Int. J. Morphol.,
39(5):1371-1382, 2021.

The Relationship of the Posterior Cranial Fossa with Age and Sex

Relación de la Fosa Craneal Posterior con la Edad y el Sexo

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ÖKSÜZLER, M.; POLAT, S.; IPEK ÇAY, E. & GÖKER, P. The relationship of the posterior cranial fossa with age and sex. *Int. J. Morphol., 39(5)*:1371-1382, 2021.

SUMMARY: This paper determined the morphometric measurements of posterior cranial fossa using MRI in Turkish healthy population. Two hundred thirty one (231; 131 females and 100 males) subjects ranging from 20 up to 85 years were included in this study. Measurements of the posterior cranial fossa were taken from subjects having brain MRI in the Radiology Department, Adana, Turkey. Statistical analysis were done by SPSS 21.00 package programme. ANOVA Test and Chi-Square Test were used to determine the relation between measurements and age groups. The p<0.05 value was considered as significant. The overall means and standard deviations of the measurements were: Clivus length,31.10±5.45 mm; McRae line, 32.59±3.89 mm; Supraocciput length,41.99 ±4.37 mm; Twining line, 79.23±5.53 mm; Posterior cranial fossa height, 66.76±5.06 mm; Cerebellum height, 55.17±5.29 mm; Clival angle, 125.59°±6.57°; Cerebellar tentorium angle, 128.30°±7.77° mm, Occipital protuberance angle, 93.27°±8.02° and hindbrain vertical length, 50.56±3.47 mmin females, respectively, whereas the corresponding values were 32.43±5.99 mm; 32.85±3.77 mm; 42.46±4.68 mm; 80.95±5.94 mm; 69.70±4.67mm; 57.01±3.43 mm; 123.90°±7.12° 128.80±8.33°; 95.35±9.19° and 52.71±3.33 mm in males, respectively. Significant difference was found in some parameters such as twining line, posterior cranial fossa height, cerebellum height and hindbrain vertical length between sex (p<0.05). Also, ages were divided into six groups as decades. Significant difference between six decades was also found in parameters including McRae line, twining line, posterior cranial fossa height, cerebellum height, clival angle, cerebellar tentorium angle, occipital tuberance angle and hindbrain vertical length (p<0.05). The posterior cranial fossa dimensions of healthy population provides important and useful knowledge in terms of comparison of abnormalities clinically, and data can be used as an anatomical landmark during surgery involving posterior cranial fossa.

KEY WORDS: Posterior cranial fossa morphometry; Age and sex changes; Clinical importance of angles of posterior cranial fossa.

INTRODUCTION

Posterior cranial fossa, which accommodates cerebellum, pons, medulla oblangata and brain lobus. It is located at the outlet of the cerebrospinal fluid flow from the ventricular system. The fossa posteriorly is surrounded by the muscles attached to the occipital bone and upper cervical vertebrae (Standring, 2008; Seker & Rhoton, 2015; Snell, 2015; Arıncı & Elhan, 2020). The posterior fossa extends from tentorial incisura to the foramen magnum. It is surrounded by the occipital, temporal, parietal, and sphenoid bones. It is bound in front by the dorsum sellae, the posterior part of the sphenoid body, and the clival part of the occipital bone, os temporale pars mastoidea and pars petrosa facies posterior; os occipitale, and os parietale angulus mastoideus. The brain lobus occipitalis is located at the cerebellar fossa where is at the superior part of the posterior cranial fossa and the two lobus cerebellaris are located at the cerebellar fossa where is the inferior part of the posterior cranial fossa (Standring; Seker & Rhoton; Snell; Arıncı & Elhan). Also, the posterior cranial fossa is the largest and deepest cranial fossa according to anterior and middle cranial fossae, and has the most complicated intracranial anatomy (arterial relationship). The pathways regulating consciousness, vital autonomic functions, and motor activities and sensory reception for the head, body, extremities and the centers for controlling balance and gait (Seker & Rhoton). Therefore, the fractures of posterior fossa result from hematom which is located at deep back muscles. If the jugular foramen loses the integrity due to trauma, the clinical symtoms emerge due to 9th, 10th and 11th cranial nerves (Standring; Snell; Arıncı & Elhan).

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Tonsillar herniation is a condition which develops in the pons and cerebellum, and passes from the foramen magnum to cervical vertebral canal (Tastemur *et al*., 2017; Tsara *et al*., 2005). Both congenital malformation such as hydrodynamic factors, traction, neuroschisis, and primary paraxial mesodermal failure (embryological defects) and acquired conditions such as pathologies in the circulation of cerebrospinal fluid, intracranial lesions (brain edema, space occupying lesion) or hypotension (chronic cerebro-spinal fluid leak, external lumbar drainage, chronic ventriculoperitoneal shunt) and osseous anomalies of the Posterior Cranial Fossa (PCF) and craniovertebral junction (Paget's disease, craniosynostosis and basilar invagination) and connective tissue disorders, play an important role in tonsillar herniation etiology (Alvarez *et al*., 1995; Milhorat *et al*., 1999; Nishikawa *et al*., 1997; Sekula Jr. *et al*., 2005; Tastemur *et al*.; Vurdem *et al*., 2012).

A reduction in the posterior cranial fossa volume which causes the posterior cranial fossa bones insufficient development to lead to Chiari malformation type I (CMI) formation. This may affect the size of its organs (Badie *et al*., 1995; Noudel *et al*., 2009; Tastemur *et al*.). Because of the structures of the posterior cranial fossa, 10 of the 12 pairs of cranial nerves are located entirely inside the posterior fossa; the ten other pairs have a segment within the posterior fossa (Seker & Rhoton; Tastemur *et al*.).

This is the first study evaluating posterior cranial fossa morphometry according to age and sex in only healthy population. Consequently, the dimensions around the posterior cranial fossa have been measured, assessed and evaluated due to complicated and critical importance of the intracranial anatomy and the vital motor and autonomic and sensory functions.

MATERIAL AND METHOD

This study was carried out from the 231 healthy adult subjects (131 females; 100 males) aged 20-85 years over a period of 3 years between January 2019 and 2021. All the test procedures were approved by our University Ethics Committee. Cranial MRI findings were evaluated by radiologist and anatomist (ICC was found as 0.887). Healthy adult subjects were selected by criteria of optimal health. Moreover, inclusion criteria for healthy adult subjects were no history of cancer, hemiplegia, intracranial tumoral mass, any psychiatric illness or neurologic disease having surgical operation related brain.

MRI was performed using a 1.5 T MRI system (Siemens; Essenza, Erlangen, Germany). Brain MRI protocol including sagittal T2-weighted spin echo (TR:3600, TE: 87 ms; slice thickness 5 mm; gap 1.5 mm) was used. The measurements were performed from digital MRI images in a hospital using caliper function with x2 magnification. Using the midsagittal T2-weighted spin echo image, the following parameters of posterior cranial fossa dimensions were evaluated (Smooker, 1994; Nishikawa *et al*.; Milhorat *et al*.; Karagöz *et al*., 2002; Aydin *et al*., 2005; Sekula Jr. *et al*.; Furtado *et al*., 2009; Dagtekin *et al*., 2011; Heiss *et al*., 2012; Hwang *et al*., 2013; Tastemur *et al*.; Özalp *et al*., 2019).

CL. The clivus length: Distance between the basion and the dorsum sellae top edge.
MRL. The McRae line (Foramen magnum anteroposterior length): Distance between basion and the opisthion.
SO. The supraocciput length: Distance between the opisthion and the protuberentia occipitalis interna.
TWL. The twining line (Posterior cranial fossa anteroposterior length): Distance from the dorsum sellae to the internal occipital protuberance.
PCFH. The posterior cranial fossa height: The length of a line perpendicularly drawn from the inferior surface of the splenium corporis callosi to the foramen magnum.
CH. The cerebellum height: The length of the cerebellar hemisphere.
CL. The clival angle (The Welcher basal angle): is formed at the intersection of the nasion-tuberculum line and the tuberculum-basion line. It' average is accepted as 132° and it should be less than 140°.
CTA. The cerebellar tentorium angle: Angle between the tentorium cerebelli and the supraocciput (tentorium cerebelli slope) or the angle between the supraocciput and the McRae line.
BSVL. The hind brain vertical length: The length of the hind brain midbrain-pons junction and the medullo cervical junction.
OTA.The occipital tuberance angle: The angle between the tentorium and a line connecting the internal occipital protuberance to the opisthion.

The data were divided into two groups: healthy adult female and male subjects (Table I). Furthermore the data were divided also into six groups according to age; subjects aged between 20-30 years for Group 1; 31-40 years for Group 2; 41-50 years for Group 3; 51-60 years for Group 4; and 61-70 years for Group 5; and 71-85 years for Group 6 (Table II).

The measurements were made on the computer screen with an electonic caliper and estimations were expressed as millimeters and degree. The SPSS 21.0 program was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), minimum (min.) and maximum (max.) values were calculated; In all statistical analyses; p value under 0.05 was considered statistically significant.

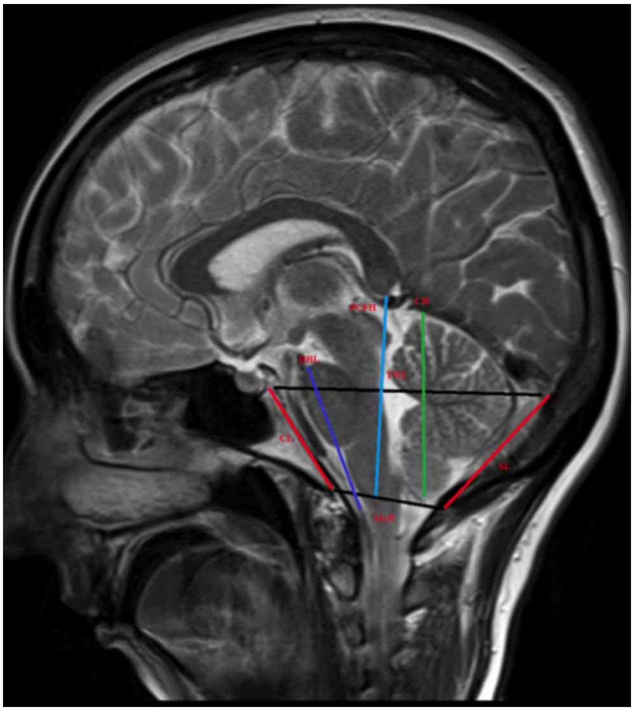

Fig. 1. Posterior cranial fossa linear measurements. CL:Clivus length; MRL: McRae Line; SO:Supraocciput length;TWL:Twining line; CH:Cerebellar height; PCFH:Posterior cranial fossa height;HBL:Hindbrain length.

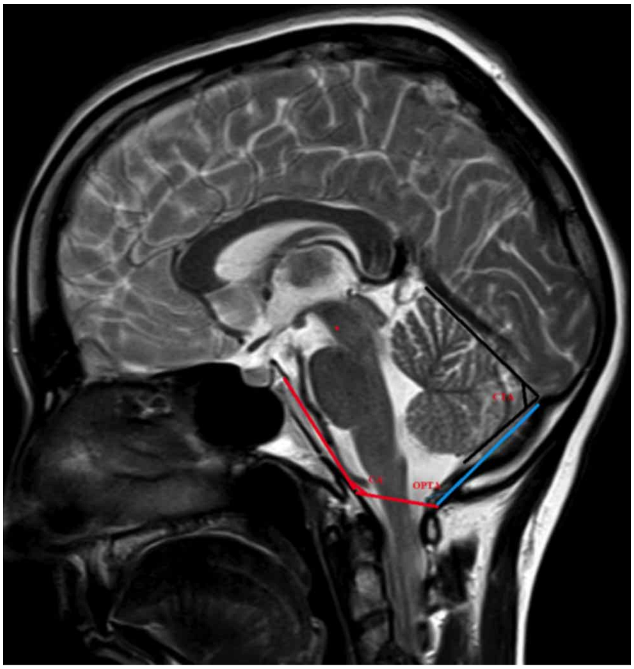

Fig. 2. Posterior cranial fossa angle measurements. CA:Clival angle; OTA:Occipital protuberance angle; CTA:Cerebellar tentorium angle.

RESULTS

The aspect of the posterior cranial fossa in sagittal MR images was shown in Figure 1 and Figure 2.

Table I. Sex related changes of posterior cranial fossa region measurements (mm/degree) with magnetic resonance imaging in Turkish healthy population (n = 231).

Posterior Cranial Fossa Values	Female (131)				Male (100)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Clivus length (mm)	31.10	5.45	19.80	41.00	32.43	5.99	18.20	45.00
P value				0.080				
McRae line (mm)	32.59	3.89	24.70	59.50	32.85	3.77	23.00	41.00
P value				0.424				
Supraocciput length (mm)	41.99	4.37	31.50	53.00	42.46	4.68	30.00	54.00
P value				0.329				
Twining line (mm)	79.23	5.53	59.00	91.00	80.95	5.94	64.00	97.00
P value				0.024				
Posterior Cranial Fossa height	66.76	5.06	54.10	83.00	69.70	4.67	60.00	83.00
P value				<0.001				
Cerebellum height (mm)	55.17	5.29	45.70	85.00	57.01	3.43	49.00	66.50
P value				0.003				
Clival angle (°)	125.59	6.57	112.70	145.00	123.90	7.12	109.00	142.00
P value				0.064				
Cerebellar tentorium angle (°)	128.30	7.77	110.00	144.00	128.80	8.33	108.70	147.00
P value				0.639				
Occipital protuberance angle	93.27	8.02	76.00	115.10	95.35	9.19	79.00	127.10
P value				0.068				
Hindbrain vertical length (mm)	50.56	3.47	41.60	59.00	52.71	3.33	43.00	59.00
P value				<0.001				

*Linear measurements in mm and angular measurements in degrees.

The value of minimum, maximum, mean and standard deviation of of the clivus length (CL), the McRae line (MRL), the supraocciput length (SO), the twining line (TWL), posterior cranial fossa height (PCFH), the cerebellum height (CH), clival angle (CA),the cerebellar tentorium angle (CTA), Hindbrain vertical length (HBL) ,the occipital tuberance angle (OTA) were measured in 231 healthy subjects (131 females and 100 males) were shown in Tables I to IV.

According to Shapiro-Wilk Test, while some measurements including the McRae line, the cerebellum height and the occipital protuberance angle was having no normal distribution ($p<0.05$), the clivus length, the supraocciput length, the twinning line, the clival angle, the cranial fossa posterior height, the cerebellar tentorium angle, brain stem vertical length measurements showed normal distribution ($p>0.05$). For this reason, the parametric tests were performed for the data showing normal distribution,

Table II. The means, standard deviations, and ranges of the posterior cranial fossa region measurements (mm/degree) with magnetic resonance imaging by age groups in Turkish healthy population (n = 231).

Posterior Cranial Fossa	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Decade 6
Values	n=65	n=49	n=45	n=22	n=28	n=22
Clivus length (mm)	31.50±6.23	31.26±6.46	32.05±5.49	31.76±3.50	32.47±4.50	31.26±6.36
	20.00-45.00	19.80-44.00	20.50-40.30	27.00-38.00	25.00-43.00	18.20-41.00
Total mean (min.-max.)	31.68±5.71 (18.20-45.00)					
P value	0.948					
McRae line (mm)	34.06±2.94	32.31±3.10	31.72±3.50	33.40±2.14	31.90±4.06	31.87±7.13
	27.20-41.00	24.70-41.00	23.00-36.10	29.00-36.00	26.00-40.00	26.00-59.50
Total mean (min.-max.)	32.70±3.83 (23.00-59.50)					
P value	0.011					
Supraocciput length (mm)	43.12±3.50	40.69±3.96	42.33±4.84	42.76±6.66	41.73±3.91	42.58±3.73
Total mean (min.-max.)	42.20±4.37 (30.00-54.00)					
P value	0.085					
Twining line (mm)	81.80±5.11	80.38±5.31	78.78±4.80	80.33±4.88	79.29±6.17	76.63±8.50
	70.00-97.00	59.00-89.00	70.70-89.00	74.00-89.00	70.00-91.90	64.00-91.00
Total mean (min.-max.)	79.97±5.76 (59.00-97.00)					
P value	0.005					
Posterior Cranial fossa height (mm)	70.42±4.74	67.25±5.85	67.46±4.25	68.95±4.44	66.57±4.56	64.85±4.42
	61.50-83.00	56.00-83.00	57.00-79.00	63.00-76.70	54.10-72.00	58.00-73.30
Total mean (min.-max.)	68.03±5.10 (54.10-83.00)					
P value	<0.001					
Cerebellum height (mm)	58.10±3.81	55.30±3.49	55.22±2.57	55.42±2.18	55.16±7.40	54.29±7.53
	51.00-66.90	49.00-64.00	50.50-59.00	53.30-60.00	46.20-84.90	45.70-85.00
Total mean (min.-max.)	55.97±4.66 (45.70-85.00)					
P value	0.001					
Clival angle (°)	123.34±6.57	125.46±6.55	125.87±8.98	128.44±3.87	124.00±5.39	123.45±6.03
	109.20-142.00	115.00-138.00	111.00-145.00	120.00-133.00	109.00-132.60	112.00-132.00
Total mean (min.-max.)	124.86± 6.85 (109.00-145.00)					
P value	0.034					
Cerebellar tentorium angle (°)	129.79±5.79	131.27±6.57	127.43±10.39	123.02±6.89	127.85±7.08	127.21±10.17
	115.00-143.20	113.00-147.00	110.00-144.00	113.00-137.00	112.90-142.00	108.70-140.00
Total mean (min.-max.)	128.52±8.01 (108.70-147.00)					
P value	0.001					
Occipital protuberance angle (°)	92.58±6.66	92.21±7.51	94.18±7.86	99.16±10.86	93.91±6.63	98.29±13.66
	78.00-107.00	76.60-107.00	80.00-109.50	79.00-113.00	81.00-111.20	76.00-127.10
Total mean (min.-max.)	94.15±8.63 (76.00-127.10)					
P value	0.04					
Hindbrain vertical length (mm)	52.34±3.46	51.10±3.02	50.68±4.20	52.80±2.16	51.29±4.15	50.45±3.31
	43.00-58.30	44.70-58.00	42.30-59.00	49.00-55.00	41.60-58.00	42.80-59.00
Total mean (min.-max.)	51.49±3.56 (41.60-59.00)					
P value	0.039					

*Linear measurements in mm and angular measurements in degrees.

Table III. The means, standard deviations, and ranges of the posterior cranial fossa region measurements (mm/degree) with magnetic resonance imaging by age groups in Turkish healthy males (n = 100).

Posterior Cranial Fossa Values	Decade 1 n=32	Decade 2 n=15	Decade 3 n=15	Decade 4 n=14	Decade 5 n=15	Decade 6 n=9
Clivus length (mm)	32.43±7.32	35.51±6.06	33.37±3.41	30.34±2.25	32.45±5.37	28.94±7.25
	20.00-45.00	23.00-44.00	27.50-39.00	27.00-32.20	25.00-43.00	18.20-38.00
Total mean (min.-max.)			32.43±5.99 (18.20-45.00)			
P value			0.102			
McRae line (mm)	34.31±3.60	31.88±2.52	31.87±4.14	33.63±2.26	32.15±5.05	30.83±3.66
	27.20-41.00	28.00-36.00	23.00-36.10	29.00-36.00	26.00-40.00	26.00-34.70
Total (min-max.)			32.85±3.77 (23.00-41.00)			
P value			0.058			
Supraocciput length (mm)	43.44±3.81	41.34±4.59	42.39±3.52	42.49±8.33	41.14±4.17	43.17±1.54
	34.00-49.00	30.00-48.00	38.00-48.00	31.00-54.00	35.00-47.20	42.00-46.00
Total mean (min.-max.)			42.20±4.37 (30.00-54.00)			
P value			0.608			
Twining line (mm)	82.98±5.74	82.35±3.83	78.89±5.24	80.80±4.72	81.48±5.77	74.22±7.85
	73.00-97.00	74.90-89.00	71.00-89.00	75.00-89.00	70.00-91.90	64.00-84.70
Total mean (min.-max.)			79.97±5.76 (64.00-97.00)			
P value			0.002			
Posterior cranial fossa height (mm)	71.15±4.72	69.87±4.92	68.80±5.46	69.77±4.94	68.67±2.66	67.43±4.45
	63.90-83.00	63.00-81.00	60.00-79.00	63.00-76.70	63.00-72.00	61.30-73.30
Total mean (min.-max.)			69.70±4.67 (60.00-83.00)			
P value			0.263			
Cerebellum height (mm)	59.22±3.65	56.85±3.19	55.91±2.43	54.80±1.54	57.04±3.41	54.67±2.31
	51.00-66.50	52.00-63.00	52.00-59.00	53.30-57.00	49.00-61.00	51.60-58.20
Total mean (min.-max.)			57.01±3.43 (49.00-66.50)			
P value			<0.001			
Clival angle (°)	123.13±7.67	125.33±7.56	119.20±5.95	130.83±1.65	123.08±5.44	122.77±6.91
	109.20-142.00	115.00-138.00	111.00-145.00	120.00-133.00	109.00-132.60	112.00-132.00
Total mean (min.-max.)			123.91± 7.12 (109.00-142.00)			
P value			<0.001			
Cerebellar tentorium angle (°)	130.67±6.23	131.24±7.71	131.03±8.46	122.46±8.03	129.46±6.94	123.18±12.19
	117.20-143.20	116.00-147.00	122.00-144.00	113.00-137.00	118.90-142.00	108.70-140.00
Total mean (min.-max.)			128.80±8.33 (108.70-147.00)			
P value			0.004			
Occipital protuberance angle (°)	92.82±6.07	94.74±6.51	92.73±9.10	100.54±12.13	93.98±6.63	103.91±13.95
	78.00-107.00	76.60-107.00	80.00-109.50	79.00-113.00	81.00-111.20	76.00-127.10
Total mean (min.-max.)			95.35±9.19 (79.00-127.10)			
P value			0.004			
Hindbrain vertical length (mm)	52.39±4.34	52.49±2.64	52.84±3.57	52.97±2.06	54.03±2.69	51.32±1.97
	43.00-58.30	44.90-56.00	48.40-59.00	50.00-55.00	48.60-58.00	49.00-55.00
Total mean (min.-max.)			52.71±3.33 (43.00-59.00)			
P value			0.505			

*Linear measurements in mm and angular measurements in degrees.

while non-parametric tests were used for the data not showing normal distribution. Significant difference in some mesurements were found in some parameters such as twinning line, cranial fossa posterior height, cerebellum height and hindbrain vertical length in females and males. Also, the supraoocciput length of females was similar to males.

The clival angle was lower in males than females. Conversely, all measurements except that the SL and CA were higher in males than in females (Table I). Additionally, the distribution of posterior cranial fossa diameters and angles according to age groups of two sexes was shown in Table II. Significant difference between decades was found in parameters including McRae line, twinning line, poste-

Table IV. The means, standard deviations, and ranges of the posterior cranial fossa region measurements (mm/degree) with magnetic resonance imaging by age groups in Turkish healthy females (n = 131).

Posterior Cranial Fossa Values	Decade 1 n=33	Decade 2 n=34	Decade 3 n=30	Deacde 4 n=8	Decade 5 n=13	Decade 6 n=13
Clivus length (mm)	30.61±4.90 21.00-40.00	29.39±5.77 19.80-40.80	31.40±6.23 20.50-40.30	34.25±4.03 28.00-38.00	32.50±3.46 27.20-38.00	32.86±5.39 26.00-41.00
Total mean (min.-max.)			31.10±5.45 (19.80-41.00)			
P value			0.122			
McRae line (mm)	33.83±2.15 29.00-38.00	32.50±3.34 24.70-41.00	31.65±3.21 26.00-36.00	33.00±2.00 31.00-36.00	31.60±2.66 27.40-35.70	32.59±8.88 26.00-59.50
Total mean (min.-max.)			32.59±3.89 (24.70-59.50)			
P value			0.305			
Supraocciput length (mm)	42.81±3.21 38.00-49.00	40.41±3.68 32.00-51.00	42.30±5.43 34.00-53.00	43.25±1.91 41.00-45.00	42.40±3.62 35.70-49.00	42.17±4.72 31.50-49.00
Total mean (min.-max.)			41.99±4.12 (31.50-53.00)			
P value			0.193			
Twining line (mm)	80.65±4.21 70.00-87.00	79.51±5.68 59.00-88.10	78.73±4.66 70.70-88.30	79.50±5.37 74.00-87.00	76.77±5.83 70.10-87.00	78.30±8.84 64.60-91.00
Total mean (min.-max.)			79.23±5.53 (59.00-91.00)			
P value			0.363			
Posterior cranial fossa height (mm)	69.72±4.73 61.50-80.90	66.09±5.92 56.00-83.00	66.79±3.40 57.00-72.00	67.50±3.16 64.00-72.00	64.15±5.17 54.10-71.00	63.07±3.56 58.00-68.00
Total mean (min.-			66.76±5.06 (54.10-83.00)			
P value			<0.001			
Cerebellum height (mm)	57.01±3.69 51.00-66.90	54.62±3.43 49.00-64.00	54.87±2.60 50.50-58.00	56.50±2.78 54.00-60.00	52.98±10.00 46.20-84.90	54.03±9.77 45.70-85.00
Total mean (min.-			55.17±5.29 (45.70-85.00)			
P value			0.167			
Clival angle (°)	123.56±5.42 112.70-138.00	125.53±6.18 115.00-138.00	129.20±8.41 115.50-145.00	124.25±2.87 120.00-127.00	125.06±5.35 118.00-132.60	123.92±5.59 113.00-132.00
Total mean (min.-max.)			125.59±6.57 (112.70-145.00)			
P value			0.017			
Cerebellar tentorium angle (°)	128.94±5.29 115.00-138.00	131.28±6.12 113.00-143.00	125.64±10.92 110.00-144.00	124.00±4.60 120.00-131.00	126.00±7.05 112.90-135.00	130.00±7.84 116.60-140.00
Total mean (min.-max.)			128.30±7.77 (110.00-144.00)			
P value			0.021			
Occipital protuberance	92.34±7.27 78.00-107.00	91.09±7.73 76.60-107.00	94.91±7.22 80.00-109.50	93.83±6.91 79.00-113.00	94.40±12.52 81.00-111.20	94.40±12.51 76.00-127.10
Total mean (min.-max.)			93.23.±8.09 (76.00-115.10)			
P value			0.316			
Hindbrain vertical length (mm)	52.31±2.38 46.60-56.00	50.49±3.00 44.70-58.00	49.59±4.12 42.30-59.00	52.50±2.45 49.00-55.00	48.12±3.18 41.6-53.00	49.85±3.95 42.80-55.00
Total mean (min.-max.)			50.56±3.47 (41.60-59.00)			
P value			0.001			

*Linear measurements in mm and angular measurements in degrees..

rior cranial fossa height, cerebellum height, clival angle, cerebellar tentorium angle, occipitotuberance angle and hindbrain vertical length ($p<0.05$). The highest value was obtained in decades 5 in clivus length, decade 1 in McRae line, supraoociput length, twinning line, posterior cranial fossa, cerebellum height, decade 4 in clival angle, occipital protuberance angle and hindbrain vertical length; in decade 2 in cerebellar tentorium angle in healthy population. Also, the lowest value was in decade 2 in the clivus length, supraoociput length and occipital protuberance angle; in decade 3 in McRae line; in decade 6 in twinning line, posterior cranial fossa length, the cerebellum length and hindbrain vertical length; in decade 1 in clival angle; and in decade 4 in cerebellar tentorium angle in healthy population (Table II).

In males, the highest value was obtained in decade 2 in clivus length and cerebellar tentorium angle; decade 1 in McRae line, Supraoociput length, twinning line, posterior cranial fossa, cerebellum height, decade 4 in clival angle; decade 6 in occipital protuberance angle and decade 5 in hindbrain vertical length. The lowest value was in decade 6 in clivus length, McRae line, twinning line, posterior cranial fossa, cerebellum height and hindbrain vertical length; decade 5 in supraocciput length; decade 3 in clival angle and occipital protuberance angle; decade 4 in cerebellar tentorium angle in males (Table III).

In females, the highest value was obtained in decade 4 in clivus length, Supraoociput length and hindbrain vertical length; decade 1 in McRae line, twinning line, posterior cranial fossa, cerebellum height, decade 3 in clival angle and occipital protuberance angle and decade 2 in cerebellar tentorium angle. The lowest value was in decade 2 in clivus length, supraocciput length, occipital protuberance angle; decade 5 in McRae line, twinning line, cerebellum height and hindbrain vertical length; decade 6 in posterior cranial fossa height; decade 1 in clival angle and decade 4 in cerebellar tentorium angle in females (Table IV). Additionally, the Post Hoc test results of healthy males and females were shown in Tables V and VII.

DISCUSSION

The supraocciput length of healthy females was similar to healthy males and the clival angle was higher in healthy females than healthy males. The other post cranial measurements was lower in females than males. In the literature to date, no studies were found in which posterior cranial fossa measurements were performed with only healthy subjects and age groups. It was observed that the studies carried out are generally related to Arnold Chiari Malformation. For this reason, we can say that our study is the first on age and sex comparisons of posterior cranial fossa.

In literature, the tonsillar herniation was defined as supraocciput length. The studies reported that the supraocciput length was lower in CMI patients than healthy subjects (Sekula Jr. *et al*.). There was significant difference in some studies (Milhorat *et al*., 99; Karagöz *et al*.; Aydin *et al*.), while some studies showed no significant difference (Sekula Jr. *et al*.; Furtado *et al*.; Hwang *et al*.). Clinical criteria for tonsillar descent was accepted as 3-5 mm or more below the foramen magnum and compatible symptomatology (Sekula Jr. *et al*.). The supraocciput length (tonsillar herniation) was found as 40.50±5.9 mm and 41.80 ± 6.2 mm in CMI patients aged between 17-65 years (mean 48 years) and control group aged between 34-68 years (mean 51 years) in USA, respectively (Sekula Jr. *et al*.). Milhorat *et al*. study performed by patients with 50 CMI and 50

Table V. The Post Hoc Test results with magnetic resonance imaging by age groups in Turkish healthy population (n = 231).

Posterior Cranial Fossa Values	CL (mm)	MRL (mm)	SO (mm)	TWL (mm)	PCFH (mm)	CH (mm)	CA (°)	CTA (°)	OTA (°)	HBL (mm)
Decade1	Decade2=0.824	Decade2=0.014	Decade2=0.003	Decade2=0.183	Decade2=0.001	Decade2=0.001	Decade2=0.098	Decade2=0.314	Decade2=0.818	Decade2=0.063
	Decade3=0.624	Decade3=0.001	Decade3=0.348	Decade3=0.006	Decade3=0.002	Decade3=0.001	Decade3=0.055	Decade3=0.118	Decade3=0.325	Decade3=0.015
	Decade4=0.856	Decade4=0.473	Decade4=0.739	Decade4=0.288	Decade4=0.217	Decade4=0.017	Decade4=0.002	Decade4<0.001	Decade4=0.002	Decade4=0.599
	Decade 5:0.457	Decade 5:0.011	Decade5=0.155	Decade5=0.049	Decade5=0.001	Decade5=0.004	Decade5=0.667	Decade5=0.270	Decade5=0.483	Decade5=0.183
	Decade6=0.863	Decade6=0.019	Decade6=0.612	Decade6<0.001	Decade6<0.001	Decade6=0.001	Decade6=0.949	Decade6=0.178	Decade6=0.006	Decade6=0.030
Decade2	Decade3=0.506	Decade3=0.452	Decade3=0.068	Decade3=0.168	Decade3=0.831	Decade3=0.926	Decade3=0.773	Decade3=0.017	Decade3=0.256	Decade=:0.557
	Decade4=0.734	Decade4=0.258	Decade4=0.063	Decade4=0.970	Decade4=0.173	Decade4=0.920	Decade4=0.088	Decade4=0.000	Decade4=0.001	Decade4=0.061
	Decade5=0.375	Decade5=0.643	Decade5=0.315	Decade5=0.414	Decade5=0.553	Decade5=0.892	Decade5=0,360	Decade5=0.064	Decade5=0.393	Decade5=0.825
	Decade6=0.999	Decade6=0.651	Decade6=0.091	Decade6=0.010	Decade6=0.055	Decade6=0.383	Decade6=0.246	Decade6=0.042	Decade6=0.005	Decade6=0.473
Decade3	Decade4=0.847	Decade4=0.087	Decade4=0.701	Decade4=0.291	Decade4=0.240	Decade4=0.863	Decade4=0.145	Decade4=0.029	Decade4=0.023	Decade4=0.021
	Decade5=0.761	Decade5=0.849	Decade5=0.561	Decade5=0.705	Decade5=0.443	Decade5=0.957	Decade5=0.252	Decade5=0.822	Decade5=0.893	Decade5=0.471
	Decade6=0.597	Decade6=0.879	Decade6: 0.827	Decade6=0.143	Decade6=0.039	Decade6=0.431	Decade6=0.170	Decade6=0.912	Decade6=0.061	Decade6=0.809
Decade4	Decade5=0.665	Decade5=0.161	Decade5=0.400	Decade5=0.518	Decade5=0.086	Decade5=0.839	Decade5=0.022	Decade5=0.029	Decade5=0.029	Decade 5=0.131
	Decade6=0.772	Decade6=0.178	Decade6=0.886	Decade6=0.030	Decade6=0.005	Decade6=0.408	Decade6=0.015	Decade6=0.074	Decade6=0.730	Decade6:0.028
Decade5	Decade6=0.460	Decade6=0.982	Decade6=0.489	Decade6=0.098	Decade6=0.215	Decade6=0.501	Decade6=0.775	Decade6=0.770	Decade6=0.068	Decade 6=0.407

Table VI. The Post Hoc Test results with magnetic resonance imaging by age groups in Turkish healthy males (n = 100).

Posterior Cranial Fossa Values	CL (mm)	MRL (mm)	SO (mm)	TWL (mm)	PCFH (mm)	CH (mm)	CA (°)	CTA (°)	OTA (°)	HBL (mm)
Decade1	Decade 2:0.096	Decade 2:0.037	Decade2:0.158	Decade2:0.715	Decade2:0.380	Decade2: 0.015	Decade2: 0.280	Decade2:0.816	Decade2:0.479	Decade2: 0.924
	Decade 3:0.611	Decade 3:0.036	Decade 3:0.480	Decade 3:0.020	Decade 3:0.109	Decade 3:0.001	Decade 3:0.056	Decade 3:0.884	Decade 3:0.972	Decade 3:0.670
	Decade 4:0.269	Decade 4:0.563	Decade 4:0.530	Decade 4:0.220	Decade 4:0.357	Decade 4:0.000	Decade 4:0.000	Decade 4:0.001	Decade 4:0.006	Decade 4:0.591
	Decade 5:0.990	Decade 5:0.063	Decade 5:0.122	Decade 5:0.386	Decade 5:0.091	Decade 5:0.025	Decade 5:0.984	Decade 5:0.622	Decade 5:0.669	Decade 5:0.121
	Decade 6:0.118	Decade 6:0.014	Decade 6:0.879	Decade 6:0.000	Decade 6:0.036	Decade 6:0.000	Decade 6:0.885	Decade 6:0.013	Decade 6:0.001	Decade 6:0.397
Decade2	Decade 3:0.318	Decade 3:0.992	Decade 3:0.542	Decade 3:0.089	Decade 3:0.530	Decade 3:0.401	Decade 3:0.011	Decade 3:0.941	Decade 3:0.524	Decade 3:0.777
	Decade 4:0.020	Decade 4:0.202	Decade 4:0.514	Decade 4:0.450	Decade 4:0.956	Decade 4:0.073	Decade 4:0.025	Decade 4:0.003	Decade 4:0.073	Decade 4:0.701
	Decade 5:0.156	Decade 5:0.838	Decade 5:0.908	Decade 5:0.666	Decade 5:0.480	Decade 5:0.867	Decade 5:0.345	Decade 5:0.534	Decade 5:0.810	Decade 5:0.212
	Decade 6:0.009	Decade 6:0.500	Decade 6:0.360	Decade 6:0.001	Decade 6:0.216	Decade 6:0.092	Decade 6:0.051	Decade 6:0.0016	Decade 6:0.013	Decade 6:0.408
Decade3	Decade 4:0.168	Decade 4:0.199	Decade 4:0.958	Decade 4:0.353	Decade 4:0.574	Decade 4:0.329	Decade 4:0.000	Decade 4:0.004	Decade 4:0.017	Decade 4:0.916
	Decade 5:0.670	Decade 5:0.831	Decade 5:0.468	Decade 5:0.201	Decade 5:0.937	Decade 5:0.314	Decade 5:0.104	Decade 5:0.584	Decade 5:0.691	Decade 5:0.333
	Decade 6:0.077	Decade 6:0.505	Decade 6:0.698	Decade 6:0.048	Decade 6:0.486	Decade 6:0.335	Decade 6:0.195	Decade 6:0.019	Decade 6:0.003	Decade 6:0.294
Decade4	Decade 5:0.335	Decade 5:0.281	Decade 5:0.444	Decade 5:0.741	Decade 5:0.523	Decade 5:0.051	Decade 5:0.002	Decade 5:0.018	Decade 5:0.043	Decade 5:0.397
	Decade 6:0.578	Decade 6:0.077	Decade 6:0.736	Decade 6:0.006	Decade 6:0.241	Decade 6:0.919	Decade 6:0.004	Decade 6:0.830	Decade 6:0.363	Decade 6:0.251
Decade5	Decade 6:0.159	Decade 6:0.385	Decade 6:0.310	Decade 6:0.002	Decade 6:0.530	Decade 6:0.068	Decade 6:0.909	Decade 6:0.060	Decade 6:0.007	Decade 6:0.058

Table VII. The Post Hoc Test results with magnetic resonance imaging by age groups in Turkish healthy males (n = 131).

Posterior Cranial Fossa Values	CL (mm)	MRL (mm)	SO (mm)	TWL (mm)	PCFH (mm)	CH (mm)	CA (°)	CTA (°)	OTA (°)	HBL (mm)
Decade1	Decade 2:0.354	Decade 2:0.162	Decade2: 0.018	Decade2:0.398	Decade2: 0.002	Decade2:0.063	Decade2: 0.205	Decade2:0.314	Decade 2:0.528	Decade2:0.063
	Decade 3:0.560	Decade 3:0.028	Decade 3:0.622	Decade 3:0.169	Decade 3:0.015	Decade 3:0.107	Decade 3:0.064	Decade 3:0.118	Decade 3:0.208	Decade 3:0.015
	Decade 4:0.087	Decade 4:0.589	Decade 4:0.794	Decade 4:0.596	Decade 4:0.233	Decade 4:0.804	Decade 4:0.098	Decade 4<0.001	Decade 4:0.167	Decade 4:0.599
	Decade 5:0.283	Decade 5:0.081	Decade 5:0.760	Decade 5:0.033	Decade 5<0.001	Decade 5:0.020	Decade 5:0.235	Decade 5:0.270	Decade 5:0.573	Decade 5:0.183
	Decade 6:0.202	Decade 6:0.332	Decade 6:0.633	Decade 6:0.195	Decade 6<0.001	Decade 6:0.084	Decade 6:0.868	Decade 6:0.178	Decade 6:0.436	Decade 6:0.030
Decade2	Decade 3:0.137	Decade 3:0.386	Decade 3:0.067	Decade 3:0.571	Decade 3:0.553	Decade 3:0.850	Decade 3:0.003	Decade 3:0.017	Decade 3:0.061	Decade 3:0.557
	Decade 4:0.023	Decade 4:0.741	Decade 4:0.079	Decade 4:0.996	Decade 4:0.447	Decade 4:0.362	Decade 4:0.015	Decade 4<0.001	Decade 4:0.076	Decade 4:0.061
	Decade 5:0.078	Decade 5:0.479	Decade 5:0.137	Decade 5:0.130	Decade 5:0.205	Decade 5:0.340	Decade 5:0.033	Decade 5=0.064	Decade 5:0.300	Decade 5:0.825
	Decade 6:0.049	Decade 6:0.940	Decade 6:0.188	Decade 6:0.502	Decade 6:0.050	Decade 6:0.732	Decade 6:0.002	Decade6:0.042	Decade 6:0.211	Decade 6:0.473
Decade3	Decade 4:0.184	Decade 4:0.384	Decade 4:0.560	Decade 4:0.725	Decade 4:0.706	Decade 4:0.434	Decade 4:0.386	Decade 4:0.029	Decade 4:0.467	Decade 4:0.021
	Decade 5:0.537	Decade 5:0.967	Decade 5:0.941	Decade 5:0.287	Decade 5:0.092	Decade 5:0.281	Decade 5:0.104	Decade 5:0.822	Decade 5:0.687	Decade 5:0.471
	Decade 6:0.413	Decade 6:0.466	Decade 6:0.923	Decade 6:0.816	Decade 6:0.018	Decade 6:0.631	Decade 6:0.195	Decade 6:0.912	Decade 6:0.849	Decade 6:0.809
Decade4	Decade 5:0.469	Decade 5:0.422	Decade 5:0.444	Decade 5:0.273	Decade 5:0.114	Decade 5:0.137	Decade 5:0.002	Decade 5:0.029	Decade 5:0.422	Decade 5:0.131
	Decade 6:0.566	Decade 6:0.815	Decade 6:0.736	Decade 6:0.629	Decade 6:0.038	Decade 6:0.296	Decade 6:0.004	Decade 6:0.074	Decade 6:0.517	Decade 6:0.028
Decade5	Decade 6:0.864	Decade 6:0.515	Decade 6:0.310	Decade 6:0.481	Decade 6:0.559	Decade 6:0.611	Decade 6:0.909	Decade 6:0.770	Decade 6:0.857	Decade 6:0.407

healthy subjects evaluated the supraocciput length as 37.7±5.9mm and 41.8±5.2 mm, respectively. In a study performed with 22 CMI patients and 21 healthy subjects by Karagöz *et al*., the corresponding value was 38±5.2 mm and 40.9±7 mm, respectively (Karagöz *et al*.).

The mean length of supraocciput length in the the 30 Japanese Chiari Malformation Type I (38.9 mm) was not significantly lower than that in the 50 Japanese control group (48.1 mm) (Nishikawa *et al*.).

The mean value of the supraocciput length was found as 38 mm (range 32–45 mm) in Indian patients with CMI, while the same value was 42 mm (range 35–63 mm) in Indian healthy subjects (Furtado *et al*.). In a study of Aydın *et al*'s performed with 30 CMI patients aged between 35.1±12.7 years and 60 healthy subjects aged between 52.2±18.2 years, the corresponding value was found 42.1±9.3mm and 46.7±4.3mm, respectively (Karagöz *et al*.). In Korean population the same measurement was determined as 34.29 mm in 12 patients with CMI and 40.18mm in 24 healthy subjects (Hwang *et al*.). In USA population, Heiss *et al*. study reported that the same measurement was found as 40.1 ± 4.0 mm in 48 CMI patients and 41.5 ± 4.4mm in18 healthy subjects, respectively. In this paper the corresponding value was 42.46±4.68 mm and 41.99±4.12 mm in males and females. Due to these data, we found differences in the mean values of supraocciput length or tonsillar herniation of studies with our population. According to this data, Karagöz *et al*. values were found greater than ours. However, Indians' values were similar to our data.

Clivus plays a critical role in both the skull base anatomic growth and congenial anomalies detection. Also, the clival angle which the angulation made with the skull base, has a significant role in terms of anterior endoscopic approaches, and congenital malformation diagnosis and fetal period evaluations. Clivus length, clivus shape and clival angle may be effective on clinical diseases which contains coloboma, heart defects, atresia choanae (also known as choanal atresia), growth retardation, genital abnormalities, and ear abnormalities, and basilar invagination, Arnold Chiari Malformation and platybasia. Considering that clivus anomalies are associated with diseases such as platybasia, basilar invagination, CHARGE syndrome or Chiari Type I, the data of the present study can be used for the detection of clivus anomalies as well as choosing the type of approach to the skull base (Özalp *et al*.).

Tastemur *et al*., reported the clivus length as 37.46±3.75 mm in the CMI patients and 39.78±4.62 mm in control group. Aydin *et al*. performed with 60 patients having Chiari Type I Malformation mean aged 35.1±12.70 years and 30 healthy subjects mean aged 52.2±18.2 years that the clivus length was 39.0±7.7 mm and 48.4±4.9 mm, respectively. In Turkish population the clivus length was measured as 39.7 mm (anatomical) and 39.4 mm (radiological) in dry skull. Also, the same value was reported as 40.8 mm in CMI patients and 42.4 mm in healthy subjects in CT examination (Dagtekin *et al*., 2011). The mean value of the clivus length was found as 35 mm in Indian patients with CMI, while the same value was 3.8 mm in Indian healthy subjects. Also, this parameter was 35 mm and 43.9 mm in patients with pediatric CMI and adult CMI (Furtado *et al*.). The clivus length was found as 32.95 ± 8.7 mm and 43.00 ± 6.6 mm in CMI patients aged between 17-65 years (mean 48 years) and control group aged between 34-68 years (mean 51 years) in USA, respectively (Sekula Jr. *et al*.). The mean length of the clivus in the 30 Japanese Chiari Malformation Type I (49.7 mm) was not significantly lower than in the 50 Japanese control group (50.1 mm) (Nishikawa *et al*.). Milhorat *et al*. study performed by patients with 50 CMI and 50 healthy subjects evaluated the clivus length as 40.4±5.1 mm and 36.6± 4.2 mm, respectively (Milhorat *et al*.). In a study performed with 22 CMI patients and 21 healthy subjects by Karagöz *et al*., the corresponding value was 35.5±6.7 mm and 40.4±4.1 mm, respectively. In Korean population the same measurement was significantly lower in the CMI patients (mean, 22.81) than in the control group (mean, 39.84 mm) ($p<0.001$) (Hwang *et al*.). In USA population, Heiss *et al*. study reported that the same measurement was found as 38.6 ± 3.4 mm in 48 CMI patients and 43.2 ± 3.5 mm in18 healthy subjects, respectively.

Welcher or basilar angle is defined as clival angle. The angle's average is accepted as 132° and it should be less than 140°. It increases when the skull base is abnormally flattened (Smooker; Özalp *et al*.) It would seem that when the literature is scanned for the angle in question, it is also defined as below 140 degrees in subjects without malformation.This angle plays an important role in clinical disease such as CHARGE syndrome or platybasia in terms of diagnostic criterion. In CHARGE syndrome, the angle was higher than normal (Smooker; Özalp *et al*.). The clival angle was reported as 126.12±9.51° (with caliper) and 124.37±10.86° (with Computed Tomography) in dry skull (Özalp *et al*.). Additionally, the clival angle which was defined as the angle between the clivus and the McRae line ($p<0.024$) was reported as 125.42 mm in patients having CMI and 117.42 mm in healthy subjects (Hwang *et al*.). In this study, the correponding value was 125.59°±6.57° and 123.90°±7.12° in females and males.

The narrowness of hind brain by underdevelopment PCF, also in bone structure may be the primary reason of CMI and syringomyelia (Aydin *et al*., 2005; Tastemur *et al*.).

The underdevelopment in the intrauterine life of bony structures leads to downward herniation of the PCF contents as the caudal hindbrain develops normally (Nishikawa *et al*.; Aydin *et al*). A less developed occipital bone as is in the CMI, may occur with the reason of underdevelopment of the occipital somite originating from the paraxial mesoderm. This induces overcrowding in the posterior cranial fossa. It has the normally developed hindbrain. It secondarily induces a downward herniation of the brain as well as an upward shift of the cerebellar tentorium. Basilar invagination is characterized with more severe downward herniation of the hindbrain because of the more severely underdeveloped occipital enchondrium. It induces the overcrowding of the posterior cranial fossa (Nishikawa *et al*.). In Turkish CMI and healthy subjects the posterior fossa height was reported between 57.31±4.21mm and 124.7±15.7 mm; 60.54±4.30 mm and 141.2±6.8 mm, respectively. Also, the height of the posterior fossa is statistically significantly lower in the CMI patients compared to the control subjects (Nishikawa *et al*.; Tastemur *et al*.). In this paper, the corresponding value was 66.76±5.06 mm and 69.70±4.67 mm in healthy females and males, respectively. The highest value was obtained between 20-30 years, while the lowest was 70 and over.

McRae line is defined as a point between basion which is the anterior middle part of the foramen magnum and opisthion which is the posterior middle of foramen magnum and marks the anteroposterior length of foramen magnum. The foramen magnum located in the middle of the posterior cranial fossa, is the major hollow. In literarure, foramen magnum AP length measurement was contradictory. Some studies found high the same value in patients with CMI (Karagöz *et al*.; Aydin *et al*., 2005; Sekula Jr. *et al*.; Dagtekin *et al*.; Snell), while some studies found the foramen magnum AP length lower in CMI patients than healthy subjects (Hwang *et al*.). Aydin *et al*., performed with 60 patients having Chiari Type I Malformation mean aged 35.1±12.70 years and 30 healthy subjects mean aged 52.2±18.2 years that the foramen magnum AP length was 31.7±6.1 mm and 25.2±3.8 mm, respectively. The same value was measured as 34.5 mm (anatomical) and 34.3 mm (radiological) in dry skull. Also, the same value was reported as 40.1 mm in CMI patients and 32.4 mm in healthy subjects in CT examination (Dagtekin *et al*.). In a comparison study performed with 22 Chiari Malformation Type I patients and 21 normal population by Karagöz *et al*., the McRae line was measured as 35.3±4.8 mm and 34.3±3.9mm in CMI patients and healthy Turkish population. In Korean population, the same measurement was determined as 24.78 mm in 12 patients with CMI and 29.54 mm in 24 healthy subjects (Hwang *et al*.). The AP length of foramen magnum was found as 43.55±4.9 mm and 42.52 ± 5.9 mm in CMI patients aged between 17-65 years (mean 48 years) and control group aged between 34-68 years (mean 51 years) in USA, respectively (Sekula Jr. *et al*.).

In Turkish CMI and healthy subjects the posterior fossa height was reported between 35.43±3.34mm and 33.74±3.57mm, respectively. Also, the measurement was statistically significantly higher in the CMI patients compared to the control subjects (Tastemur *et al*.). The twinning line or posterior cranial fossa AP length may be defined as distance between the dorsum sellae and the protuberentia occipitalis interna (Tastemur *et al*.). The increase in the anteroposterior dimension of the posterior fossa was attributed to a compensatory remodeling of a small posterior fossa. In a study performed with 22 CMI patients and 21 healthy subjects by Karagöz *et al*. the corresponding value was 38±5.2 mm and 93.7±3.6 mm, respectively. In a study of Aydın *et al*'s performed with 30 CMI patients aged between 35.1±12.7 years and 60 healthy subjects aged between 52.2±18.2 years, the corresponding value was found 60.4±10.6 mm and 74.7±3.5 mm, respectively (Aydin *et al*.). The twining line was found as 84.55 ± 7.8 mm and 87.32 ± 6.6 mm in CMI patients aged between 17-65 years (mean 48 years) and control group aged between 34-68 years (mean 51 years) in USA, respectively (Sekula Jr. *et al*.). Additionally, in Korean population the hindbrain vertical length was determined as 52.99mm in 12 patients with CMI and 51.18mm in 24 healthy subjects (Hwang *et al*.). The corresponding value was measured as 50.56 mm and 52.71mm in healthy females and males in the present study. The same value was found as 42.9mm in CMI patients and 44.6mm in healthy subjects, respectively.

Tastemur *et al*. study showed that the size of the cerebellum was greater in the CMI patients than normal subjects. For this reason, the risk of tonsillar herniation may be higher than the normal population in patients with a small posterior cranial fossa and a large cerebellum. The significant difference was found in the superior-inferior cerebellar hemisphere measurement between patients having CMI and healthy subjects in Tastemur *et al*. and Hwang *et al*. studies. The other study performed by Nishikawa *et al*. and Sekula Jr. *et al*., reported that there was no significant difference. In Turkish population, the superior-inferior cerebellar hemisphere was found as 59.13±5.33 mm in the CMI patients and 53.32±5.37 mm in the healthy subjects (Tastemur *et al*.). The corresponding value was measured as 47.36±7.9 mm (patients with CMI) and 47.04±4.8 mm (healthy subjects) (Sekula Jr. *et al*.); 49.1 mm in the Chiari group and 47.7 mm in the healthy subjects (Nishikawa *et al*.); and 58.50 mm and 53.89 mm (patients with CMI and healthy subjects) (Hwang *et al*.). In this paper, the same value was 55.17±5.29 mm and 57.01±3.43 mm in healthy females and males.

Angle measurements obtained in morphometric studies have supported the view that the tentorium was pushed forward and became steeper to compensate the undersized bony posterior fossa (Karagöz *et al*.). The angle between the tentorium and a line connecting the internal occipital protuberance to the opisthion was used to estimate the steepness of the cerebellar tentorium. In Karagöz *et al*. study, the angle between tentorium and opisthion was 91±21° and 85±6° in patients with CMI and normal subjects, respectively. In a study performed by Tastemur *et al*, in Turkish population, the tentorial angle was found as 89.08±7.78° in the CMI patients and 90.33±7.66° in the controls. Also, the same value was reported as 86.1° in CMI patients and 84.4° in healthy subjects in CT examination (Dagtekin *et al*.). Milhorat *et al*'s study performed by patients with 50 CMI and 50 healthy subjects evaluated the supraocciput length as 90.0±7.7° and 82.5±7.2° mm, respectively (Milhorat *et al*.). In Korean population the same measurement was determined as 116.83° in 12 patients with CMI and 103.78° in 24 healthy subjects (Hwang *et al*.). The tentorial angle was found as 41.27±6.5° and 34.84 ± 7.2° in CMI patients aged between 17-65 years (mean 48 years) and control group aged between 34-68 years (mean 51 years) in USA, respectively (Sekula Jr. *et al*.). The mean of the corresponding value in the the 30 Japanese Chiari Malformation Type I (44.6°) was not significantly lower than that in the 50 Japanese control group (36.2°) (Nishikawa *et al*.). In Korean population the same measurement was determined as 130.91 degree in 12 patients with CMI and 123.08 degree in 24 healthy subjects (Hwang *et al*.). In our study, the angle was measured as 128.30°±7.77 in healthy females and 128.80°±8.33 in healthy males.

The clival angle plays an important role in estimating the steepness of clivus as well as the occipital protuberance angle. There were some differences in measurements. We consider that these differences in all data could be a result of such factors such as race, genetic variables, demographic variables (age, sex), many diseases and the measurement method differences in posterior cranial fossa measurements.

CONCLUSIONS

The findings of various studies have been compared with those in the current study and demonstrate differences and similarities in the distances and angles measured. presenting morphometric and angle data play an important role in surgical procedures in the region and viewing the skull base and images of the posterior cranial fossa due to the vulnerability in surgical operation. Having a detailed knowledge of the anatomical structures of this region can help to prevent intraoperative damage to neurovascular structures, as well as improve surgical techniques and decrease the morbidity and mortality rate during the surgical procedures.

While many studies have been published based on posterior cranial fossa, it is concluded that the observations of the past studies were related to especially Chiari Malformation type I. In this regard, we can say that this is the first study considering posterior cranial fossa morphometry according to especially, age related changes and sex differences in Turkish healthy population. Also, our study provides important information and reference data related to posterior cranial fossa measurements in terms of clinical work. These presented findings, which include the age and sex related normal values changes, will provide an evaluation opportunity to data regarding age and sex related posterior cranial fossa studies and shed light on patients with CHARGE disorders or CMI diseases or platybasia and in the aging process.

ÖKSÜZLER, M.; POLAT, S.; IPEK ÇAY, E. & GÖKER, P. Relación de la fosa craneal posterior con la edad y el sexo. *Int. J. Morphol., 39(5)*:1371-1382, 2021.

RESUMEN: Se determinaron las medidas morfométricas de la fosa craneal posterior mediante resonancia magnética en una población turca. Se incluyeron doscientos treinta y un (231; 131 mujeres y 100 hombres) sujetos sanos con edades entre los 20 y los 85 años. Por medio de una resonancia magnética cerebral se tomaron medidas de la fosa craneal posterior de sujetos en el Departamento de Radiología de Adana, Turquía. El análisis estadístico se realizó mediante el programa de SPSS 21.00. Se utilizó la prueba ANOVA y la prueba de chi-cuadrado para determinar la relación entre las medidas y los grupos de edad. Se consideró significativo el valor de p <0,05. Las medias generales y las desviaciones estándar de las medidas en las mujeres fueron: longitud del clivus, 31,10 ± 5,45 mm; Línea McRae, 32,59 ± 3,89 mm; Longitud del supraoccipucio, 41,99 ± 4,37 mm; línea de Twining (desde el tubérculo selar hasta la confluencia de los senos), 79,23 ± 5,53 mm; Altura posterior de la fosa craneal, 66,76 ± 5,06 mm; Altura del cerebelo, 55,17 ± 5,29 mm; Ángulo clival, 125,59 ° ± 6,57 °; Ángulo del tentorio cerebeloso, 128,30 ° ± 7,77 ° mm, Angulo de protuberancia occipital, 93,27 ° ± 8,02 ° y Longitud vertical del rombencéfalo, 50,56 ± 3,47 mm. En los hombres los valores obtenidos fueron 32,43 ± 5,99 mm; 32,85 ± 3,77 mm; 42,46 ± 4,68 mm; 80,95 ± 5,94 mm; 69,70 ± 4,67 mm; 57,01 ± 3,43 mm; 123,90 ° ± 7,12 ° 128,80 ± 8,33 °; 95,35 ± 9,19 ° y 52,71 ± 3,33 mm, respectivamente. Se encontraron diferencias significativas entre ambos sexos (p <0,05) en algunos de los parámetros, como la línea de Twining, la altura de la fosa craneal posterior, la altura del cerebelo y la longitud vertical del rombencéfalo. También se encontró una diferencia significativa entre las edades de los individuos (división en seis décadas) en los parámetros que incluyen la línea de McRae, la línea de Twining , la altura de la fosa craneal posterior, la altura del cerebelo, el ángulo de clivación, el ángulo de la tienda del cerebelo, el ángulo de protuberancia occipital y la longitud vertical del rombencéfalo (p <0,05). La población estudiada nos proporciona información importante y útil en términos de comparación clínica de anomalías y los datos pueden eventualmente ser utilizados como un punto de referencia anatómico durante la cirugía que involucra la fosa craneal posterior.

PALABRAS CLAVE: Morfometría de la fosa craneal posterior; Cambios de edad y sexo; Importancia clínica de los ángulos de la fosa craneal posterior.

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Received: 23-03-2021
Accepted: 26-06-2021