

Morphometric Study of Posterior Cranial Fossa Using Computerized Tomographic (CT) Images

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Abstract

Introduction: The posterior cranial fossa is the largest and the deepest of the three fossae. Contents of posterior cranial fossa include occipital part of cerebral hemispheres, cerebellum, midbrain, pons and medulla oblongata. Variations in the volume of posterior cranial fossa may cause compression of these structures which may lead to various disorders. There is increasing evidence on the diagnostic potential of posterior cranial fossa measurements. The present study on morphometry of posterior cranial fossa based on CT images of patients without any clinical abnormality was undertaken for the first time in south Indian population. **Subjects and Methods:** To study and compare sex-wise and age-wise differences in the supratentorial and posterior cranial fossa (PF) measurements in the normal CT scan images of 62 males and 38 females who attended the Neurology department of SVIMS belonging to Rayalaseema region was undertaken. The measurements that were recorded are transverse diameter (TD) and anteroposterior diameter (APD) of supratentorial part and also posterior cranial fossa and height and volume of posterior cranial fossa. **Results:** The mean supratentorial TD and APD were found to be less in male but were not statistically significant sex-wise and age-wise. The mean posterior fossa APD was significant, PF height and volume were highly significantly in males. **Discussion:** There are no reports on supratentorial parameters in literature for comparing the results of present study. Except for one study on CT on height and volume of posterior cranial fossa there are no other studies for comparing the values of present study. **Conclusion:** Observations on supratentorial parameters of the present study are the first to be reported in literature. Age-wise and sex-wise observation of parameters of TD and APD of PF are the first to be reported in literature.

Keywords: Basion, computerized tomographic scan, internal occipital protuberance, Mc Rae line, opisthion, posterior cranial fossa, supratentorial, Twinning's line, tuberculum sellae, torcula.

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Introduction

Knowledge of normal anatomy of a region is important to the clinician for better diagnosis, classification and treatment of diseases related to the region and serve as a future reference for defining an anatomic range.

Pathological conditions of posterior cranial fossa (PF) and cranio-vertebral junction are very common. Knowledge of anatomy of this region and the normal range of dimensions of these regions are important for proper planning of medical/surgical line of management. A wide spectrum of central nervous system diseases has been associated with alterations in size, shape and contents of posterior cranial fossa such as Chiari malformations, Dandy-Walker syndrome, autism, olivo-Ponto-cerebellar atrophy, cerebellar vermian hypoplasia, Down's Syndrome etc.^[1-6] the measurement of volume of posterior cranial fossa and its relationship with supra tentorial volume is of great clinical significance in the diagnosis and prognosis of Chiari malformations.

The parameters of posterior cranial fossa region may present

variations depending on race, religion, body habitus, gender, geographical and genetic factors.^[7] In the literature only one study on posterior cranial fossa using radiological method on North Indian population was available. The radiological measurement of the posterior cranial fossa is the easiest method to obtain these parameters.

In the literature the supratentorial volume is correlated with the endocranial capacity.^[10] Dimensions of supratentorial region alone are not quoted in the literature to the best of our knowledge. The dimensions of supratentorial region are helpful in the study of low grade supratentorial tumours like astrocytoma, ganglioglioma, oligodendroglioma etc. These dimensions are essential in the neurosurgeries involving supratentorial tumours, atrophies.^[8]

There are limited studies on the morphology of the posterior cranial fossa (PF). There is only one reported study on posterior cranial fossa measurements in dry skulls by Gautam Kanodia et al,^[7] who conducted studies on posterior fossa in 100 dry skulls. They reported that the mean height of PF in dry skulls as 3.01 cm (± 0.22) (range 2.5–4.0 cm) and volume as 122.49 cm³ (± 14.66).

Most of the reported studies available in literature on CT scan morphometry of posterior cranial fossa were on patients with Chiari malformations or on those with underlying pathologies in posterior cranial fossa.^[9-13]

Prassopoulos et al.,^[8] studied the developmental changes in children using Computerized tomography. They reported rapid increase in the volume of posterior fossa during first 3 years of life and later the rate of growth decreases. The values at the age of 3 years are 165cm³ in boys and 155cm³ in girls. At the age of 15 the values are 220cm³ in boys and 207cm³ in girls.

Sabri et al.,^[11] conducted studies in paediatric patients of 6-12 years age group on posterior cranial fossa using magnetic resonance imaging with different pathologies underlying and compared with the controls. They reported reduction in all the values in children with underlying pathology. They reported for anteroposterior diameter (APD) of 60.4±10.6 mm in patients and 74.7 ±3.5mm in controls. Height of posterior fossa in patients is 124.7±15.7 mm and in controls is 141.2±6.8mm in their study.

Gautam Kanodia et al.,^[7] conducted studies on posterior fossa in 100 CT scans. They reported that the mean height of PF in CT was 3.52 cm (±0.43) and the mean value of PFV were 157.88 (±27.94) cm³ (range 98.75–216.88 cm³) and 159.58 (±25.73) cm³(range 116.03– 252.99 cm³).

Apolito et al.,^[9] conducted morphometric and volumetric studies on posterior fossa in three groups of paediatric patients.

Subjects and Methods

A prospective study of one hundred (100) computerized tomographic (CT) scan images collected from department of Radiology, Sri Venkateswara Institute of Medical Sciences, Tirupati, Andhra Pradesh were utilized for observing morphological parameters and for recording morphometric parameters of posterior cranial fossa. CT scans of patients admitted to neuro-surgery unit with general complaints of headache and dizziness and without any bony or soft tissue abnormalities were included in the study. Those with fracture, hematoma, or lesions were excluded from the study.

Study Sample

In the present study using SOMATOM CT scanner, 100 CT scan images of normal individuals of both sexes and in the age group of 6-80 years were taken with a slice thickness of 6mm. The CT scans were evaluated for the following morphological and morphometric parameters of posterior cranial fossa.

A. Supra tentorial part [Figure 1]

1. Anteroposterior diameter (APD)- distance measured from anterior part of frontal crest to the internal occipital protuberance.
2. Transverse diameter (TD)-the maximum horizontal distance from the mid-point of the AP diameter.

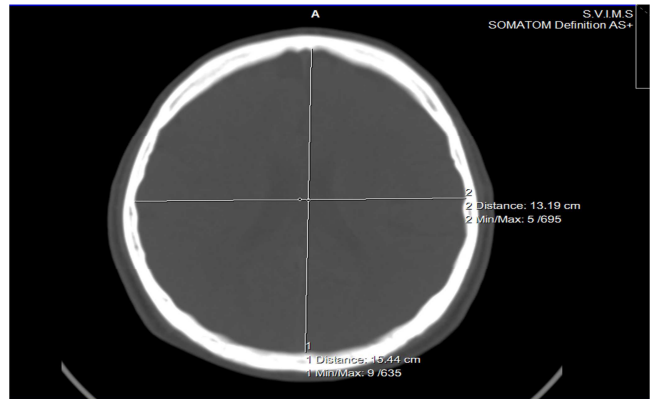


Figure 1: APD and TD of supra-tentorial part

B. Posterior fossa (PF) [Figure 2,3]

1. Height of PF is perpendicular distance between the following two lines^[7] [Figure 2]
 - Twinning's line-line between tuberculum sellae and torcula.
 - Mc Rae line-radiographic line drawn on sagittal section of CT or MRI, joining the opisthion and basion.
2. Anteroposterior diameter (APD) - distance between posterior clinoid process and internal occipital protuberance.^[7] [Figure 4.5]
3. Transverse diameter (TD)-distance measured at right angles to the anteroposterior diameter of posterior cranial fossa.^[7] [Figure 3]
4. Volume is measured using the formula^[7]

$$\frac{abc}{2}$$
 where
 'a' is height
 'b' is AP diameter
 'c' is transverse diameter

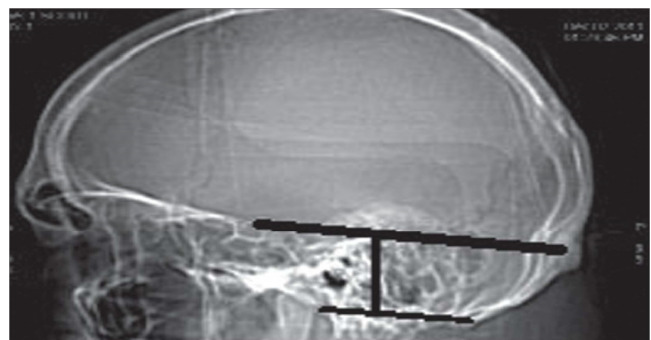


Figure 2: A. Twinning's line-line B. Mc Rae line

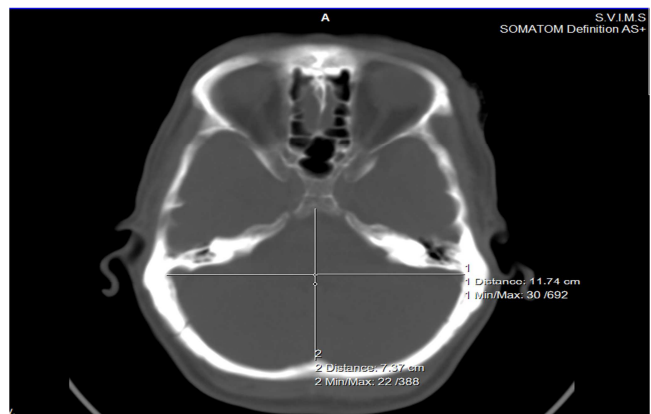


Figure 3: APD and TD of Posterior cranial fossa

Majority of the subjects were males (62%) than females (38%). Age-wise distribution of subjects was represented in [Figure 4].

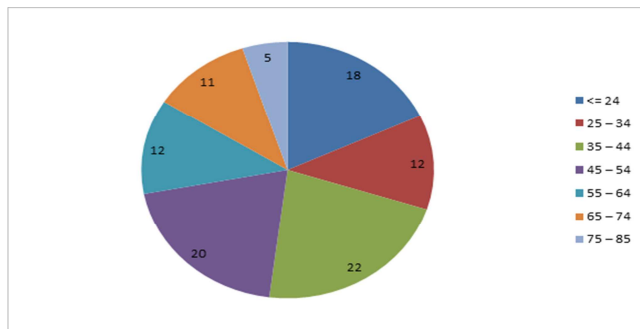


Figure 4: Age distribution (%) of subjects

Age and gender wise distribution of subjects were presented in [Figure 5]. The age distribution of subjects was found to be similar in both males and females. The differences in the proportion between male and female subjects were also not statistically significant (P=0.78; NS).

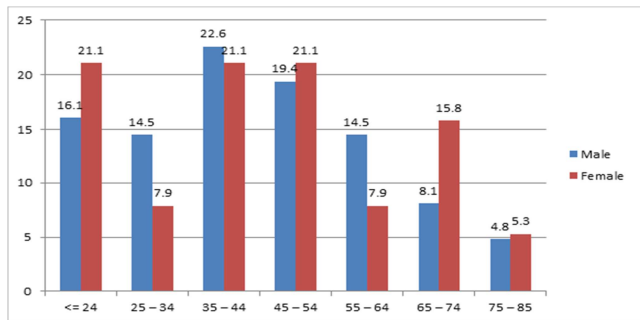


Fig 5: Age and sex distribution (%) of subjects

A. Analysis of supra tentorial part parameters:

The results on morphometric parameters of TD and APD of supratentorial part were represented in [Tables 1 & 2] based on gender and age respectively. These two values were not statistically significant in both gender wise and age wise groups.

Table 1: Supra tentorial transverse and anteroposterior diameter by gender

Gender	Supratentorial diameters (Mean ± SD)	
	Transverse	Anteroposterior
Male	12.24 ± 0.53	14.98 ± 0.74
Female	12.39 ± 0.59	15.06 ± 0.68
Statistical significance	t=1.31; P=0.19; NS	t=0.56; P=0.58; NS

Table 2: Supratentorial transverse and anteroposterior diameter by age group

Age group	Supratentorial diameters (Mean ± SD)	
	Transverse	Anteroposterior
<= 24	12.44 ± 0.57	14.97 ± 0.70
25 - 34	11.95 ± 0.64	15.07 ± 0.54
35 - 44	12.31 ± 0.59	15.04 ± 0.80
45 - 54	12.42 ± 0.48	15.05 ± 0.83
55 - 64	12.11 ± 0.50	14.96 ± 0.69
65 - 74	12.38 ± 0.45	15.06 ± 0.68
75 - 85	12.38 ± 0.67	14.72 ± 0.81
Statistical significance	F=1.43; P=0.21; NS	F=0.19; P=0.97; NS

B. Analysis of Posterior fossa parameters:

The results on morphometric parameters of TD and APD of posterior fossa, height of posterior fossa and volume of posterior fossa were represented gender-wise and sex-wise in [Tables 3-8]. The mean posterior fossa TD was found to be similar in the male and female subjects and the difference was not statistically significant (P=0.60). The mean posterior fossa APD was however found to be significantly higher in males (7.06) compared to that in females (6.74) and the difference was statistically significant (P=0.02; S) [Table 3].

Table 3: Posterior fossa transverse and anteroposterior diameter by gender

Gender	Posterior fossa diameters (Mean ± SD)	
	Transverse	Anteroposterior
Male	10.63 ± 0.54	7.06 ± 0.59
Female	10.69 ± 0.55	6.74 ± 0.73
Statistical significance	t=0.52; P=0.60; NS	t=2.41; P=0.02; S

The mean posterior fossa transverse and anteroposterior diameters were found to be similar in the various age groups and the differences were not statistically significant (P=0.76; NS). [Table 4].

Table 4: Posterior fossa transverse and anteroposterior diameter by age group

Age group	Posterior fossa diameters (Mean ± SD)	
	Transverse	Anteroposterior
<= 24	10.70 ± 0.57	6.67 ± 0.75
25 - 34	10.73 ± 0.50	7.05 ± 0.69
35 - 44	10.66 ± 0.58	6.94 ± 0.51
45 - 54	10.71 ± 0.46	7.05 ± 0.65
55 - 64	10.40 ± 0.72	6.83 ± 0.68
65 - 74	10.71 ± 0.48	7.22 ± 0.61
75 - 85	10.61 ± 0.36	6.82 ± 0.78
Statistical significance	F=0.56; P=0.76; NS	F=1.08; P=0.38; NS

The mean posterior fossa height was found to be significantly higher in male subjects (3.57) compared to that in females (3.12) and the difference was also very highly significant (P<0.001; S) [Table 5].

Table 5: Posterior fossa height by gender

Age group	Posterior fossa height (Mean ± SD)
Male	3.57 ± 0.35
Female	3.12 ± 0.35
Statistical significance	t=6.20; P<0.001; S

The mean posterior fossa height was found to be similar in the various age groups and the differences were also not statistically significant (P=0.36; NS) [Table 6].

Table 6: Posterior fossa height by age group

Age group	Posterior fossa height (Mean ± SD)
<= 24	3.37 ± 0.46
25 - 34	3.50 ± 0.50
35 - 44	3.35 ± 0.31
45 - 54	3.41 ± 0.34
55 - 64	3.41 ± 0.46
65 - 74	3.22 ± 0.37
75 - 85	3.73 ± 0.52
Statistical significance	F=1.11; P=0.36; NS

The mean posterior fossa volume was found to be significantly higher in male subjects (134.5) compared to that in females (113.7) and the difference was also very highly significant ($P < 0.001$; S) [Table 7].

Table 7: Posterior fossa volume by gender

Age group	Posterior fossa volume (Mean ± SD)
Male	134.46 ± 21.04
Female	113.73 ± 25.11
Statistical significance	t=4.43; P<0.001; S

The mean posterior fossa volume was found to be similar in the various age groups and the differences were also not statistically significant ($P = 0.76$; NS) [Table 8].

Table 8: Posterior fossa volume by age group

Age group	Posterior fossa volume (Mean ± SD)
≤ 24	121.33 ± 25.96
25 – 34	133.67 ± 29.13
35 – 44	124.65 ± 21.00
45 – 54	129.62 ± 22.95
55 – 64	122.28 ± 26.29
65 – 74	125.81 ± 26.08
75 – 85	136.88 ± 31.08
Statistical significance	F=0.56; P=0.76; NS

Discussion

Overcrowding of posterior cranial fossa (PF) can be determined if the normal range of the volume and height are available.^[7] Short height of PF and underdeveloped bony structures could lead to downward herniation of the contents in adults and in paediatric patients could result in syringomyelia due to obstruction of the normal CSF circulation. This indicates the importance of normal values in the clinical approach.

Very limited literature was available on morphometric parameters of posterior cranial fossa by normal CT studies. Hence in the present study all the parameters on supratentorial and posterior fossa could not be compared with the literature.

Observations on supratentorial parameters of the present study are the first to be reported in literature. The mean supratentorial TD was found to be less in male (12.24 ± 0.53) than in female (12.39 ± 0.59) subjects. They are more or less similar in different age groups. The mean supratentorial APD was found to be less in male (14.98 ± 0.74) than in female (15.06 ± 0.68) subjects. They are more or less similar indifferent age groups. These dimensions are helpful in the study about supratentorial gliomas and supratentorial tumours.^[8]

The gender-wise and age-wise differences in TD and APD of supra tentorial part of posterior cranial fossa were not statistically significant in the present study. There are no reported values in literature for comparing these parameters. The mean posterior fossa TD was found to be similar in the male and female subjects and the difference was not statistically significant ($P = 0.60$). There were no reports in literature for comparing this parameter.

The mean posterior fossa APD was significantly higher in males (7.06 cm) compared to that in females (6.74cm) and the difference was statistically significant ($P = 0.02$; S). The only reported value in literature was a mean of 7.47 cms for APD by Sabriet.al,^[11] [Table 6,5] based on MRI in both sexes together. The combined mean 36mm in the present study for APD was less than that reported by Sabriet.al.^[11]

The mean posterior fossa TD and APD were found to be similar in various age groups and the differences were also not statistically significant ($P = 0.76$; $P = 0.38$). There are no reports in literature on this parameter.

The mean posterior fossa height was found to be significantly higher in male subjects (3.57) compared to that in females (3.12) and the difference was also very highly significant ($P < 0.001$; S).

Table 9: Comparison of Mean posterior fossa parameters reported in literature with that of present study

Author and method of observation	Height(cm)		Volume (cm ³)		APD (mm)		TD (mm)	
Gautam Kanodia et al [7] (CT)	3.55cm (M)	3.46 cm (F)	162.88cm ³ (M)	148.99cm ³ (F)	-	-	-	-
Gautam Kanodia et al [7] (Dry bones)	3.01cm		122.49cm ³		-	-	-	-
Sabri et al [11] (MRI)	141.2mm (N)	124.7mm (Pt)	-	-	74.7mm (N)	60.4mm (Pt)	-	-
Triglydas et.al, [13] (MRI)			146.83(AS)	127.4(S)				
			107.19(N)					
Prassopoulos [8] (MRI)			3years	15 years				
			165cm ³ (M)	155cm ³ (F)				
			220cm ³ (M)	207cm ³ (F)				
Present study (CT)	3.57cm (M)	3.12 cm (F)	134.5cm ³ (M)	113.7cm ³ (F)	7.06cm (M)	6.74cm (F)	10.63 Cm (M)	10.69cm (F)

Comparison of posterior fossa values with previous studies.

M = male; F = Female; N = Normal; Pt = patients; AS = Asymptomatic Chiari malformation; S = Symptomatic Chiari malformation.

Gautam Kanodia et.al,^[7] based on observations in 100 CT scans reported a mean height of 3.55cm in males and 3.46 cm in females for posterior fossa. The values in both sexes were more or less similar in the present study as that of

Gautam Kanodia.

The mean value of PF volume reported by Gautam Kanodia et al,^[7] were 157.88 (±27.94) cm³ (range 98.75–216.88 cm³) and 159.58 (±25.73) cm³ (range 116.03– 252.99 cm³) which

shows a higher value than the present study (Table.9). They also reported the values in dry skulls as mean height of 3.01 cm (± 0.22) (range 2.5–4.0 cm) and volume of 122.49 (± 14.66), for posterior fossa. The values obtained in dry skulls are less than those obtained by CT studies in their study.

The mean posterior fossa volume was found to be significantly higher in male subjects (134.5cm³) compared to that in females (113.7cm³) and the difference was also very highly significant ($P < 0.001$; S) in the present study. The values reported in the literature [Table 9] were greater than the values in the present study in both sexes.

Trigylidas et al.^[13] conducted studies on posterior fossa dimensions and volume using MRI in Canada. They calculated the volume of posterior fossa using Cavalieri method and reported as 107.19 which is lower than the values obtained in the present study using CT findings [Table 9].

Prassapoulos,^[8] values are also higher than the present study which he reported in normal children between 3-15 years using MRI [Table 9]

Mean posterior fossa height reported by Gautam Kanodia et al.^[7] is similar to the values obtained in the present study in males. In females the values obtained in the present study are less than that reported by Gautam Kanodia et al.^[6] Sabriet et al.^[11] reported the value of mean height of posterior fossa as 14.12cms in MRI studies which was higher than the values obtained in the present study.

The mean posterior fossa height and volume were found to be similar in the various age groups and the differences were also not statistically significant ($P = 0.36$; $P = 0.76$). There is no reported literature on age-wise study on posterior fossa parameters as was done in the present study.

Conclusion

All the parameters observed in the present study did not show statistically significant differences. Statistically significant differences between sexes were observed in the APD of posterior fossa, mean posterior fossa height and posterior fossa volume. Between the different age groups the parameters were not significant.

The present study is of great use to radiologists and neurosurgeons, as the morphometric parameters of posterior fossa, are essential for performing surgeries of the cranio-vertebral junction disorders, supra tentorial tumours etc.

As the present study is performed in controls it forms a base for comparing with that is various cranio-vertebral junction diseases and for determining the extent of neuro-surgical procedure.

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