

Morphometry of Sella Turcica in an Indian Population Using Computed Tomography

SRINIVAS M R, VEDARAJU KS, VIJAY KUMAR KR, DEEPASHRI B

ABSTRACT

Introduction: Morphology of sella turcica varies with demographic factors such as gender and race. Hence, knowledge of normal sella turcica size is important for neurologists, surgeons and endocrinologists.

Aim: The purpose of the study was to obtain normative data of measurements pertaining to sella turcica in an Indian population using Multidetector Computed Tomography (MDCT).

Materials and Methods: A morphometric analysis of the sella turcica was done in 400 patients (200 males and 200 females) aged 1 – 93 years using high resolution CT-imaging of skull base after obtaining Institutional ethics committee approval. Anteroposterior (AP) dimension, length and depth of sella turcica were measured in each case and mean, standard deviation and correlation with age and gender derived.

Results: The majority of persons belonged to the age group 26- 40 years, comprising 41.5 % males and 42%

for females. The mean AP diameter, length and depth of sella in the study group was measured, and found to be 10.13 mm, 9.51 mm and 7.39 mm respectively. The mean AP diameter, length and depth of sella in males were found to be 10.0 mm, 9.87 mm and 7.42 mm respectively. The mean AP diameter, length and depth of sella in females were found to be 10.25 mm, 9.1 mm and 7.36 mm respectively. There is significant linear correlation between age of study group and the measured parameters below 18 years of age. Considering p-value < 0.01 as significant, unpaired 't'- test revealed significant difference between males and females only in the length of sella. The p-value was not found to be significant when comparing the AP dimension and height of males and females.

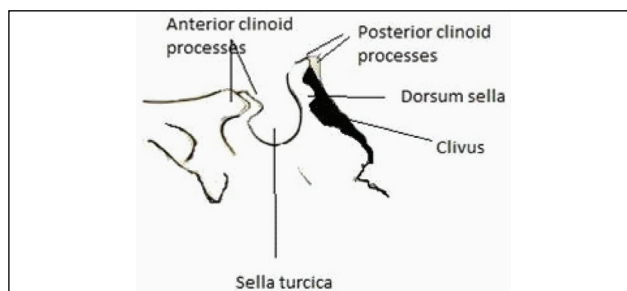
Conclusion: The results obtained from our study can be utilised as normative data of sella turcica for Indian population. Statistically significant difference was seen between the linear dimensions of the two genders with significant linear correlation between age and the dimensions of sella turcica below 18 years of age.

Keywords: MDCT, Morphology, Pituitary fossa

INTRODUCTION

The sella turcica ("Turkish-saddle") is a saddle-shaped depression in the body of sphenoid bone that houses the pituitary gland. Anteriorly, the sella turcica is bounded by the anterior clinoid processes and tuberculum sellae and posteriorly by the posterior clinoid processes and dorsum sellae. The floor of the sella turcica is formed by the roof of the sphenoid sinus [1] [Table/Fig-1].

Pituitary gland is comprised of the anterior or adenohypophysis and posterior or neurohypophysis. Anterior hypophysis has three parts - pars anterior, pars intermedia and pars tuberalis, with pars anterior being the largest part. The adenohypophysis secretes the hormones-prolactin, Growth Hormone (GH) or somatotrophin, Adrenocorticotrophic Hormone (ACTH), Follicle Stimulating Hormone (Fsh)/ Luteinizing Hormone (LH)



[Table/Fig-1]: Graphical image showing sella turcica [1].

and Thyroid-Stimulating Hormone (TSH). Posterior pituitary consists of two parts - pars nervosa and infundibulum. Pars nervosa secretes two hormones transported to it by nerve axons from the hypothalamus. These two hormones are anti-diuretic hormone or vasopressin and oxytocin [1].

Changes in the size of the sella turcica may reflect pathological processes that affect the pituitary gland and other adjacent structures. These changes may or may not be accompanied by bony erosion. Common pathologies affecting the pituitary gland that alter the shape of sella include craniopharyngioma in children and macroadenoma in adults. Pituitary neoplasms can cause alteration in levels of the various hormones produced by it. Clinical manifestations include acromegaly/gigantism, galactorrhea and menorrhagia, hyperthyroidism and Cushing's syndrome due to disturbances in the levels of GH, prolactin, TSH and ACTH respectively [2-3].

The increase in size of sella turcica on lateral cephalometric radiographs in patients leading to an incidental diagnosis of pituitary adenoma has been reported in previous studies [4-5].

Other causes of enlarged sella include empty sella syndrome wherein there is herniation of cerebrospinal fluid containing meninges into the sella, Rathke's cleft cyst which is a benign cyst of the sellar region and aneurysms [6]. A small sized sella may be seen in or as a consequence of primary hypopituitarism, Sheehan's syndrome (post-partum pituitary necrosis) and other causes of pituitary apoplexy [7].

Shape of the sella may be altered in many conditions. These conditions include spina bifida, Down's syndrome and Seckel's syndrome. Abnormalities in the shape of sella turcica were detected antenatally in fetuses with spina bifida. Normal shape of sella was found less often in Down's syndrome, in addition to an increase in the diameter and depth of the sella turcica. Seckel's syndrome is an extremely rare congenital cause of dwarfism with severe microcephaly. Other causes of craniofacial anomalies also cause abnormalities in the morphology of sella turcica [8-10].

Morphology of sella turcica also varies with demographic factors such as gender and race. Identification of the above morphological variations may give important clues in diagnosing sellar pathologies as well as other conditions that indirectly affect the skull base [11].

Normative data of measurements of sella turcica has been previously reported, with vertical dimension ranging between 4-12 mm and antero-posterior dimension measuring between 5-16 mm. Size of the sella turcica appears to increase with age and stabilises by 18 years of age [12].

The shapes and sizes of sella have been reported in Saudi and Greek subjects with different skeletal types on lateral cephalometric radiographs. The five morphological variants described include oblique anterior wall, bridging of sella turcica, double contour of the floor, irregularity in the posterior part of the floor and pyramidal shape of the dorsum sella [5,13]. Sella turcica bridging may be seen in patients with severe craniofacial anomalies [14].

Normative data for each population is important to detect those variations in the measurements that represent pathology and those that are within acceptable limits. So far most studies have been based on lateral cephalometric radiographs [11-16]. Widespread availability of MDCT has led to improved bony resolution of the sellar region allowing better morphometric analysis [17].

The objective of the present study was to obtain normative data of measurements pertaining to sella turcica in Indian patients using MDCT.

MATERIALS AND METHODS

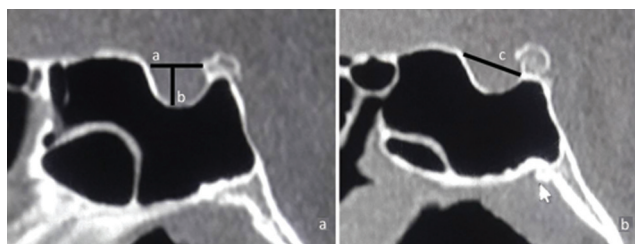
After obtaining Institutional ethics committee approval we studied 400 patients prospectively who have undergone high resolution CT imaging of skull base in south India as part of evaluation of clinical symptoms such as headache or symptoms relating to the paranasal sinuses. Informed written consent was obtained for the study from all the patients. CT images of 400 patients (200 males and 200 females) aged 1-93 years obtained during duration of one year between July 2015 to July 2016 were used in this study. None of the patients had craniofacial syndromes, clefts, or other malformations. We also excluded the patients with history of surgery in sellar/parasellar region and patients with traumatic involvement of sella turcica.

Patients fulfilling the aforementioned criteria were admitted into the study. All CT imaging examinations were done in Siemens multidetector computed tomography machine present in Victoria Hospital, Bangalore Medical College. CT was chosen over MRI for the present study as the bony landmarks for obtaining the measurements were more consistently seen in CT.

Protocol for CT of sella turcica morphometry: A preliminary AP scannogram was obtained. Serial transaxial sections were acquired from the mandible to the vault of skull. 1 mm sections in bone window were obtained and were reconstructed in sagittal and coronal planes. The following measurements were obtained after appropriate reconstruction [Table/Fig-2].

- a. Length of Sella Turcica: The distance between the tuberculum sella and posterior clinoid process.
- b. Depth of Sella Turcica: The maximum perpendicular distance between the line joining the tuberculum sella and the posterior clinoid process and the floor of sella turcica.
- c. Antero-posterior Diameter: The maximum distance between the anterior and posterior walls of sella measured parallel to the Frankfurt horizontal.

Descriptive statistics such as mean, standard deviation and standard error of mean was determined in different age groups. Regression analysis and unpaired 't'-test were done to determine correlation with age and gender.



[Table/Fig-2]: Mid- sagittal CT image showing sella turcica and sphenoid sinus. A: 'a' and 'b' represent length and depth of sella respectively. B: 'c' represents AP diameter of sella measured parallel to the Frankfurt plane.

RESULTS

Out of a total of 400 patients, 200 were females and 200 were males, constituting 50% each. The age distribution of the study population is shown in [Table/Fig-3].

The highest number of persons belonged to the age group 26-40 years, comprising 41.5 % males and 42% females respectively. The youngest male in the study group was aged 2 years and the oldest male in the study group was aged 93 years. The average age of males in the study group was 34.3 years.

MALES		FEMALES	
Age Group	Number (%)	Age Group	Number (%)
<19 years	24 (12)	<19 years	29 (14.5)
19- 25 years	33 (16.5)	19- 25 years	25 (12.5)
26- 40 years	83 (41.5)	26- 40 years	84 (42)
41- 50 years	34 (17)	41- 50 years	31 (15.5)
>50 years	26 (13)	>50 years	31 (15.5)

[Table/Fig-3]: Age distribution of study group.

		Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval	Minimum Value	Maximum Value
Study Group		10.133	1.464	0.073	9.989 to 10.277	4.6	15.1
Males		10.01	1.425	0.101	9.811 to 10.209	6.3	15.1
1	< 19 years	9.117	1.317	0.269	8.561 to 9.673	6.3	10.9
2	19- 25 years	10.155	1.623	0.282	9.579 to 10.730	7.7	15.1
3	26- 40 years	10.047	1.428	0.157	9.735 to 10.359	6.7	14.4
4	41- 50 years	9.941	1.07	0.183	9.568 to 10.314	8.2	14.5
5	> 50 years	10.623	1.339	0.263	10.082 to 11.164	7.5	14.3
Females		10.256	1.496	0.106	10.047 to 10.465	4.6	14
1	< 19 years	8.71	1.461	0.271	8.155 to 9.266	4.6	11.4
2	19- 25 years	10.44	1.343	0.269	9.890 to 10.998	8.1	13.1
3	26- 40 years	10.47	1.425	0.156	10.161 to 10.780	6.8	13.9
4	41- 50 years	10.41	1.14	0.205	9.991 to 10.828	7.5	13.9
5	> 50 years	10.816	1.29	0.232	10.343 to 11.289	8	14

[Table/Fig-4]: Table showing mean, standard deviation, standard error of mean, confidence intervals and maximum and minimum values of AP diameter of sella obtained in males and females.

Similarly, the minimum, maximum and average age of the female study group was 1, 80 and 35.5 years respectively.

The mean and standard deviation of various measurements obtained in males and females are tabulated below [Table/Fig-4-6].

The mean AP diameter, length and depth of sella in the study group were found to be 10.13 mm, 9.51 mm and 7.39 mm respectively.

The mean AP diameter, length and depth of sella in males were found to be 10.0 mm, 9.87 mm and 7.42 mm respectively. The mean AP diameter, length and depth of sella in females were found to be 10.25 mm, 9.1 mm and 7.36 mm respectively.

There is significant linear correlation between age of study group and the measured parameters below 18 years of age. The p-values are plotted in the graphs below [Table/Fig-7a-7c].

The p-values and respective correlation coefficients for the parameters AP diameter, length and depth in persons below 18 years of age were 0.0007 (0.451), 0.0029 (0.40) and 0.0001(0.51) respectively. The values of the variables on the right hand side of these graphs do not get affected by age beyond 18 years.

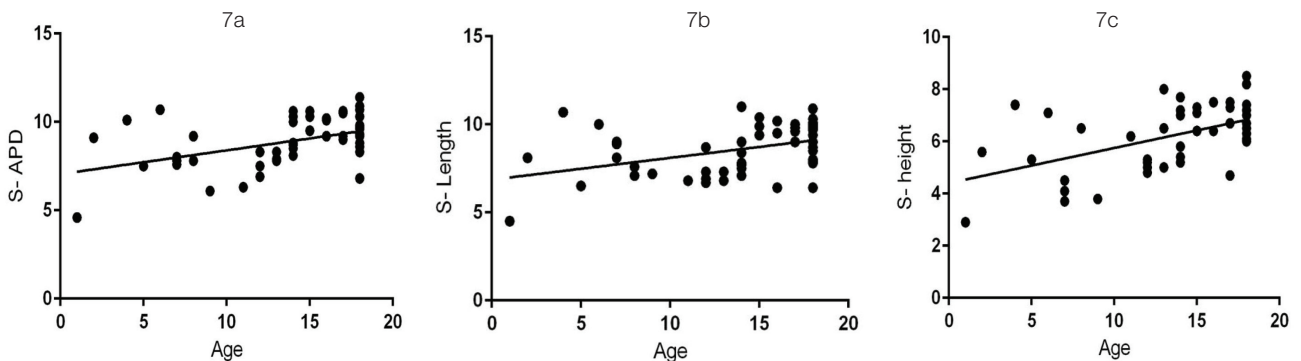
The unpaired student 't'- test was done to determine if significant difference was present between the measured parameters of males and females respectively. The p-value of less than 0.05 was considered significant. Considering this level, significant difference was found between males and females in the length of sella where the two- tailed p- value was found to be less than 0.0001. The p-value was not found to be significant when comparing the AP dimension (0.093)

		Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval	Minimum Value	Maximum Value
Study Group		9.51	1.602	0.08	9.353 to 9.667	4.3	16
Males		9.876	1.514	0.107	9.665 to 10.087	6	14
1	< 19 years	9.242	1.282	0.262	8.7 to 9.783	6.4	11
2	19- 25 years	9.876	1.653	0.288	9.289 to 10.462	6	13
3	26- 40 years	9.865	1.528	0.168	9.531 to 10.199	6.8	14
4	41- 50 years	9.906	1.205	0.207	9.485 to 10.326	7.8	13.8
5	> 50 years	10.458	1.712	0.336	9.766 to 11.149	7.4	13.6
Females		9.144	1.607	0.114	8.920 to 9.368	4.3	16
1	< 19 years	8.003	1.359	0.252	7.487 to 8.520	4.5	10.2
2	19- 25 years	9.66	1.899	0.38	8.876 to 10.444	4.3	12.88
3	26- 40 years	9.427	1.46	0.159	9.110 to 9.744	4.7	13.33
4	41- 50 years	8.803	0.937	0.168	8.459 to 9.147	6.8	13.4
5	> 50 years	9.368	1.968	0.354	8.646 to 10.090	6.9	16

[Table/Fig-5]: Table showing mean, standard deviation, standard error of mean, confidence intervals and maximum and minimum values of length of sella obtained in males and females.

		Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval	Minimum Value	Maximum Value
Study Group		7.39	1.257	0.063	7.266 to 7.514	2.9	11.6
Males		7.418	1.173	0.083	7.254 to 7.581	4.1	11.6
1	< 19 years	6.45	0.952	0.194	6.048 to 6.852	4.1	8.2
2	19- 25 years	7.291	1.102	0.192	6.900 to 7.682	5.2	10.0
3	26- 40 years	7.594	0.888	0.152	7.284 to 7.904	5.1	9.4
4	41- 50 years	7.625	1.237	0.136	7.335 to 7.895	5.6	10.6
5	> 50 years	7.557	1.168	0.229	7.105 to 8.049	5.1	11.6
Females		7.363	1.338	0.095	7.176 to 7.549	2.9	11.5
1	< 19 years	6.086	1.433	0.266	5.541 to 6.631	2.9	8.5
2	19- 25 years	7.508	1.111	0.222	7.049 to 7.967	5	10.4
3	26- 40 years	7.415	1.088	0.119	7.179 to 7.652	4.1	9.8
4	41- 50 years	7.926	1.127	0.202	7.512 to 8.339	6	11.2
5	> 50 years	7.732	1.533	0.275	7.170 to 8.295	4.9	11.5

[Table/Fig-6]: Table showing mean, standard deviation, standard error of mean, confidence intervals and maximum and minimum values of depth of sella obtained in males and females.



[Table/Fig-7a-7c]: Showing linear correlation between age and AP diameter (7A), length (7B) and height/depth (7C) of sella. There is statistically significant deviation of the slope from the horizontal and increase in the dimensions with age.

and depth (0.663) of males and females.

The shape of the sella turcica can be classified into three groups- U shape in which the tuberculum and dorsum sellae are at the same height (55%), J shape where the tuberculum is lower than dorsum sella (25%) and shallow (20%) where the depth is minimum.

DISCUSSION

In our study we have obtained the linear dimensions of the sella using computed tomography. All measurements were carried out in the mid sagittal plane. We compared the values of linear dimensions obtained in our study with previous studies.

Most of the previous studies however, have been done using lateral cephalometric radiographs. The size of sella turcica on lateral cephalometric radiographs was studied in Norwegian population aged 6-21 years by Axelsson et al., They found that while the length of the sella turcica was almost constant, the diameter and height increased with age. They did not find any difference between males and females with respect to the depth and diameter of sella turcica. However, length was found to be larger in males [15].

Alkofide E et al., described the shape and measured the size of sella turcica in 180 Saudi patients. The linear dimensions obtained were 2.02 to 2.73 mm larger than that obtained in the Norwegian group. They did not find any statistically significant difference between the two genders. They also found that the sella sizes were larger in older age groups [13].

In a study by Andredaki M et al., in 184 Greek subjects with age range of 6-17 years, they provided quantitative data for the objective assessment of shape of the sella turcica in addition to the linear dimensions. Only anterior sella height was found to be significantly different in their study, being larger in females. They also found a statistically significant correlation between age and size of the sella, with size of the sella increasing with age [12].

In South Indian population, a study by Sathyanarayana HP et al., [16] found average length and depth of sella turcica as 9.15mm and 7.3mm, which correlates well with our study where the dimensions obtained, are 9.5 mm and 7.4 mm respectively. The linear dimensions obtained in both our studies vary from that obtained in the Saudi group, who had an average sella turcica length of 10.9 mm and depth of 9.1 mm. The average linear dimensions obtained by Andredaki et al., [12] were length of 7.1 mm and depth of 6.7 mm which is relatively smaller compared to that obtained in our study and in the study by Sathyanarayana HP et al., The above differences in linear dimensions are most likely due to the different ethnicities [16].

Like us, Sathyanarayana HP et al., they found a statistically significant difference in length of sella turcica between males

and females. They also found an increased sella size with age [16]. A positive correlation between age and size of the sella turcica in age less than 25 years was also reported by Choi et al., [17].

In a recent morphometric study of the sella turcica done using computed tomography by Ruiz et al., the average length was 10.3 mm and the depth 6.3 mm. Computed tomography has higher contrast resolution compared to lateral cephalometric radiographs allowing easier and accurate measurements. Capability of multi- dimensional reconstruction has helped in minimising the effects of patient position on the plane of image used for measurement [18]. In Indian population a morphometric study of the sella turcica by CT has not been done earlier.

LIMITATION

The limitations of the present study include non- uniform distribution of age of selected studies. While shape of the skull was classified according to CT, correlation with cephalic index was not done. Patients with pituitary pathology and abnormal craniofacial morphology were not selected.

CONCLUSION

The results obtained from our study can be utilised as normative data of sella turcica for Indian population. Statistically significant difference was seen between the linear dimensions of the two genders.

Significant linear correlation was found between age and the dimensions of sella turcica below 18 years of age. Previous studies were based predominantly on lateral cephalometric radiographs. The results obtained in our study can be utilized for interpretation of these radiographs as well. In addition to providing an easier method for measuring the above dimensions, CT can help in assessing the pituitary gland itself and the surrounding structures.

REFERENCES

- [1] Osborne AG. Osborn's Brain- Imaging, Pathology and Anatomy. Amirsys Inc, 2013; Pages 681- 726.
- [2] Pisaneschi M, Kapoor G. Imaging of the sella and parasellar region. *Neuroimaging Clinics of North America*. 2005;15:203-19.
- [3] Elster AD. Imaging of the sella: anatomy and pathology. *Semin Ultrasound CT MR*. 1993;14(3):182-94.
- [4] Alkofide EA. Pituitary adenoma: a cephalometric finding. *Am J Orthod Dentofacial Orthop*. 2001;120(5):559-62.
- [5] Dostalova S, Sonka K, Smahel Z, Weiss V, Marek J. Cephalometric assessment of cranial abnormalities in patients with acromegaly. *J Craniomaxillofac Surg*. 2003;31(2):80-87.
- [6] De Marinis L, Bonadonna S, Bianchi A , Maira G , Giustina A. Extensive clinical experience primary empty sella . *Journal of Clinical Endocrinology and Metabolism*. 2005;90:5471-77.
- [7] Kelestimur F. Sheehan's syndrome. *Pituitary*. 2003;6(4):181-88.
- [8] Kjaer I, Fischer Hansen B, Reintoft I, Keeling JW. Pituitary gland and axial skeletal malformations in human fetuses with spina bifida. *Eur J Pediatr Surg*. 1999;9(6):354-58.

- [9] Korayem M, Alkofide E. Size and shape of the sella turcica in subjects with Down's syndrome. *Orthod Craniofac Res.* 2015;18:43-50.
- [10] Kjær I, Hansen N, Becktor KB, Birkebæk N, Balslev T. Craniofacial morphology, dentition, and skeletal maturity in four siblings with Seckel syndrome. *Cleft Palate Craniofac J.* 2001;38(6):645-51.
- [11] Chauhan P, Kalra S, Mongia SM, Ali S, Anurag A. Morphometric analysis of sella turcica in North Indian population: a radiological study. *Int J Res Med Sci.* 2014;2:521-26.
- [12] Andredaki M, Koumantanou A, Dorotheou D, Halazonetis DJ. A cephalometric morphometric study of the sella turcica. *European Journal of Orthodontics.* 2007;29: 449–56.
- [13] Alkofide EA. The shape and size of the sella turcica in skeletal class I, class II and class III Saudi subjects. *European Journal of Orthodontics.* 2007;29:457–63.
- [14] Becktor J P, Einersen S, Kjær I. A sella turcica bridge in subjects with severe craniofacial deviations. *European Journal of Orthodontics.* 2000;22:69–74.
- [15] Axelsson S, Storhaug K, Kjaer I. Post-natal size and morphology of the sella turcica. Longitudinal cephalometric standards for Norwegians between 6 and 21 years of age. *Eur J Orthod.* 2004;26:597-604.
- [16] Sathyanarayana HP, Kailasam V, Chitharanjan AP. The size and morphology of sella in different skeletal patterns among South Indian population: a lateral cephalometric study. *J Ind Orthod Soc.* 2013; 47:266-71.
- [17] Choi WJ, Hwang H, Lee SR. The study of shape and size of normal sella turcica in cephalometric radiographs. *Korean Journal of Oral Maxillofacial Radiology.* 2001;31:43 –49.
- [18] Ruiz CR, Wafae N, Wafae GC. Sella turcica morphometry using computed tomography. *Eur J Anat.* 2008;12:4750.

AUTHOR(S):

1. Dr. Srinivas M R
2. Dr. Vedaraju KS
3. Dr. Vijay Kumar KR
4. Dr. Deepashri B

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Radiodiagnosis, Bangalore Medical College and Research Institute, Bangalore, Karnataka, India.
2. Associate Professor, Department of Radiodiagnosis, Bangalore Medical College and Research Institute, Bangalore, Karnataka, India.
3. Associate Professor, Department of Radiodiagnosis, Bangalore Medical College and Research Institute, Bangalore, Karnataka, India.

4. Post Graduate, Department of Radiodiagnosis, Bangalore Medical College and Research Institute, Bangalore, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Srinivas M R,
Department of Radiodiagnosis, Fort Road,
Victoria Hospital, Near K R Market, Bangalore,
Karnataka-560002, India.
E-mail: sinumr25@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS:

None.

Date of Publishing: Jan 01, 2017