



SEX DETERMINATION BASED ON MORPHOMETRIC MEASUREMENTS OF FORAMEN MAGNUM USING COMPUTED TOMOGRAPHY SCAN.

Anatomy

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ABSTRACT

Introduction: Foramen magnum is the largest foramina of the skull, located in the lower part of posterior cranial fossa. Sex determination is one of the principle objectives when examining human skeletal remains, the successful identification of the deceased is vital to the progress of forensic investigation. Morphometric measurements of Foramen magnum were useful in sex determination.

Aims & Objectives: To study various morphometric dimensions of Foramen magnum in males and females using CT-scan images. Sex determination of dry human skulls of unknown sex by comparing morphometric parameters of skulls of known sex using CT-scan, parameters like APD, TD, Area, Circumference.

Materials & Methods: The present study was conducted on 50-CT images of skulls of known sex (25 male and 25 female) and on 50- dry skulls of unknown sex. Various dimensions of Foramen Magnum like APD, TD, Area, Circumference of both CT- images of skulls & dry skulls were measured. Collected data analysed statistically.

Results: The morphometric parameters of Foramen Magnum were significantly higher in males as compared to females. The mean APD was 38 ± 1.7 mm in males, 34 ± 1.5 mm in females. Mean TD in males and females were 30.6 ± 1.7 mm and 27.8 ± 0.9 mm respectively. The mean area was 919 ± 58 mm² in males, 764.8 ± 50 mm² in females. Mean circumference in males and females were 99.3 ± 9.6 mm, 80.8 ± 6.5 mm respectively. Based on CT-scan parameters as reference values 21 dry skulls of unknown sex were identified as male, 20 dry skulls of unknown sex were identified as female skulls.

Conclusions: CT-scan images provide valuable measurements for the Foramen Magnum and could be used for sex determination even when other methods are inconclusive. The dimensions of Foramen Magnum were useful in sex determination thus opening avenues in the field of forensic medicine and anthropology.

KEYWORDS

Foramen magnum, Dry skull, CT-scan, Sex determination

INTRODUCTION:

Gender is one of the main biological properties that can be determined from skeletal remains [1]. The skull, pelvis, femur are the most suitable bones for radiological determination of gender [2]. When entire skeleton is available, gender determination with 100% certainty. Analyses on the pelvis, skull each may give 95% and 92% respectively. The inclusion of pelvis and skull increases the accuracy up to 98% [3].

Foramen Magnum is a three-dimensional large aperture located in the basal region of occipital region of the skull [4]. Foramen Magnum is well protected in anatomical position as it covered by large volume of soft tissue and skeleton of head [5]. Diameter of Foramen Magnum does not change after puberty [6].

Dimensions of Foramen Magnum can be utilized for sex determination in medico-legal conditions especially in circumstances of explosions, aircraft accidents and war fare injuries [7].

The present study was conducted to determine accuracy of dimensions of Foramen Magnum using CT-scan images and sex determination of dry human skulls of unknown sex based on CT- parameters of skulls of known sex.

Aims And Objectives:

To study the accuracy of Foramen Magnum dimensions in sex determination using CT-scan images

Determination of sex of dry human skulls of unknown sex by comparing the CT- parameters of Foramen Magnum of skulls of known sex.

MATERIALS & METHODS:

The present study was conducted on 50CT- scan images of both sexes (25males and 25 females) and also on 50 dry human skulls of unknown sex. CT-images were collected from diagnostic centres of Hyderabad and dry skulls from the department of anatomy.

This study has taken prior approval from institutional ethical committee. Study included adult cranial CT-scans with complete Foramen Magnum, fully ossified dried skull. Images with signs of trauma, surgery, pathological lesions in the region of Foramen Magnum, broken& deformed skulls were excluded from this study.

Images were analysed using Picture Archiving Communication System (PACS) application on grey-scale monitor. Following four parameters were measured on spiral CT scan images and dry skulls and were recorded in millimetres:

Maximum Antero-Posterior diameter (APD): Maximum anteroposterior dimension measured from the highest point on the anterior border (Basion) up to the inferior-most point (Opisthion).

Maximum Transverse diameter (TD): The maximum dimension between two lateral margins measured from the point of highest convexity on the medial border up to the point of highest convexity on the distalmost margin

Area: $\frac{1}{4} \times \pi \times$ Antero-Posterior diameter $\times$ Transverse diameter (Formula given by Routal et al)[12]

Circumference of Foramen Magnum (C): Perimeter obtained by tracing the entire border of Foramen Magnum.

All measurements were repeated twice to eliminate observer bias. The data was compiled and analysed statistically using Microsoft Excel Software.

Mean, standard deviation were calculated, student's t-test was performed and p-value < 0.05 was considered as statistically significant.

Observations And Results:

The present study was done on 50CT-scan images of skulls of known sex (25male and 25 female) and 50dry human skulls of unknown sex.

The results were represented below in table no-1 and table no-2.



Fig 1: CT- Scan image showing a Female Skull with Measurements of Foramen Magnum

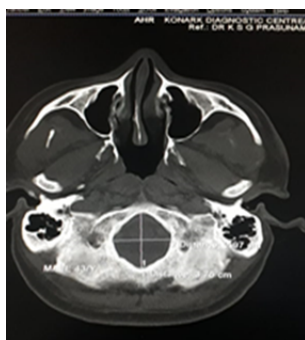


Fig 2: CT-Scan image showing a Male Skull with Measurements of Foramen Magnum.

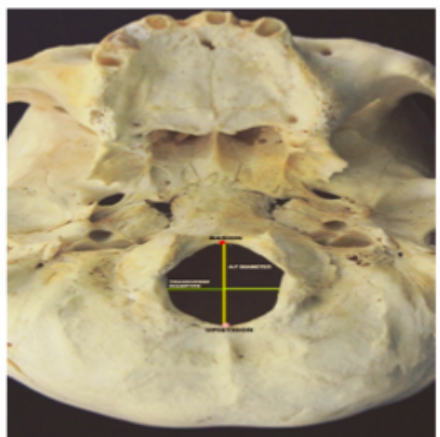


Fig 3: Showing Foramen Magnum along with its Basion, Opisthion, Antero- Posterior diameter and transverse diameter (Dry skull)

Table No -1: Comparison Of Morphometric Data Of Foramen Magnum Between Dry Skulls And CT-scan Images

Parameter	Dry skulls (50)	CT- images (50)
APD	35.8±3.0	35.9±2.4
TD	30.0±2.8	29.0±1.8
Area	823.4±98.9	820.2±90.9
Circumference	90.2±11.6	88.7±11.3

Table No-4. Comparison of Foramen Magnum variables in male and female CT-scan images with previous authors.

S. No	Author & year	Sample Size	Gender	APD	TD	Area	Circumference	Overall accuracy
1	A.T. Uthman, et al, 2012 [9]	88	M-43	34.9±2.0	29.5±2.5	765.2±98	99.3±6.2	68%
			F-45	32.9±2.0	27.3±2.5	670.2±93.7	92.6±6.5	
2.	Aghakani K, et al, 2016[6]	100	M-50	37.71±1.46	31.68±1.26	939.4±62.4	-	96%
			F-50	34.37±1.4	28.34±1.4	766.8±70.3	-	
3.	Mayuri jaitley, et al, 2016[5]	280	M-140	37.3±2.61	37.1±3.6	916±145	115±11.6	72
			F-140	35.95±2.38	29.51±2.77	812.2±95.9	109.23±9.68	
4.	Harshita Rai, et al, 2017[10]	200	M-100	39.5±0.19	31.2±0.29	970±93	-	94%
			F-100	32±1.40	25.8±1.8	657±57	-	
5.	Metin A et al,2017[1]	100	M-50	34.73±2.21	30.47±2.25	817±109	119.82±10.23	67%
			F-50	32.99±2.65	28.4±2.72	727±90	113.08±9.09	
6.	S.P.Vinutha, et al,2018[11]	200	M-110	35.96±3.75	30.38±2.84	799.3±134	124.87±10.49	65%
			F-90	33.83±3.51	27.98±2.53	697.7±116	116.6±9.67	
7.	Vidisha Gargi, et al,2018[2]	110	M-55	34.84±1.83	30.65±1.79	839.6±69.7	106.28±3.71	90%
			F-55	32.96±2.21	28.7±1.91	752.1±88.3	99.46±3.7	
8.	Present study 2020	50	M-25	38±1.7	30.6±1.7	919±58	99.3±9.6	90%
			F-25	34±1.5	27.8±0.9	764.8±50	80.8±6.5	

The present study revealed that the dimensions of Foramen Magnum such as APD, TD, Area, circumference were significantly higher in males compared to female skull (p-value <0.001).

The results of our study were in accordance with several studies like A.T. Uthman et al [9], Maruthi Jaitley et al [5], Metin et al [1], S.P. Vinutha et al [5].

Table No -2: Comparison Of Morphometric Values Of Foramen Magnum In Male And Female Skulls

	Males				Females				
Parameter	Range	Mean	SD	SE	Range	Mean	SD	SE	P-value
APD	36.1-41.4	38	1.7	0.3	31.1-35.7	34	1.5	0.3	<0.001
TD	29.1-33.7	30.6	1.7	0.3	26.4-28.9	27.8	0.9	0.2	<0.001
Area	821-1010	919	58	11.6	668.9-815	764.8	50	10	<0.001
Circumference	88.7-116.6	99.3	9.6	1.9	68.1-88	80.8	6.5	1.3	<0.001

The mean APD was 38±1.7mm in males, 34±1.5mm in females. Mean TD in males and females were 30.6±1.7mm and 27.8±0.9mm respectively. The mean area was 919±58mm² in males, 764.8±50mm² in females. Mean circumference in males and females were 99.3±9.6mm, 80.8± 6.5mm respectively. All dimensions were significantly higher in males as compared to female skulls and showed statistical significance (P-value<0.001). Overall accuracy of sex determination using CT-measurements of Foramen Magnum was 92% in male 90% in female skulls.

Based on CT-parameters of Foramen Magnum as reference values, the authors evaluated determination of sex of dry human skulls of unknown sex and the results were represented below in table no-3.

Table No -3: Sex Determination Of Dry Human Skulls Using CT-parameters Of Skulls Of Known Sex

	Male skulls		Female skulls		Overlapping skulls	
Parameter	Value	Number	Value	Number	Value	Number
APD	>38	21	<34	19	34-38	10
TD	>30.6	22	<27.8	22	27.8-30.6	6
Area	>919	23	<764	22	764-919	5
Circumference	>99.3	18	<80.8	17	80.8-99.3	15

Based on the above CT- parameters out of 50 dry skulls of unknown sex 21(82%) were identified as male skulls and 20(80%) were identified as female skulls by using multivariate analysis. However, overlapping of gender was observed in all the parameters. This may be due to difference between the anatomic and radiographic methods, number of parameters and geographical variations.

DISCUSSION:

Morphometric analysis of Foramen Magnum may provide a statistically useful indication as to determine the sex of unknown skulls in the field of forensic medicine and anthropology [8].

The present study was done on 50CT-scan images of skulls (25male and 25 female) and 50dry human skulls. The results were represented below in table no-4.

In the present study the mean APD was 38±1.7mm in males, 34±1.5mm in females. Mean TD in males and females were 30.6±1.7mm and 27.8±0.9mm respectively. The mean area was 919±58mm² in males, 764.8±50mm² in females. Mean circumference in males and females were 99.3±9.6mm, 80.8± 6.5mm respectively. These findings were close to the results of Aghakhani et al [6], Mayuri Jaitley et al [5].

Conflicts of Interest: None**Acknowledgements:**

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CONCLUSIONS:

This study was done on 50CT-scan images of skulls of known sex (25male and 25 female) and 50dry skulls of unknown sex. The mean values of AP, TD, Area, circumference was significantly higher in males than in females in CT-scan images of skulls. These measurements serve as a database for determination of sex of dry skulls of unknown sex.

Based on these CT- parameters out of 50 dry skulls of unknown sex 21(82%) were identified as male skulls and 20(80%) were identified as female skulls.

The present study highlighted the importance of skulls from skeleton remains of the deceased whose identification is not known; thus, it helps in the forensic experts in medico-legal issues and also anthropologist in their study of evolution of mankind and migration of races.

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