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ORIGINAL ARTICLE

Cone Beam Computed Tomographic Evaluation of Shape, Linear Dimensions and Volume of Sella Turcica: A Retrospective Observational Study

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ABSTRACT

Background: Sella turcica is an important saddle shaped structure that houses the pituitary gland. Any deviation in the development of the pituitary gland may affect the size and shape of the sella turcica as well. So, the morphology of the sella turcica gains special importance in certain clinical conditions. The aim of this study was to assess the shape, linear dimensions and volume of sella turcica in healthy adults using cone beam computed tomography (CBCT).

Material and Methods: This retrospective study involved CBCT images of 108 healthy adults. The sagittal, axial, and coronal slices of CBCT images were used to evaluate the shape, volume and linear dimensions.

Results: The overall linear dimensions of sella turcica were length 8.59 ±1.49 mm, depth 7.27 ±1.16 mm, diameter 10.24 ±1.75 mm and volume 1499.69 ± 395.5 mm3 respectively. The length of sella turcica was higher in males than females which was statistically significant (p = 0.015) while the depth, diameter and volume reported non-significant results. The most frequent shape of sella turcica was normal and the least frequent was sella turcica bridging. The Pearson correlation co-efficient was statistically significant for the length vs diameter and volume alongwith diameter vs volume in both genders (p < 0.01). The depth was statistically correlated with length, diameter and volume in males (p <0.01).

Conclusion: The sella turcica shape and dimensions can be used in forensic and medicolegal purposes. So, a thorough of knowledge about this important structure is necessary.

keywords | Sella Turcica; cone-beam computed tomography; morphology; shape.

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INTRODUCTION

An important saddle shaped structure that houses the pituitary gland is the "sella turcica" that is located in the middle cranial fossa.[1-4] Due to its position as the central reference point in the assessment of cranial morphology and intermaxillary relations,

the sella turcica is considered to be of special significance.[2,5-7]

Accumulating evidence suggests that the radiological diagnosis of sella turcica is important in the field of orthodontics during cephalometric analysis. Investigations concerning the sella turcica have not only focused on size but also on morphology as they assist for diagnosis and evaluating the treatment results.[3,8-10] Various attempts to classify the sella turcica size have been made in pre-pubertal groups (till age 14 years) revealing that its size increases with age until skeletal maturation.[8,10,11] Also, conflicting results have been reported in the literature regarding the difference in size of sella turcica in males and females.[3,11-13]

Since the size of sella turcica influences the size of pituitary gland, any deviation in the development of the pituitary gland may affect the size and shape of the sella turcica as well. In this context, the morphology size and shape of the sella turcica gains importance under some clinical conditions such as Type I diabetes, Acromegaly, Turner syndrome, Sheehan's syndrome (SS), Trisomy 21, Neurofibromatosis type 1, Velocardiofacial syndrome, Meckel–Gruber syndrome and cleft lip and palate.[1,6,7,14,15] This necessitates the role of radiologist to carefully interpret such malformations and deviations that would provide significant insights in appropriate and timely diagnosis.

The analysis of the sella turcica has been emphasized in the literature by 2D cephalometric and cadaveric analysis. [12,13,16-20] However, with the introduction of 3D imaging i.e. Cone beam computed tomography (CBCT), the radiographic analysis of 3D structures has improved, with the added benefits of a lower effective radiation dose and reduced time.[2,5,14,21] The morphology of the sella turcica appears to be more precise and accurate, with no superimposition or distortion, and measurements can be taken using 3-D images.[2,21]

As a result, a detailed understanding of sella turcica morphology in various populations has been thought to be beneficial in defining normal standards that differentiate abnormal morphology in various craniofacial syndromes and aberrations. There appears to be a paucity of literature on evaluating sella morphology using CBCT imaging. This research employed CBCT images to determine the dimensions and volume of the sella turcica in a population of healthy adults in order to establish a range of normal values.

MATERIAL AND METHODS

The present retrospective CBCT based analysis of sella turcica morphology was approved by the Institutional Ethics Committee (Ref no: SDCH/SAC/2017-18/90). Full Field of view (FOV) CBCT images of 108 healthy individuals aged 18 years and above were analyzed randomly which had been collected previously for several reasons (orthodontic treatment, prior to planning of implant angulations and/or occlusal plane constructions, evaluation of stabilization occlusal splint or periodontal problems, etc.). The patients having cleft lip and palate, impacted canines, dental transposition, and dental anomalies and patients with previous history of orthognathic treatment were excluded from the study.

CBCT images were obtained from the archives of Department of Oral Medicine and Radiology. All CBCT images were obtained using a Promax 3D Mid Proface CBCT unit (Planmeca, Helsinki, Finland), operating at voltage of 60-120 kVp, current of 1-12 mAs, Time 9-33 seconds and voxel size of 200-600 micrometer. The CBCT images were evaluated with in-built software Romexis version 4.2.0 R 10/13/15 software viewer and was analyzed by two investigators. To improve the reliability of data measurements, investigators were tested for intra and inter examiner variability. All measurements were analyzed twice by both examiners with an interval of one week before the study analysis and in between each measurement. If the variability between the two examiners was found to be upto 10%

then the average was considered. However, the variability more than 10% was reassessed by another investigator. The measurements were made to the nearest of 0.6 mm with a caliper. The sagittal, axial, and coronal slices of CBCT images were used to evaluate the volume and linear dimensions. The linear dimensions (length, depth and diameter) were evaluated according to Silverman and Kisling method.[22,23] The measurements were as follows:

1. ***Length:*** From the tip of the dorsum sella to the tuberculum sella;
2. ***Depth:*** As a perpendicular from the line extending to the deepest point of the sellar floor;
3. ***Diameter:*** As the furthest point on the postero-inferior aspect of the pituitary fossa to the most superior point on the tuberculum sella. (Fig. 1 and 2)

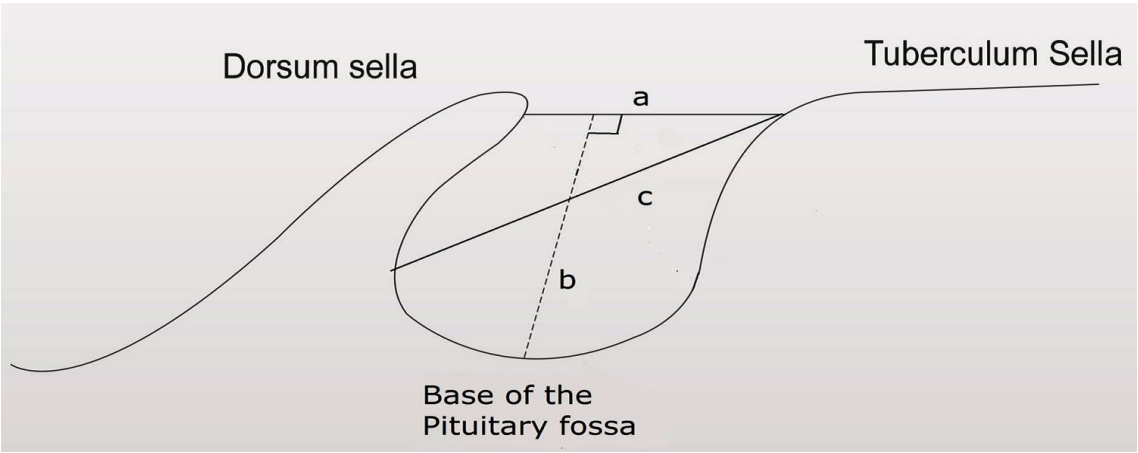

Fig. 1: Measurements of linear dimensions of sella turcica (according to Silverman). (length - a, depth - b and diameter - c).

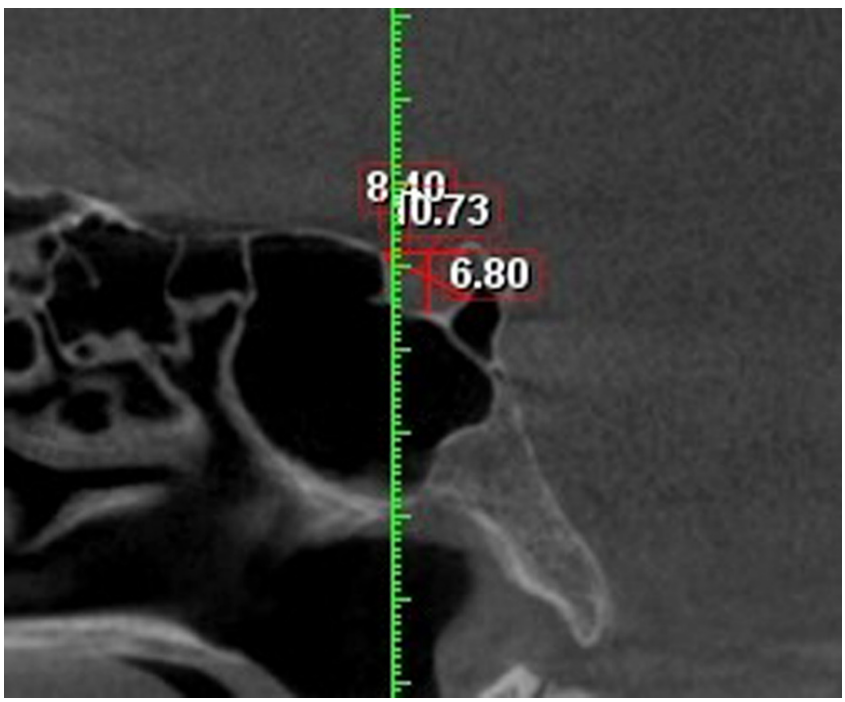

Fig. 2: Linear Diamensions of sella turcica.

4. ***Shape:*** The sella turcica was described according to the sella turcica shape classification given by Axelsson et al. (Fig. 3)

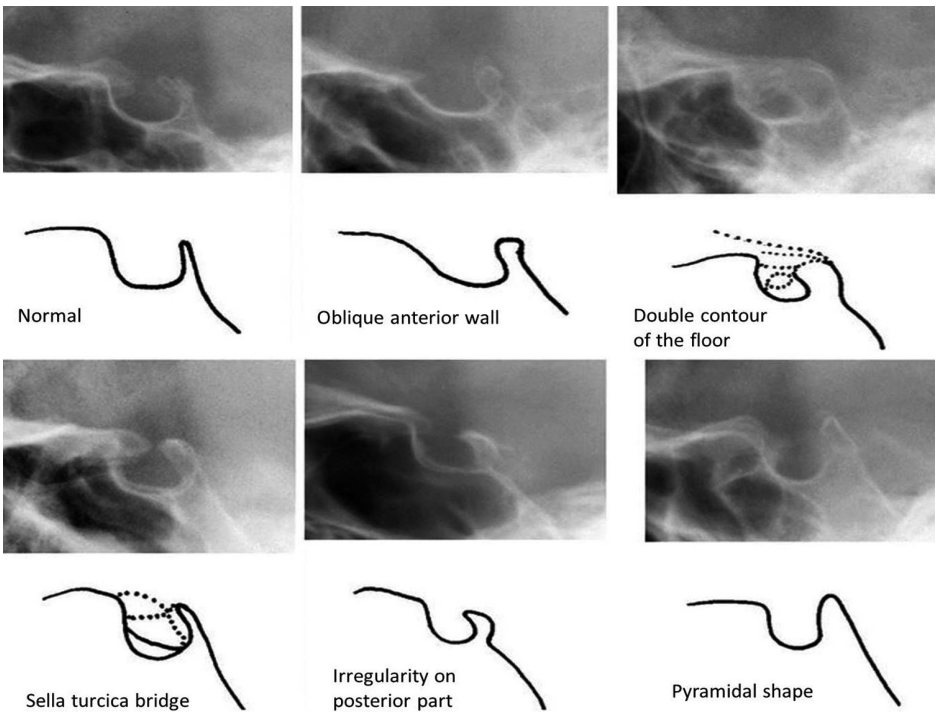

Fig. 3: Shapes of sella turcica.

5. Volume of sella turcica: In the sagittal slice, a circle most fitting the outer contours of the sella turcica was constructed on the image. Simultaneously, this circle was formed multiplanarly in the axial and coronal slices and the volume was calculated by the romexis software programme. (Fig. 4) (TanerL et al.)[14]

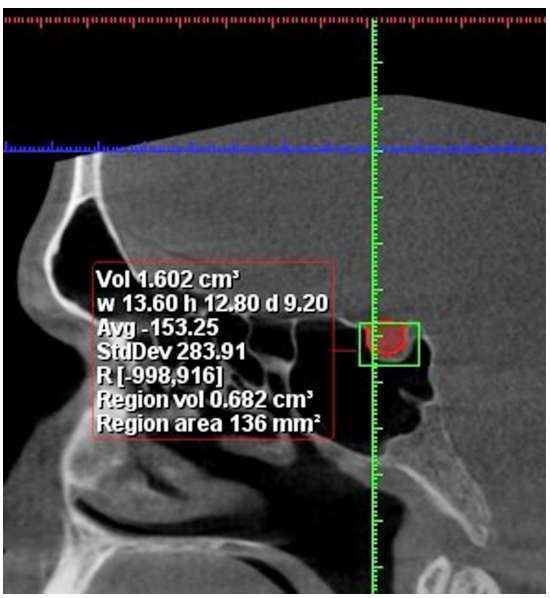

Fig. 4: CBCT image of volume of sella turcica.

Statistical analysis

Data was analyzed using SPSS software (v.21). Normality of data was checked using Shapiro -Wilk test or Kolmogorov-Smirnov test. Descriptive measures were assessed in both genders. Frequency analysis was performed for the prevalence of shape of sella turcica. Unpaired 't' test was used for gender wise comparison. Correlation between variables was assessed by Pearson correlation test. The $p<0.05$ was considered statistically significant.

RESULTS

The overall dimensions of sella turcica were length – 8.59 ±1.49 mm, depth – 7.27 ±1.16 mm, diameter – 10.24 ±1.75 mm and volume – 1499.69 ± 395.5 mm^3 (Table 1). In females the mean dimensions were length 8.25±1.24 mm (range 5.6 – 10.81 mm), depth – 7.26±1.09 mm (range 5.2 – 9.60 mm), diameter – 10.24±1.51 mm (range 4.8 – 13.97 mm) and volume -1461.52 ± 337.57 mm^3 (range 430 – 2209 mm). In males the mean dimensions were length 8.94 ± 1.64 mm (range 6.00–13.20 mm), depth – 7.28 ± 1.24 mm (range 5.6–10.41 mm), diameter – 10.25 ± 1.98 (range 1.63–13.96 mm) and volume 1537.87 ± 445.95 mm^3 (range 810–2959mm^3) (Table 2).

The comparison of length of sella turcica in males and females were statistically significant (p=0.015) with males showing higher dimensions compared to females. All other dimensions reported were statistically non-significant (Table 2).

The most frequent shape of sella turcica was normal and the least frequent was sella turcica bridging (Table 3). In females, the most common shape of sella turcica was normal (70.4%) and in males, normal (64.8%) was most frequently found. (Table 3).

The Pearson correlation co-efficient was statistically significant for the length vs diameter and volume and diameter vs volume in both genders ($p < 0.01$). The depth was statistically correlated with length, diameter and volume in males ($p < 0.01$) (Table 4).

Table 1: Descriptive Statistics in all samples

	Length mm	Depth mm	Diameter mm	Volume mm
Mean ± Std. Deviation	8.59 ±1.49	7.27 ±1.16	10.24 ±1.75	1499.69 ± 395.5
Median	8.49	7.2	10.07	1419.5
Minimum	5.6	5.2	1.63	430
Maximum	13.2	10.41	13.97	2959

Table 2: Gender wise descriptive statistics

	Length mm		Depth mm		Diameter mm		Volume mm	
	Females	Males	Females	Males	Females	Males	Females	Males
Mean ± Std. Deviation	8.25 ±1.24	8.94 ±1.64	7.26 ±1.09	7.28 ±1.24	10.24 ±1.51	10.25 ±1.98	1416.52 ±337.57	1537.87 ± 445.95
Median	8.4	8.81	7.21	7	10.24	10.03	1466	1419
Minimum	5.6	6	5.2	5.6	4.8	1.63	430	810
Maximum	10.81	13.2	9.6	10.41	13.97	13.96	2209	2959
t value	2.475	–	0.126	–	0.025	–	1.003	–
P value	0.015 *	–	0.9	–	0.98	–	0.318	–

* significant at $p < 0.05$

Table 3: Shape of sella turcica in all study samples.

Shape	Total number	Frequency
	(Females / Males)	(Females / Males) in %
Normal	73 (38 / 35)	67.6 (70.4 / 64.8)
Oblique anterior wall	9 (5/4)	8.3 (9.3 / 7.4)
Double contour of the floor	10 (8/2)	9.3 (14.8 / 3.7)
Sella turcica bridge	1 (0/1)	0.9 (0 / 1.9)
Irregularity on posterior part of sella turcica	7 (0/7)	6.5 (0 / 13)
Pyramidal shape of dorsum sella	8 (3/5)	7.4 (5.6 / 9.3)
Total	**108**	**100**

Table 4: Correlations of dimensions of sella turcica with age in females and males.

Correlation	Gender	'r' value	p value
Age v/s Length	Females	-0.011	0.935
	Males	0.152	0.273
Age v/s Depth	Females	0.13	0.35
	Males	-0.034	0.808
Age v/s Diameter	Females	-0.078	0.576
	Males	0.11	0.428
Age v/s Volume	Females	0.149	0.281
	Males	0.119	0.391
Length v/s Depth	Females	-0.178	0.197
	Males	0.491**	0
Length v/s Diameter	Females	0.574**	0
	Males	0.649**	0
Length v/s Volume	Females	0.378**	0.005
	Males	0.563**	0
Depth v/s Diameter	Females	0.255	0.063
	Males	0.486**	0
Depth v/s Volume	Females	0.235	0.087
	Males	0.683**	0
Diameter v/s Volume	Females	0.450**	0.001
	Males	0.533**	0

** Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Sella turcica is an important landmark in the skull base and the changesin its size correlate with pathologies of pituitary gland.[2,3,21] The size of sella turcica also varies with race and geographical location.[5] Studies have been done in cadavers, 2D and 3D imaging to find the length, depth and diameter in various populations.[4,7,12,14,17,18,19,24,25] The Silverman and Kisling's method for calculating the dimensions of sella turcica, has been adopted by most authors.[2-4,6,8,11,14,16,26,27] The same method was followed in the present study. Few authors have used additional measurements to more accurately quantify the sella turcica, such as anterior and posterior sella height, tranverse width, and so on.[4,5,10]

The length of the sella turcica is the most commonly studied parameter in the literature.[2-6] Various studies reported that the length of the sella turcica ranged from 7 ± 1.7 mm to 10.41±2.25 mm.[2,5,6,10,11] The length of the sella turcica found in this study is consistent with previous findings.

A few authors have categorized the linear dimensions of sella turcica according to skeletal classes, but the findings have been conflicting.[6,7,12] Sathyanarayan et al.[12] noted significant differences in linear dimensions between skeletal class, while most authors reported no difference.[3,4,6,7,8,13,27]

In determining if gender played a difference in terms of linear dimension i.e. length of sella turcica, contradictory findings were reported.[3,11-13] Males were found to have higher length than females in previous research which is consistent with findings of present research.[4,11,12,16,26] However, few others reported no gender difference.[3,7,8,13,14,16,27]

In the literature, various authors have analyzed the relationship between age and the length of the sella turcica, with contradictory results.[5,10,11,12,13] A few authors found no correlation between age and sella turcica length[11,13] whereas others found a positive correlation.[5,10,12,24]

Many authors conclude that the length of sella turcica showed higher values in males from 1 month to 18 years of age; while females experience a significant increase in the size from 11 to 15 years of age as a result of the pubertal growth spurt, which occurs two years earlier in females compared to males. Following that, both genders show a more roundening-out of the sella region.[8,22,25,27,28] Also, until the age of 25 years, the dimensional changes in the sella turcica show a strong positive trend in length, depth, and diameter. After that, the growth ceases.[8,11,20,25,27]

The mean depth in various studies ranged from 7.3±1.1 to 9.87±2.42 mm.[4,5,6,8,11,26,29] The least dimension was reported by Axelsson et al.[11] (7.3±1.1 mm in males and 7.2±1.2 mm in females) and the highest dimension was reported by Chaurasia et al.[5] (9.87±2.42 mm in males and 9.47±1.98 mm in females). In the present study, the mean depth reported is in accordance to Axelson et al.[11] Differences in imaging methods and the degree of radiographic enlargement may explain the variance in depth dimension. This may also be due to the different population sample and diversity in distribution of sample.

Analysis of gender related difference in depth and diameter was found to be non-contributory in most of the studies.[4,6,7,8,11,12,13,14,16,27] In the present investigation, similar findings were obtained. However, Kumar M et al.[16] found that depth of sella turcica was more in females. Similarly, Magat et al.[6] reported females had more diameter of sella turcica than males.

Regarding the correlation of age with the depth of sella turcica, there was a positive correlation of depth and age in most of the studies.[2,6,11,12,16,24] But, Chaitanya et al.[13] found no correlation of depth with age. Also, the conclusions of a positive correlation between diameter and age werereported in most of the studies.[2,7,11,12,16,24] In the present study correlation of age with linear dimensions of sella turcica was not done.

There is a paucity of literature on the measurement of sella turcica volume with authors reporting different methods and formulae for calculating volume.[24,25,26,30] However, no standard protocol has yet been

stated in any imaging modalities. In the present study, the method of assessing the volume of sella turcica is followed according to that given by Taner L et al.[14] Though we reported that males showed slightly higher volume than females, it was statistically non-significant, while Taner L. et al.[14] reported a higher volume in males (1102±285.3 mm^3) as compared to females (951.3±278.5 mm^3). However, Taner L et al.[14] reported a lower volume of sella turcica as compared to the present study.

The sella turcica has been classified by several authors.[11,29,31,32,33,34] The Axelsson classification was used in this study because it is elaborate and simple to understand. Various authors have used this classification and stated that the normal sella turcica ranges from 39-76%.[3,6-9,12,13,16,25,27,35] The normal shape of sella was found to be 67.6% in the current analysis.

Other forms of sella turcica shapes include oblique anterior wall, which ranged from 5-20%; while we reported 8.3% in the current study.[7,12]

Sellat urcica bridging is more often seen in patients with craniofacial disorders, but it can also occur in healthy individuals.[36,37] In the literature, the sella turcica bridging rangedfrom 1.1%-17%.[8,9] It was revealed to be 9.3% in the current research.

Double contour (0.9%) was the least commonly recorded form in the present study, while in the literature it ranges from 5 to 22.8 %.[12,35] Thus, being much lower than previously published.

Other forms include irregular ranging from 3 to 16% and we reported 6.5%[25,35] The pyramidal form ranges from 2.8-15.5% in the literature[6,8] while we found 7.4% in the current analysis.

In the present study, the length of sella turcica was higher in males than females. Also, the depth of sella turcica correlated with length, diameter and volume in males. Thus, from forensic perspective, this study highlights that sella turcica could be useful landmark in gender determination.

The study's limitations include a limited sample size and an unequal distribution of age groups. To increase the reliability of the data, future studies should provide a larger sample population with comparable samples in all age groups.

The results of this study emphasize the role of CBCT in the 3-dimensional evaluation of sella turcica. Since this an important landmark is seen in the CBCT images, it is the responsibility of the maxillofacial radiologist to have a thorough knowledge that will differentiate a normal morphologyof sella from an abnormal one while correlating the radiological findings with the clinical parameters if any. This could be helpful for an appropriate and complete diagnosis of the CBCT image in question and would help in forensic, medico legal and orthodontic diagnosis and treatment evaluation.

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