Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2021;38:404-409

Morphometric Analysis of the Sella Turcica in Northeast Brazil

Pablo Mariz de Oliveira,[1] Amanda do Nascimento Oliveira Carneiro,[2] Ivon Marcos Inácio Rodrigues,[1] Fábio Antônio Serra de Lima Júnior,[1] Thales Henrique de Araújo Sales,[3] André de Sá Braga Oliveira,[4] Jalles Dantas de Lucena[5]

[1]Medical Sciences Center, Federal University of Paraiba – UFPB, João Pessoa - PB, Brazil.
[2]Health Sciences Center, Federal University of Paraiba – UFPB, João Pessoa - PB, Brazil
[3]Medical School Nova Esperança (FACENE/FAMENE), Department of Morphology, Medicine Course. Gramame, João Pessoa - PB, Brazil
[4]Department of Morphology, Federal University of Paraiba – UFPB, João Pessoa - PB, Brazil
[5]Medicine Course, College Santa Maria (FSM), Cajazeiras, PB, Brazil

Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: the sella turcica is a structure of the median region of the sphenoid bone. Variations in its morphology are relevant as it is a region subjected to several surgical procedures, mainly related to the pituitary gland. The aim of this study was to analyze the morphology of sella turcica and its sexual dimorphism in Northeastern Brazil.

Material and Methods: the research was carried out at the Human Anatomy Laboratory of the Federal University of Paraíba (UFPB) and at the Anatomy Laboratory of the Nova Esperança College (FACENE/FAMENE - João Pessoa, Paraíba, Brazil). Thirty-one skulls were analyzed. In qualitative analysis, the sella turcica was classified as U-shaped, J-shaped, and Flat-shaped. The morphometric analysis was done through a digital pachymeter and the data analyzed statistically, to obtain a possible relation between morphometry and sex, besides the relation between sella and skull measurements. Values of $p \leq 0.05$ were considered significant.

Results: the most prevalent sella in this study was J-shaped (51.6%). No differences ($p > 0.05$) between sexes in all measures were found, but male skulls have high values expected for bitemporal width and maximum width. There was positive linear correlation between the anteroposterior diameter of sella and two measures: sella turcica length and sella turcica width. Furthermore, bitemporal width and sella turcica width also present positive linear correlation. The results point to original findings for this population.

Conclusion: knowledge of the morphology of the sella is essential to plan safer surgical approaches in the pituitary gland or related anatomical structures.

Keywords: Anatomy; Morphometric; Osteology; Sella turcica; Skull.

Introduction

The sella turcica is a fossa-shaped bone structure located in the median region of the sphenoid bone. It presents an intimate relationship with important anatomical structures of the region, such as the pituitary gland - sheltered in its interior - some cranial nerves and the cavernous part of the internal carotid artery.[1]

It is bounded anteriorly by the tuberculum sellae and posteriorly by the dorsum sellae, region where the sphenoid bone continues with the occipital bone clivus. Anterior and posterior clinoid processes in both sides project over the sella. Significant variations in its morphology, usually observed in lateral cephalograms, are clinically relevant as it is a region subjected to several surgical procedures, mainly related to the pituitary gland.[2]

Given its importance as a reference point in lateral cephalograms, the knowledge of normal sella morphology is crucial to identify possible abnormalities in the pituitary gland or the craniofacial region, indicating the need for complementary exams for a correct diagnosis.[2] Furthermore, with the development of skull base endoscopic surgery techniques, studies on this region have grown,[1,2,3,4,5,6,7,8,9] as a way to understand the local anatomy to assist in surgeries accessing the sella turcica through the sublabial or endonasal transsphenoidal approach.[10,11] Moreover, the population of Northeast of Brazil have a tendency to cranio-cervical junction abnormalities, such as platibasia, basilar invagination, and brachycephaly[12] - condition when the width of skull is disproportionately larger. Given the intimate relationship of the cranio-cervical transition with the sella turcica, we hypothesize that the anatomy of sella turcica in Northeast of Brazil may be unique.

Thus, the aim of this study was to analyze the morphometry and morphology of the sella turcica and its sexual in a specific population in Northeast Brazil.

DOI: 10.51929/jms.38.70.2021
ISSN 2177-0298

Material and Methods

The research was conducted at the Department of Morphology of the Federal University of Paraíba (UFPB, Brazil) and at the Anatomy Laboratory of the Nova Esperança College (FACENE/FAMENE - João Pessoa, Paraíba, Brazil), under the approval of the research ethics committee (CAAE register: 28405619.8.0000.5188).

The study included 31 skulls. Of these, 27 were analyzed quantitatively and 31 qualitatively. Some skulls did not allow the measurement of all quantitative parameters, so they were not included in this sample. Skulls with infantile conformation and important bone degradation in the sella turcica region, which made the analysis impossible, were excluded from the analysis.

The identification of the skull gender was performed according to Vanrell (2002)[13] criteria for cranial sexual dimorphism. For the qualitative analysis, the sella turcica was classified into 3 types: U-shaped (tuber and dorsum at the same height), J-shaped (dorsum inferior compared to the tuber), or flat-shaped (sella turcica with minimal depth) (Figure 1), according to an adaptation of the analysis carried out on lateral cephalograms.[9] The analysis was performed upon lateral and upper observation of the skull bases.

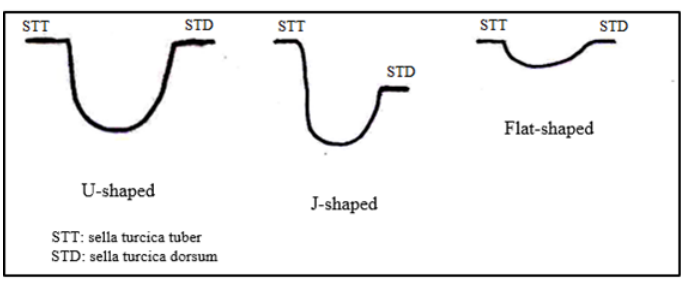

Figure 1. Schematic drawing of the shapes of the sella turcica.

The quantitative analysis included the following measurements (Figure 2): Sella Turcica Length (STL) - distance between the tubercle and the back of the sella; and Sella Turcica Width (STW) - distance between the most lateral points of the sella; Anteroposterior diameter of the sella (APDS) - distance between the tubercle of the sella and the lower part of the sella's rear wall; Sella turcica height (STH) - distance between the mid-point between the tubercle and the back of the sella and the floor of the sella or distance between the line drawn between the back of the sella and the tubercle of the sella and the lower region of the sella floor; Skull length (SL) - from glabella to irion; bitemporal width (BTW) - measured from one temporal eminence above the zygomatic arch to the other; and maximum skull width (MSW) - measured from the most lateral point of the parietal bone on one side, on the same axial plane of the glabella, to the same point on the opposite side. Linear measurements were taken by a digital pachymeter with 0.01mm precision (Eccofer®, João Pessoa, Paraíba, Brazil).

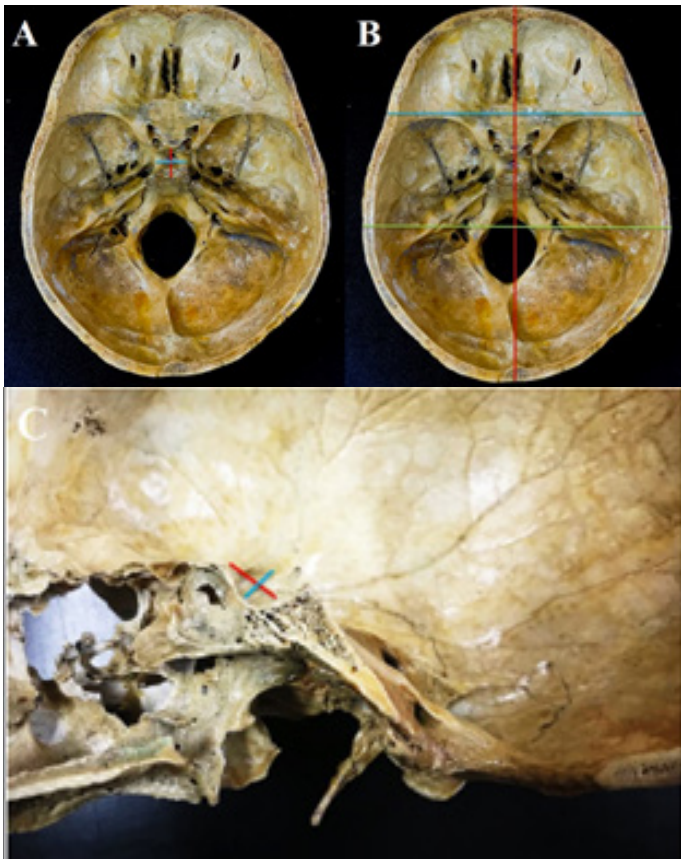

Figure 2. Morphometric analysis of sella turcica. (A): Superior view of the skull, presenting the sella turcica length (STL) on red and the sella turcica width (STW) on blue. (B): Superior view of the skull presenting craniometric measures: skull length (SL) on red, bitemporal width (BTW) on blue and maximum skull width (MSW) on green (Author's collection). (C): Medial view from a sagittal section of the skull, presenting anteroposterior diameter of sella (APDS) on red and sella turcica height (STH) on blue (Author's collection).

The data were submitted to statistical analysis using IBM SPSS 23 software. Categorical variables were described by frequencies. The analysis of normality was performed by the Shapiro-Wilk test, the homoscedasticity test by the Levene test, the difference between means of parametric variables by the T test for independent samples and by the Mann-Whitney test for those who have nonparametric variables. The correlation analysis was performed using linear regression (ANOVA). The significance level considered was 5%.

Results

After evaluating the eligibility criteria, 31 skulls (15 females and 16 males) were eligible for qualitative analysis of sella region. Considering the total number of sellas analyzed (n = 31), the highest prevalence was of the J shape (51.6%), followed by the U shape (32.3%) and flattened (16.1%). Among the female samples, the predominant format was J (66.7%), followed by U (13.3%) and flat (20%). Males showed 50% of U-shaped sellas, 37.5% were J-shaped and 12.5% were flattened (Table 1).

Table 1. Sella turcica classification (n=31).

ST Classification	Female ST	Male ST	Total
U-shaped	2 (13.3%)	8 (50%)	10 (32.3%)
J-shaped	10 (66.7%)	6 (37.5%)	16 (51.6%)
Flat-shaped	3 (20%)	2 (12.5%)	5 (16.1%)
Total	15 (100%)	16 (100%)	31 (100%)

ST= sella turcica

For the quantitative analysis, 27 skulls were included (15 females and 12 males) Descriptive analysis of morphometric variables is shown in Table 2. The STL in male skulls had a mean of 11.02±2.51 mm (range= 6.20-13.80 mm). In female skulls, the STL presented a mean of 9.87±1.87 mm (range= 7.60-13.80 mm). The measurement of STW in male skulls shows a mean of 13.47±3.82 mm (range= 6.00-17.80 mm), with a mean of 11.91±3.14 (range= 6.90-17.40 mm) for female skulls.

The APDS in male skulls presented a mean of 13.62±3.04 mm (range= 9.20-18.00 mm) while in female skulls had a mean of 12.57±2.48 mm (range= 8.70-17.90 mm). In STH, male skulls presented a mean 8.10±2.38 mm (range= 5.30-11.90 mm). In female skulls, the STH presented a mean of 7.79±2.27 mm (range= 4.90-12.00 mm). The BTW had a mean of 110.31±12.40 mm (range= 90.20-132.20 mm) in male skulls, and a mean of 111.68±9.78 mm (range= 93.70-120.50 mm) in female skulls. The last measurement, MSW, had a mean of 135.94±16.35 mm (range= 109.60-160.20 mm) in male skulls, while female skulls had a mean of 141.40±4.02 mm (range= 133.10-143.10 mm) (Table 2). No differences between genders in all morphometric variables analyzed were observed ($p>0.05$), although it was a little larger in males the measurements STL, STW, STH, APDS, SL, it was smaller in males the morphometric variables BTW and MSW.

When analyzing the presence of correlation according to linear regression (ANOVA), an association between APDS and STL (positive association), between BTW and STW (positive association), and between APDS and STW (positive association) was evidenced. The coefficients and significance of the hypotheses are shown in Table 3, while the scatterplots are shown in Figure 3.

Table 2. Descriptive analysis of collected morphometric variables (n=27).

Parameter	Mean (mm) ± SD (minimum-maximum)	Levene (Sig)	T test/Mann-Whitney test
STL	F 9.87±1.87 (7.60-13.80)	0.232	p = 0.184
	M 11.02±2.51 (6.20-13.80)		
	Total 10.38±2.21 (6.20-13.80)		
STW	F 11.91±3.14 (6.90-17.40)	0.814	p = 0.255
	M 13.47±3.82 (6.00-17.80)		
	Total 12.60±3.48 (6.00-17.80)		
APDS	F 12.57±2.48 (8.70-17.90)	0.407	p = 0.332
	M 13.62±3.04 (9.20-18.00)		
	Total 13.04±2.74 (8.70-18.00)		
STH	F 7.79±2.27 (4.90-12.00)	0.557	p = 0.736
	M 8.10±2.38 (5.30-11.90)		
	Total 7.93±2.28 (4.90-12.00)		
SL	F 162.41±9.27 (144.20-181.30)	0.628	p = 0.113
	M 168.30±9.23 (149.70-188.00)		
	Total 165.03±9.55 (144.20-188.00)		
BTW	F 111.68±9.78 (93.70-120.50)	0.110	p = 0.719
	M 110.31±12.40 (90.20-132.20)		
	Total 111.07±9.50 (90.20-132.20)		
MSW	F 141.40±4.02 (133.10-146.10)	<0.05	p = 0.300
	M 135.94±16.35 (109.60-160.20)		
	Total 138.83±11.34 (109.60-160.20)		

* STL = sella turcica length; STW = sella turcica width; APDS = anteroposterior diameter of sella; STH = sella turcica height; SL = skull length; BTW = skull width; MSW = maximum skull width; M = male; F = female; p = statistical significance of statistical tests comparison between genders.

Table 3. Linear regression models analyzed (ANOVA)

Correlation (YxX)	B0	B1	R	R2	p-value	Std. Error	Model
APDSxSTL	4.317	0.465	0.576	0.331	0.002	1.84	APDS = 0.465 STL + 4.317
BTWxSTW	-3.849	0.148	0.404	0.163	0.037	3.25	BTW = 0.148 STW – 3.849
APDSxSTW	4.320	0.636	0.500	0.250	0.008	3.07	APDS = 0.636 STW + 4.32

* APSD = anteroposterior diameter of sella; STL = sella turcica length; BTW = bitemporal width; STW = sella turcica width; B0 and B1 = equation coefficients; R = correlation coefficient.

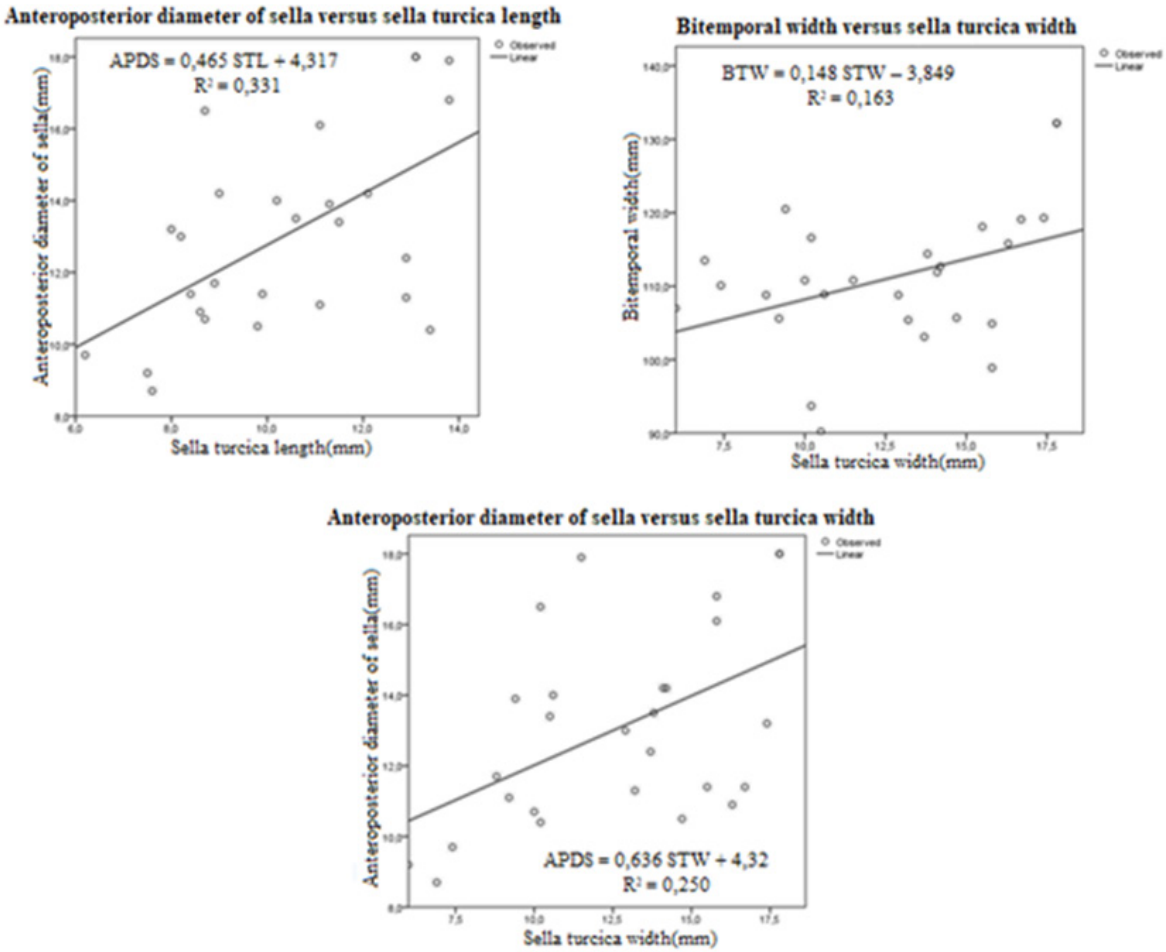

Figure 3. Scatterplots of the linear regression models between the observed values of the following measures: anteroposterior diameter of sella (APDS) and sella turcica length (STL); bitemporal width (BTW) and sella turcica width (STW); APDS and STW.

Discussion

Considering the pronounced morphological alterations in the sella turcica resulting from pituitary abnormalities, as well as the importance of recognizing this bone structure in orthodontic and neurosurgical procedures,[8,12] previous studies analyzed the sellar region to better understand its morphology and possible changes. Among the studies, five performed the analysis by lateral radiographs of the skull,[4,5,6,8,9] two by measuring cadaveric pieces,[1,3] and one by computed tomography.[7]

The qualitative results of the present study corroborate with the previous literature regarding the lower percentage of flattened sellas turcica.[14,15,16] Only one of the samples of a study presented the flat-shaped as the most prevalent, in a Chinese population.[9] In addition, our study was the only one that showed the predominance of the J format, differing from the others, in which the U format was dominant.[14] All these studies were carried out with imaging exams – computed tomography[14] and lateral cephalograms[9] – and in two of them there was the presence of infantile skulls,[9,14] (Table 4).

Morphometric analysis of the present study presented interesting results compared to the literature (Table 5). The study by Sathyanarayana *et al.* (2013)[5] presented a statistical difference between genders, pointing out female dimensions smaller than the male ones. Differently, other samples did not show a significant difference between the STL means of the

Table 4. Comparison of the distribution of sella turcica classification in different populations.

Study	Sample (n)	U-shaped	J-shaped	Flat-shaped
Present study	31	10 (32.3)	16 (51.6%)	5 (16.1%)
Muhammed *et al.*, 2019[9] (group 1 - China)	180	28.3%	35%	36.7%
Muhammed *et al.*, 2019[9] (group 2 - Nepal)	180	90%	8.3%	1.7%
Hasan *et al.*, 20161[6]	183	106 (57.9%)	45 (24.5%)	32 (17.5%)
Hasan *et al.*, 201615	71	36 (50.7%)	23 (32.4%)	12 (16.9%)
Ruiz *et al.*, 2008[14]	100	48%	41%	11%

Table 5. Gender comparison of sella turcica measurements in different populations.

Study	Sample (n)	STL (mm)		APDS (mm)		STH (mm)		STW (mm)	
		M	F	M	F	M	F	M	F
Present study	27	11.02	9.87	13.62	12.57	8.10	7.79	13.47	11.91
Henriques *et al.*, 2000[3]	20	10.29	-	-	-	7.65	-	15.76	-
Andredaki *et al.*, 20074	184	7.10	7.00	-	-	6.6	6.8	-	-
Sathyanarayana *et al.*, 2013[5]	180	9.4	8.9	11.2	10.9	7.3	7.3	-	-
Chauhan *et al.*, 2014[6]	180	7.80	7.53	-	-	5.60	7.53	-	-
Yasa *et al.*, 2017[7]	139	10.44	10.05	11.51	11.74	7.71	7.55	-	-
Magat *et al.*, 2018[8]	362	7.98	8.10	10.78	11.22	7.51	7.71	-	-
Muhammed *et al.*, 2019 (group 1)[9]	180	9.20	8.80	10.40	10.70	7.00	7.00	-	-
Muhammed *et al.*, 2019 (group 2)[9]	180	8.65	8.60	9.73	9.73	6.61	6.93	-	-

* STL = sella turcica length; APSD = anteroposterior diameter of sella; STH = sella turcica height; STW = sella turcica width.

genders,[4,6,7,8,9] as our study. However, in these six studies presented, the male averages of STL were considerably lower than the average of our study, which may present a regional difference, possibly related to the local phenotype and the cranio-cervical abnormalities or derive from samples with different age groups. It is worth mentioning that two of these studies used the distance from the sella tubercle to the clinoid process to measure the length.[4,6]

The study performed by Henriques and Pianetti (2020)[3], which was also with cadavers, presented STL mean value of 10.29 mm, however, no sexual distinction was made between the skulls. This study was the only one that measured STW with reference points similar to ours, and the result of its mean (SD) was 15.76 mm (±4.93) (Table 5). When comparing these measures with the descriptive analyzes of our sample without distinction of gender (Table 2), it can be seen that the average values of the STL was higher than ours, which maybe reinforce the hypothesis that the sella turcica in the northeast has a different anatomy from the other regions, since Henriques' study was done with cadavers from Southeastern Brazil.

Regarding APDS, the study by Magat and Ozcan (2018)[8] presented difference between genders, while other studies,[5,7,9] as well as ours, did not show relevant variation ($p>0.05$). In previous studies evaluating APDS, the mean values for men and women are lower than the means for our study. These values may reflect an important difference in the anatomy of the sella in the study region, implying a sella with a relatively larger space for surgical access.

In the present study, the male and female STH mean did not show a statistical difference, corroborating the previous literature.[4,5,7,8,9] Besides that, it is noted that the average values in male skulls are again higher when compared to skulls in other regions, pointing again to a singularity in male skulls in Northeast Brazil. However, it must be considered that the referred studies made their measurements through image exams, which may be responsible for the measured difference. The study with cadaveric samples, which did not distinguish genders and was also realized in Brazil,[3] showed a mean value of 7.65 mm for STH, a value slightly smaller to that of our sample (7.93 mm) (Table 5).

The normal dimensions of the sella turcica range from 4 mm to 16 mm for length, depth (measured with reference points similar to STH), and diameter.[8] It is considered accepted dimensions from 5 mm to 16 mm for anteroposterior diameter and 4 mm to 12 mm for depth.[5] Variations in studies may result from different degrees of magnification, from variety of reference points for the same dimensions, in addition to groups with different ages, genders, ethnicities, etc.[8] It should be noted that in the case of the present study, it is necessary to take into account the way of

measuring the measurements, which were performed on cadaveric specimens.

Analyzing the measurements in the present study statistically, we cannot observe a significant difference ($p>0.05$) between genders (Table 2). Moreover, there was a significant linear correlation ($p<0.05$) between measurements of APDS and STL; BTW and STW; APDS and STW (Table 3), which may demonstrate a possible predictive factor between craniometric measurements and sella turcica measurements, especially the correlation between STW and BTW, since individuals from northeastern Brazil tend to have larger skull width dimensions,[12] thus indicating that they may also have larger sella turcica widths.

Conclusion

The sellas turcicas in our study was predominantly J-shaped. The skulls of our sample presented measurements of length, anteroposterior diameter and sella height greater than those reported in literature from other regions, indicating a singular anatomy of skulls in northeast Brazil. In addition, it was observed proportionality between the measures of the skull and the sella turcica, indicating that craniometry can predict measures of the sella, assisting in neurosurgical planning. Knowledge of the morphology of the sella is essential to plan safer surgical approaches in the pituitary gland or related anatomical structures.

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Received: August 25, 2021
Accepted: September 21, 2021

Corresponding author
Jalles Dantas de Lucena
Email: jallesdantas@gmail.com