumatization (sagittal section; Hammer and Radberg classification). The extent of the aerated cavity (blue) progresses from front to back; the red lines mark the anterior wall (tuberculum) and posterior wall (dorsum) of the sella turcica. The percentages correspond to the present series (n = 150).

Neurovascular variants were assessed on each side on bone-window reconstructions. Protrusion was defined as bulging of more than half of the circumference of the ICA or optic nerve canal into the sphenoid sinus cavity. Dehiscence was defined as the absence of an identifiable bony covering between the neurovascular structure and the sinus air cavity; dehiscence could therefore be recorded in the absence of protrusion.

2.4. Data Collection

A standardized form recorded, for each patient: demographic data (sex, age); si-

nus characteristics (main type of pneumatization and variants, presence and characteristics of the septation, ICA and optic nerve variants, sella turcica morphology); and four sphenoid distances measured on the reconstructions (**Figure 3**): nasal orifice-sphenoid sinus distance, anterior edge-posterior edge of the sinus distance, sinus superior edge (or anterior skull base)-sphenoid ostium distance, and sinus floor-sphenoid ostium distance.

Sphenoid distances measured on the sagittal CT reconstruction

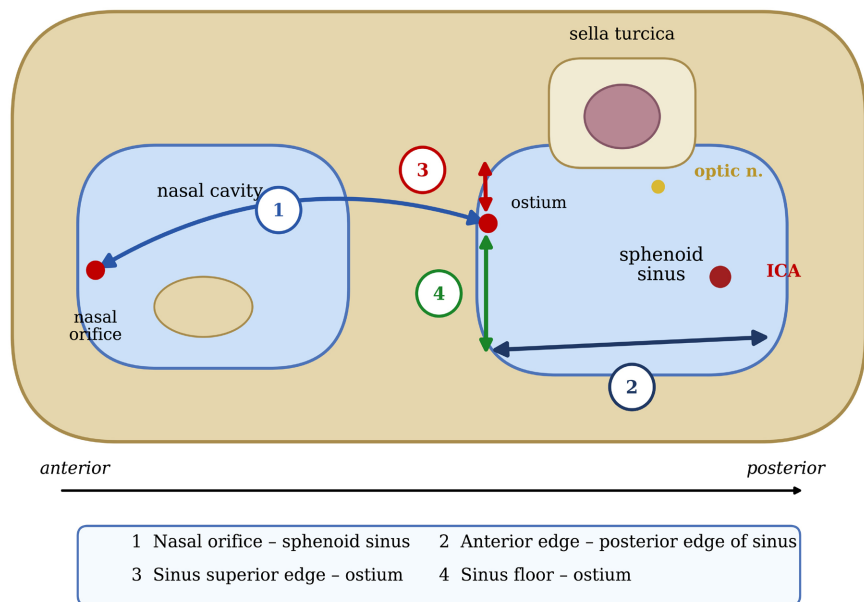


Figure 3. Schematic representation of the four sphenoid distances measured on the sagittal CT reconstruction (sphenoid sinus, ostium and nasal cavity).

2.5. Statistical Analysis

The analysis followed the SAMPL guidelines. Data were entered in Microsoft Excel 2019 and analyzed with SPSS version 25. Qualitative variables are expressed as counts and percentages. Normality of each distance within each sex was examined with the Shapiro-Wilk test; it was not rejected for any distance in either sex (all $p \geq 0.133$). In line with the prespecified plan, distances are therefore summarized as mean $\pm$ standard deviation and compared between sexes with the t test, in its Welch form because the variances were larger in women; medians [interquartile range] with the Mann-Whitney U test are reported as a sensitivity analysis. Qualitative variables were compared with the chi-square test, Fisher's exact test or the Fisher-Freeman-Halton exact test. Age was analyzed as a continuous variable against each distance with Spearman's rank correlation (ρ), which avoids arbitrary age grouping. Effect estimates accompany the p values. For ICA protrusion, they comprise the proportion affected within each pneumatization type (Wilson 95% confidence interval [CI]), the risk difference between the broad sellar and the presellar/conchal types (Newcombe hybrid score CI), the odds ratio between postsellar and sellar types (conditional exact CI) and Cramér's V. For distances, they

comprise the mean difference between men and women with its Welch 95% CI and Hedges' g ; for correlations, ρ with a 95% CI obtained by Fisher's z transformation. These estimates were computed from the tabulated data with Python (SciPy 1.17, statsmodels 0.15). The significance threshold was set at $p < 0.05$. Because about twenty tests were performed without a prespecified primary hypothesis, a Bonferroni-adjusted threshold is reported as a sensitivity analysis ($0.05/15 = 0.0033$ for the associations with the type of pneumatization; $0.05/4 = 0.0125$ for the sex comparisons of distances), and all analytical findings are interpreted as exploratory.

2.6. Ethical Considerations

The study used anonymized archived CT images acquired between March and June 2026 as part of routine clinical care. The protocol subsequently received a favorable opinion from the institutional ethics committee of Bouaké University Hospital (opinion no. CEI/CHU-BKE/230/2026; written notification received on 18 August 2026). Study-specific extraction, review and analysis of the archived images were undertaken after this approval. Given the retrospective design and the exclusive use of anonymized archived images, the committee waived the requirement for individual informed consent.

3. Results

3.1. Descriptive Study

Demographic characteristics. Of 150 patients, 97 were male (64.7%) and 53 female (35.3%), a sex ratio of 1.83. Mean age was 39.3 ± 13.9 years (median 35.5 years; range 20 - 79 years). The [20 - 35[year age group was the most represented (45.3%), followed by the [35 - 50[(32.7%), [50 - 65[(16.7%) and [65 - 80] (5.3%) groups (**Table 1**).

Table 1. Distribution of patients by sex and age group.

Variable	Count	%
Sex		
Male	97	64.7
Female	53	35.3
Age group (years)		
[20 - 35[	68	45.3
[35 - 50[	49	32.7
[50 - 65[	25	16.7
[65 - 80]	8	5.3
Total	150	100.0

Main type of pneumatization. The sellar type was the most frequent (60 patients; 40.0%), followed by the postsellar (55; 36.7%), presellar (32; 21.3%) and conchal (3; 2.0%) types (**Table 2, Figure 4**). Combining sellar and postsellar, broad sellar pneumatization concerned 76.7% of patients.

Table 2. Distribution of patients by main type of pneumatization.

Type of pneumatization	Count	%
Conchal	3	2.0
Presellar	32	21.3
Sellar	60	40.0
Postsellar	55	36.7
Total	150	100.0

Distribution of sphenoid sinus pneumatization types (n = 150)

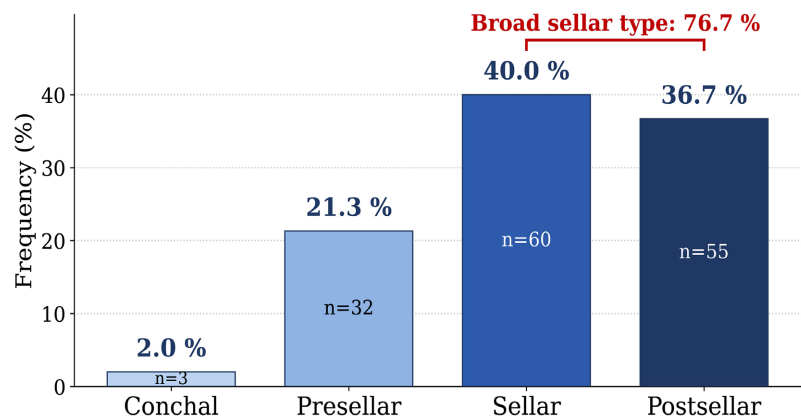


Figure 4. Distribution of sphenoid sinus pneumatization types (n = 150).

Variants, septation, neurovascular variants and sella turcica. Associated pneumatization variants were found in 28 patients (18.7%), exclusively within the sellar and postsellar types, dominated by lateral pneumatization (16 cases; 10.7%), foremost among which the “greater wing of the sphenoid” variant (11 cases). A septation was present in 144 patients (96.0%), single in 88.7% of cases and multiple in 7.3%; among single septations, the complete vertical form predominated (122 cases; 91.7%) and median positioning was the most frequent (66 cases; 49.6%). Variants of the ICA and/or optic nerve were identified in 44 patients (29.3%): ICA protrusion in 15 (10.0%), optic nerve dehiscence in 14 (9.3%), ICA dehiscence in 10 (6.7%), and optic nerve protrusion in 5 (3.3%). Among these 44 patients, 20 (45.5%) had bilateral involvement and 24 (54.5%) had unilateral involvement. The sella turcica was normal in 85 patients (56.7%), with posterior wall irregularity in 57 (38.0%) and another unclassifiable morphology in 8 (5.3%) (**Table 3**).

Table 3. Distribution of septation, ICA/optic nerve variants and sella turcica morphology.

Characteristic	Count	%
Septation—single	133	88.7
Septation—multiple	11	7.3
Septation—absent	6	4.0
ICA—protrusion	15	10.0
ICA—dehiscence	10	6.7
Optic nerve—protrusion	5	3.3
Optic nerve—dehiscence	14	9.3
Sella turcica—normal	85	56.7
Sella turcica—posterior wall irregularity	57	38.0
Sella turcica—other/unclassifiable	8	5.3
Total (sella turcica)	150	100.0

Sphenoid measurements. The nasal orifice-sphenoid sinus and anterior edge-posterior edge distances were on average greater in men, whereas the sinus superior edge-ostium and floor-ostium distances were on average greater in women. **Table 4** gives the four distances as mean $\pm$ SD with the Shapiro-Wilk normality test for each sex; effect estimates and between-sex comparisons are reported below with the analytical results.

Table 4. Sphenoid distances (mm) by sex: mean $\pm$ standard deviation and Shapiro-Wilk normality test.

Distance (mm)	Men (n = 97), mean $\pm$ SD	Men, Shapiro-Wilk W (p)	Women (n = 53), mean $\pm$ SD	Women, Shapiro-Wilk W (p)
Nasal orifice-sphenoid sinus	88.21 $\pm$ 3.76	0.980 (0.151)	82.59 $\pm$ 5.44	0.992 (0.969)
Anterior edge-posterior edge of the sinus	19.05 $\pm$ 2.56	0.989 (0.583)	17.85 $\pm$ 3.68	0.966 (0.133)
Sinus superior edge-ostium	9.08 $\pm$ 2.32	0.991 (0.768)	10.22 $\pm$ 2.65	0.971 (0.231)
Sinus floor-ostium	8.44 $\pm$ 1.50	0.988 (0.550)	8.94 $\pm$ 1.88	0.988 (0.864)

3.2. Analytical Study

Associations between the type of pneumatization and the main characteristics were tested (**Table 5**). No significant difference was observed with sex, age group (overall or by sex), the presence or type of lateral variant, the presence, number, orientation or positioning of the septation, septal deviation, ICA or optic nerve dehiscence, optic nerve protrusion, or sella turcica morphology. Only ICA pro-

trusion differed across pneumatization types (Fisher-Freeman-Halton exact test, $p = 0.012$; Cramér's $V = 0.27$). Protrusion was absent in the conchal (0/3) and presellar (0/32) types and was observed in 6.7% (95% CI 2.6 to 15.9) of sellar and 20.0% (95% CI 11.6 to 32.4) of postsellar sinuses. The risk difference between the broad sellar and the presellar/conchal types was 13.0 percentage points (95% CI 2.0 to 20.4), and the odds of protrusion were higher in postsellar than in sellar sinuses (odds ratio 3.5, exact 95% CI 0.94 to 15.9). Resting on 15 events, with two empty cells and a p value above the Bonferroni threshold of 0.0033, this association is exploratory (**Table 6, Figure 5**).

Table 5. Associations tested between the type of pneumatization and patient characteristics (chi-square/Fisher test; unadjusted p values, Bonferroni threshold 0.0033).

Variable tested	p value	Conclusion
Sex	0.787	Not significant
Age group	0.692	Not significant
Age group in men	0.690	Not significant
Age group in women	0.664	Not significant
Presence/type of lateral variant	0.662	Not significant
Presence of septation	0.580	Not significant
Number (single/multiple) of septation	0.711	Not significant
Orientation of the septation	0.767	Not significant
Positioning of the septation	0.617	Not significant
Septal deviation toward ICA/optic nerve	0.793	Not significant
ICA protrusion	0.012	Significant (unadjusted)
ICA dehiscence	0.122	Not significant
Optic nerve protrusion	0.094	Not significant (trend)
Optic nerve dehiscence	0.380	Not significant
Sella turcica morphology	0.674	Not significant

Table 6. Distribution of the type of pneumatization by internal carotid artery (ICA) protrusion.

ICA protrusion	Conchal	Presellar	Sellar	Postsellar	p value
No	3 (2.0%)	32 (21.3%)	56 (37.4%)	44 (29.3%)	
Yes	0	0	4 (2.7%)	11 (7.3%)	
Protrusion within type, % (95% CI) ^a	0 (0 - 56.1)	0 (0 - 10.7)	6.7 (2.6 - 15.9)	20.0 (11.6 - 32.4)	$V = 0.27$
Total	3 (2.0%)	32 (21.3%)	60 (40.0%)	55 (36.7%)	0.012

^aWilson score 95% CI. Other percentages refer to the whole sample ($n = 150$). Broad sellar vs presellar/conchal: 15/115 (13.0%) vs 0/35, risk difference 13.0 percentage points (95% CI 2.0 to 20.4; Newcombe). Postsellar vs sellar: odds ratio 3.5 (exact 95% CI 0.94 to 15.9). V : Cramér's V . The p value exceeds the Bonferroni threshold (0.0033): exploratory association.

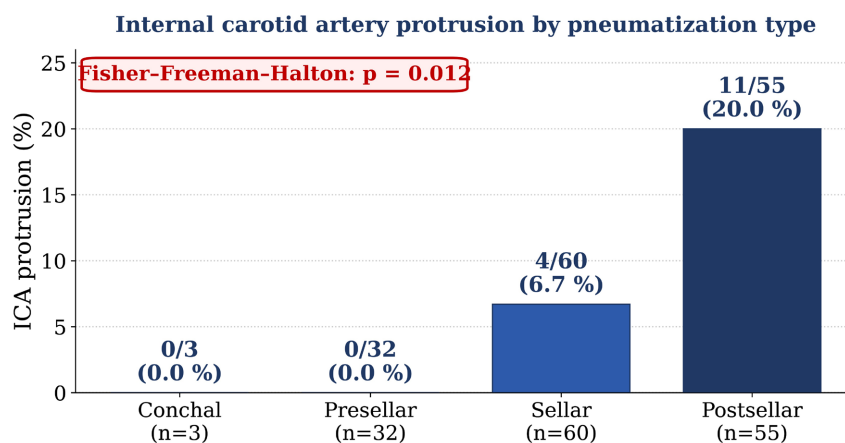


Figure 5. Frequency of internal carotid artery protrusion by type of pneumatization (Fisher-Freeman-Halton exact test, $p = 0.012$; exploratory association, see [Table 6](#) for 95% CIs).

Comparison of distances by sex and age. Three of the four distances differed between men and women with the Welch t test. The nasal orifice-sphenoid sinus distance was longer in men (mean difference 5.62 mm, 95% CI 3.95 to 7.29; Hedges' g 1.26; $p < 0.001$), as was the anterior edge-posterior edge distance (1.20 mm, 95% CI 0.07 to 2.33; g 0.40; $p = 0.038$), whereas the sinus superior edge-ostium distance was longer in women (1.14 mm, 95% CI 0.28 to 2.00; g 0.46; $p = 0.010$). The floor-ostium distance did not differ (0.50 mm longer in women, 95% CI -0.10 to 1.10; $p = 0.099$). After Bonferroni correction (threshold 0.0125), the nasal orifice-sphenoid sinus and superior edge-ostium differences remained significant; the anterior edge-posterior edge difference did not, and it was also non-significant in the Mann-Whitney sensitivity analysis ($p = 0.092$), so it should be regarded as uncertain ([Table 7](#), [Figure 6](#)). Age, analyzed as a continuous variable, was not correlated with any distance: all $|\rho|$ were below 0.12, and the 95% CIs exclude correlations stronger than 0.28 in absolute value ([Table 8](#)).

Table 7. Comparison of sphenoid distances between men and women: effect estimates, Welch t test and Mann-Whitney sensitivity analysis.

Distance (mm)	Men, median [Q1 - Q3]	Women, median [Q1 - Q3]	Mean difference M - W (95% CI) ^a	Hedges' g (95% CI)	p Welch	p MW ^b
Nasal orifice-sphenoid sinus	87.79 [85.67 - 91.37]	82.97 [79.03 - 86.31]	5.62 (3.95 to 7.29)	1.26 (0.90 to 1.63)	<0.001	<0.001
Anterior edge-posterior edge	18.95 [17.62 - 20.56]	18.50 [15.01 - 20.45]	1.20 (0.07 to 2.33)	0.40 (0.06 to 0.74)	0.038	0.092
Sinus superior edge-ostium	9.16 [7.52 - 10.86]	10.61 [8.34 - 11.93]	-1.14 (-2.00 to -0.28)	-0.46 (-0.80 to -0.13)	0.010	0.016
Sinus floor-ostium	8.55 [7.62 - 9.46]	8.82 [7.85 - 10.35]	-0.50 (-1.10 to 0.10)	-0.30 (-0.64 to 0.03)	0.099	0.113

^aMen minus women, with Welch 95% CI (primary analysis). ^bMann-Whitney U test (sensitivity analysis). All p values unadjusted; Bonferroni threshold for four comparisons: 0.0125.

Sphenoid distances by sex — median, IQR and distribution (M = 97, F = 53)

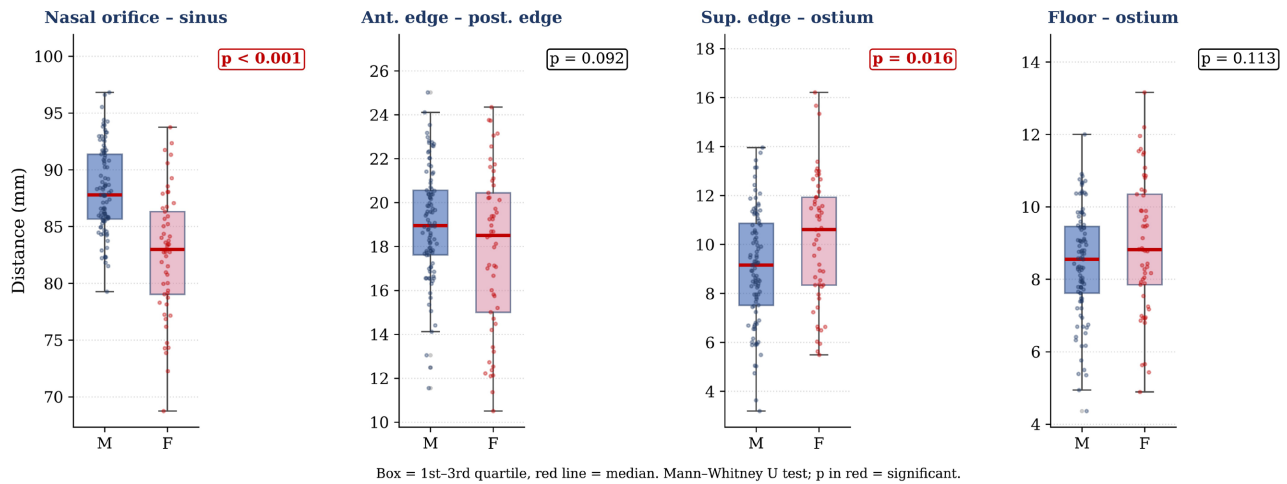


Figure 6. Sphenoid distances by sex (median, interquartile range and individual distribution; men = 97, women = 53). The p values shown are those of the Mann-Whitney sensitivity analysis; the primary comparisons (Welch t test) and effect estimates are given in Table 7.

Table 8. Correlation between age and sphenoid distances (Spearman coefficient ρ with 95% CI).

Distance	ρ (95% CI)	p value
Nasal orifice-sphenoid sinus	-0.098 (-0.26 to 0.07)	0.233
Anterior edge-posterior edge of the sinus	-0.089 (-0.25 to 0.08)	0.278
Sinus superior edge-ostium	0.116 (-0.05 to 0.28)	0.159
Sinus floor-ostium	0.104 (-0.07 to 0.27)	0.203

4. Discussion

4.1. Demographic Aspects

Our population was predominantly young (nearly three quarters under 50) and male (sex ratio 1.83). This predominance was also reported by Yataco-Wilcas *et al.* [16] in Peru and by Dogan *et al.* [1] in Turkey, the latter having demonstrated an association between the type of pneumatization and age group, unlike our work, in which no association was found with sex or age.

4.2. Main Type of Pneumatization

The broad sellar type was the most frequent (76.7%), with the presellar accounting for 21.3% and the conchal 2.0%. This hierarchy is consistent with the systematic review by Bechev *et al.* [2] (sellar type $\approx$ 72%, presellar 10% - 15%, conchal 2% - 5%) and with the Ethiopian study by Degaga *et al.* [17]. The isolated proportion of strict sellar type (40.0%) remained lower than that of several earlier series (50% [17], 52.9% [9], 59.4% and 69% [18]), suggesting ethno-geographic variants of pneumatization [2].

4.3. Variants, Septation and Neurovascular Variants

Lateral pneumatization (10.7%) remained below the frequency of about 20% reported in the literature [2]. Septation was present in 96.0% of patients, single in 88.7%, a proportion close to the 90% reported in Ethiopia [17], multiple septation (7.3%) being rarer than the usual 20% - 35% [2]. No association was found between the type of pneumatization and septal characteristics. ICA protrusion and dehiscence (10.0% and 6.7%) and those of the optic nerve (3.3% and 9.3%) were lower than the Ethiopian values [17] [19] [20]; differences in the CT definitions of protrusion and dehiscence across series may contribute to these gaps. ICA protrusion was confined to sellar and postsellar sinuses and was most frequent in the postsellar type (20.0%, 95% CI 11.6 to 32.4), consistent with wall thinning as pneumatization extends behind the sella [2] [3]. This estimate, however, rests on 15 events and did not withstand correction for multiple testing; it should be regarded as a hypothesis to be confirmed in larger series.

4.4. Sella Turcica

The sella turcica was normal in 56.7% of patients, posterior wall irregularity—which may reflect a thinning exposing to intraoperative cerebrospinal fluid leakage—being the most frequent abnormality (38.0%) [1]. Unlike Dogan *et al.* [1], no significant association with the type of pneumatization was demonstrated ($p = 0.674$), sellar pneumatization moreover being predominant in our series.

4.5. Sphenoid Measurements

The nasal orifice-sphenoid sinus distance was longer in men by about 5.6 mm (95% CI 4.0 to 7.3), a large and robust difference also found in Peru [16]. The sinus superior edge-ostium distance was longer in women by about 1.1 mm (95% CI 0.3 to 2.0), unlike the Peruvian series [16], a discrepancy possibly related to the interindividual variability of the sinus [2]. The anteroposterior depth of the sinus was slightly greater in men (1.2 mm, 95% CI 0.1 to 2.3), but this difference did not withstand correction for multiple testing or the rank-based analysis, and the floor-ostium distance did not differ by sex. The width of these intervals, of the order of millimeters, is comparable to the margins that matter in the sellar approach, which is a further argument for individual measurement. No meaningful correlation was found between age and the distances ($|\rho| < 0.12$), suggesting stable sphenoid dimensions in adulthood [2].

4.6. Surgical Implications

The predominance of sellar and postsellar pneumatization indicates that, in most patients of this series, the sphenoid sinus offers a potentially favorable bony corridor to the sella. This anatomical observation does not, by itself, establish that the transsphenoidal approach is feasible or safe in a given patient: ICA protrusion was found precisely in the most extensively pneumatized sinuses, and septal insertions, dehiscences and distances vary widely from one patient to another [2] [21].

Each patient therefore still requires a specific preoperative CT assessment of the corridor, of the septa and of the carotid and optic relationships, with instruments and trajectory adapted to the measured distances [16] [22] [23], together with careful intraoperative observation [24] [25]. Our data can guide the reading of these examinations locally, not replace it.

4.7. Study Limitations

This study has the limitations of a retrospective single-center work. The sample consisted of patients referred for cranial CT, who may not represent the general population, and no a priori sample-size calculation was performed; classification criteria may also differ across published series [2]. Scans were rated in consensus by two readers without prior independent reading, so inter-observer reproducibility could not be quantified, and the distinction between protrusion and dehiscence remains partly subjective on CT. The absence of association for some variables may reflect a lack of power related to rare variants rather than a true absence of relationship, and several contingency tables contained sparse or empty cells, which makes the effect estimates imprecise. Finally, about twenty tests were performed: only the sex differences in the nasal orifice-sphenoid sinus and superior edge-ostium distances withstand Bonferroni correction, and the association with ICA protrusion must be considered exploratory.

5. Conclusion

In this CT series of 150 adults from Bouaké, sellar and postsellar pneumatization predominated (76.7%), septation was almost constant, and ICA or optic nerve variants were found in nearly one third of patients. These pneumatization patterns describe a potentially favorable bony corridor for the transsphenoidal approach. The exploratory concentration of ICA protrusion in postsellar sinuses and the interindividual variability of the distances, however, call for a systematic, patient-specific preoperative CT assessment rather than reliance on population patterns. These data provide a local imaging reference and call for multicenter studies in Côte d'Ivoire that include an assessment of reading reproducibility.

Author Contributions

All authors contributed to the study design, data collection or analysis, drafting or critical revision of the manuscript, and approved the final version.

Conflicts of Interest

The authors declare no conflict of interest.

Data and Material Availability

The data used in this study are available from the corresponding author upon reasonable request.

Consent for Publication

Not applicable: the study used anonymized archived images containing no data allowing the identification of a patient.

References

- [1] Dogan, M.E., Kotanlı, S., Yavuz, Y., Wahjuningrum, D.A. and Pawar, A.M. (2023) Computed Tomography-Based Assessment of Sphenoid Sinus and Sella Turcica Pneumatization Analysis: A Retrospective Study. *PeerJ*, **11**, e16623. <https://doi.org/10.7717/peerj.16623>
- [2] Bechev, K., Fasova, A., Yotova, N., Markov, D. and Aleksiev, V. (2025) Anatomical Features of the Sphenoid Sinus and Their Clinical Significance in Transsphenoidal Accesses to the Pituitary Gland and Parasellar Region: A Systematic Review. *Diagnostics*, **15**, 3125. <https://doi.org/10.3390/diagnostics15243125>
- [3] García-Garrigós, E., Arenas-Jiménez, J.J., Monjas-Cánovas, I., Abarca-Olivas, J., Cortés-Vela, J.J., De La Hoz-Rosa, J., et al. (2015) Transsphenoidal Approach in Endoscopic Endonasal Surgery for Skull Base Lesions: What Radiologists and Surgeons Need to Know. *RadioGraphics*, **35**, 1170-1185. <https://doi.org/10.1148/rg.2015140105>
- [4] Kilty, S.J., McLaughlin, N. and Bojanowski, M.W., et al. (2010) Extracranial Complications of Endoscopic Transsphenoidal Sellar Surgery. *Journal of Otolaryngology—Head & Neck Surgery*, **39**, 309-314.
- [5] Gondim, J.A., Almeida, J.P.C., Albuquerque, L.A.F., Schops, M., Gomes, E., Ferraz, T., et al. (2010) Endoscopic Endonasal Approach for Pituitary Adenoma: Surgical Complications in 301 Patients. *Pituitary*, **14**, 174-183. <https://doi.org/10.1007/s11102-010-0280-1>
- [6] Nduom, E.K., Barrow, E.M., Patel, Z.M. and Oyesiku, N.M. (2013) Transnasal Approaches to the Sellar and Parasellar Region: Open and Endoscopic. *Operative Techniques in Otolaryngology—Head and Neck Surgery*, **24**, 208-212. <https://doi.org/10.1016/j.otot.2013.04.012>
- [7] Orringer, D.A., Golby, A. and Jolesz, F. (2012) Neuronavigation in the Surgical Management of Brain Tumors: Current and Future Trends. *Expert Review of Medical Devices*, **9**, 491-500. <https://doi.org/10.1586/erd.12.42>
- [8] Pérez-Piñas, I., Sabaté, J., Carmona, A., Catalina-Herrera, C.J. and Jiménez-Castellanos, J. (2000) Anatomical Variations in the Human Paranasal Sinus Region Studied by CT. *Journal of Anatomy*, **197**, 221-227. <https://doi.org/10.1046/j.1469-7580.2000.19720221.x>
- [9] Kayalioglu, G., Erturk, M. and Varol, T. (2005) Variations in Sphenoid Sinus Anatomy with Special Emphasis on Pneumatization and Endoscopic Anatomic Distances. *Neurosciences*, **10**, 79-84. <https://doi.org/10.17712/1658-3183.1319>
- [10] Hamberger, C.A., Hammer, G., Norlen, G. and Sjogren, B. (1961) Transantrosphenoidal Hypophysectomy. *Archives of Otolaryngology—Head and Neck Surgery*, **74**, 2-8. <https://doi.org/10.1001/archotol.1961.00740030005002>
- [11] Hammer, G. and Rådberg, C. (1961) The Sphenoidal Sinus. *Acta Radiologica*, **56**, 401-422. <https://doi.org/10.3109/00016926109172836>
- [12] Cho, J.H., Kim, J.K., Lee, J. and Yoon, J. (2010) Sphenoid Sinus Pneumatization and Its Relation to Bulging of Surrounding Neurovascular Structures. *Annals of Otolaryngology, Rhinology & Laryngology*, **119**, 646-650. <https://doi.org/10.1177/000348941011900914>

- [13] Gldner, C., Pistorius, S.M., Diogo, I., Bien, S., Sesterhenn, A. and Werner, J.A. (2012) Analysis of Pneumatization and Neurovascular Structures of the Sphenoid Sinus Using Cone-Beam Tomography (CBT). *Acta Radiologica*, **53**, 214-219. <https://doi.org/10.1258/ar.2011.110381>
- [14] Kajoak, S.A., Ayad, C.E. and Najmeldeen, M., et al. (2014) Computerized Tomography Morphometric Analysis of the Sphenoid Sinus and Related Structures in Sudanese Population. *Global Advanced Research Journal of Medicine and Medical Sciences*, **3**, 160-167.
- [15] Axelsson, S., Storhaug, K. and Kjær, I. (2004) Post-Natal Size and Morphology of the Sella Turcica. Longitudinal Cephalometric Standards for Norwegians between 6 and 21 Years of Age. *The European Journal of Orthodontics*, **26**, 597-604. <https://doi.org/10.1093/ejo/26.6.597>
- [16] Yataco-Wilcas, C.A., Diaz-Llanes, B.E., Coasaca-Tito, Y.S., Lengua-Vega, L.A. and Salazar-Campos, C.E. (2024) Morphometric Analysis of Transsphenoidal Surgery in Peruvian Population. *Surgical Neurology International*, **15**, 156. https://doi.org/10.25259/sni_239_2024
- [17] Degaga, T.K., Zenebe, A.M., Wirtu, A.T., Woldehawariat, T.D., Dellie, S.T. and Gemechu, J.M. (2020) Anatomographic Variants of Sphenoid Sinus in Ethiopian Population. *Diagnostics*, **10**, 970. <https://doi.org/10.3390/diagnostics10110970>
- [18] Lupascu, M., Comsa, G.I. and Zainea, V. (2014) Anatomical Variations of the Sphenoid Sinus—A Study of 200 Cases. *ARS Medica Tomitana*, **20**, 57-62. <https://doi.org/10.2478/arism-2014-0011>
- [19] Akanni, D., de Souza, C.O., de Tov, K.S., N'zi, K.P., Ykp, P., Biauou, O., et al. (2018) Sphenoid Sinuses Pneumatization and Association with the Protrusion of Surrounding Neurovascular Structures amongst Beninese. *Open Journal of Radiology*, **08**, 209-216. <https://doi.org/10.4236/ojrad.2018.84024>
- [20] Jaworek-Tro, J., Zarzecki, M. and Bonczar, A., et al. (2019) Sphenoid Bone and Its Sinus-Anatomo-Clinical Review of the Literature Including Application to FESS. *Folia Medica Cracoviensia*, **59**, 45-59.
- [21] Fernandez-Miranda, J.C., Prevedello, D.M., Madhok, R., Morera, V., Barges-Coll, J., Reineman, K., et al. (2009) Sphenoid Septations and Their Relationship with Internal Carotid Arteries: Anatomical and Radiological Study. *The Laryngoscope*, **119**, 1893-1896. <https://doi.org/10.1002/lary.20623>
- [22] Chumnanvej, S., Pillai, B.M., Chalongsongse, S. and Suthakorn, J. (2021) Endonasal Endoscopic Transsphenoidal Approach Robot Prototype: A Cadaveric Trial. *Asian Journal of Surgery*, **44**, 345-351. <https://doi.org/10.1016/j.asjsur.2020.08.011>
- [23] Van Lindert, E.J., Ingels, K., Mylanus, E. and Grotenhuis, J.A. (2010) Variations of Endonasal Anatomy: Relevance for the Endoscopic Endonasal Transsphenoidal Approach. *Acta Neurochirurgica*, **152**, 1015-1020. <https://doi.org/10.1007/s00701-010-0629-2>
- [24] Azab, W.A., Abdelnabi, E.A., Mostafa, K.H., Burhamah, T.A., Alhaj, A.K.H., Khalil, A.M.B., et al. (2020) Effect of Sphenoid Sinus Pneumatization on the Surgical Windows for Extended Endoscopic Endonasal Transsphenoidal Surgery. *World Neurosurgery*, **133**, e695-e701. <https://doi.org/10.1016/j.wneu.2019.09.126>
- [25] Raseman, J., Guryildirim, M., Beer-Furlan, A., Jhaveri, M., Tajudeen, B.A., Byrne, R.W., et al. (2019) Preoperative Computed Tomography Imaging of the Sphenoid Sinus: Striving towards Safe Transsphenoidal Surgery. *Journal of Neurological Surgery Part B: Skull Base*, **81**, 251-262. <https://doi.org/10.1055/s-0039-1691831>