

**Morphometry of the Foramen Magnum: An Important Tool in Sex Determination.**

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**ABSTRACT**

To determine the sexual dimorphism from the foramen magnum of South Indian human skulls and its importance in the field of forensic medicine as well as in clinical medicine. The study was conducted on 101 dry South Indian human skulls (Male – 63 and Female - 38) which belong to the museum of the department of Forensic Medicine and Toxicology and the Department of Anatomy, JJM Medical College, Davangere, Karnataka. Anteroposterior (LFM) and transverse (WFM) diameters of foramen magnum were measured by using Vernier calliper. All measurements were tabulated followed by student “t” test and descriptive statistics were done in SPSS version to know the “p” value for the significance. The mean anteroposterior diameter of foramen magnum in males was 34.37 mm and in females it was 33.80 mm. The mean transverse diameter of foramen magnum in males was 28.98 mm and in females it was 27.60 mm. The result obtained demonstrated that significant sexual dimorphism is present in the foramen magnum of South Indian human skulls.

**INTRODUCTION**

In forensic or archaeological context estimation of sex is a very important step in the identification of any human skeletal remains discovered [1]. Skull is one of the commonest parts of the skeleton used to determine the sex, and it is probably the second best region of the skeleton, next to the pelvis for this purpose [1,2]. Foramen magnum is an important landmark of the skull base and is of particular interest for anthropology, anatomy, forensic medicine, and other medical field [3]. Foramen magnum is a three dimensional aperture within the basal central region of the occipital bone. It is one of several oval or circular apertures in the base of the skull, through which medulla oblongata is transmitted. The anterior border of the foramen magnum is formed by basilar process of the occipital bone, the lateral border by the left and right ex-occipitalis and posterior border is formed by the supraoccipital part of the occipital bone [4]. Two convex kidney shaped condylar facets are found on either side of the foramen for articulation with the first cervical vertebra at the synovial atlanto-occipital joint [5]. The most accurate results are obtained when the entire skeleton is available for study, but in most of the forensic studies the skeleton will be incomplete and makes the determination of sex difficult. Therefore, it is important to establish methods for determining sex from skeletal elements likely to survive and be recovered [6]. Due to the thickness of the cranial base and its relatively protected anatomical position, this area of the skull tends to withstand both physical insults and inhumation somewhat more successful than many other areas of the cranium [7].

The aim of this study is to determine the presence of sexual dimorphism in the foramen magnum of South Indian human skulls and its importance in the field of forensic medicine as well as in clinical medicine.

**MATERIALS AND METHODS**

This study was conducted on 101 dry South Indian human skulls in the museum of the department of Forensic medicine and toxicology and the department of Anatomy, JJM Medical College, Davangere, Karnataka. The skulls used

in this study met the selection criteria which composed complete record of the sex, age and conservation conditions that permit measurements. The skulls with signs of diseases, visible abnormalities and damaged skulls were excluded from the study.

The following parameters were studied using the Vernier calliper to an accuracy of 0.02mm.

#### **Length or Antero posterior diameter of Foramen Magnum (LFM)**

Maximum length between anterior and posterior margins of the foramen magnum as measured from basion to opisthion along the mid-sagittal plane.

#### **Width or Transverse Diameter of Foramen Magnum (WFM)**

Maximum width between the lateral margins of the foramen magnum as measured from perpendicular to the mid-sagittal plane.

We studied the parameters as mentioned above and all the variables are recorded and tabulated. Intra-observer error in measurement was calculated by randomly selecting 15 skulls from the original sample. These skulls were measured for second time without reference to the original measurements taken for the first time on the same skull. Intra observer error was estimated using paired t - test. Statistical descriptions were calculated from the measurements, the mean, standard deviation (SD) and differences were analyzed using t-test and a value of  $P < 0.05$  was considered significant. (Table 1&2). The data was analyzed using SPSS (Statistical package for social sciences, version 21.0) statistical software package and presented as mean (mm)  $\pm$  SD.

### **RESULTS**

The differences seen between the measurements recorded at two different occasions were found to be non-significant. The data collected was analyzed and the results of descriptive analysis for each parameter indicate that the mean length and breadth of foramen magnum among the males were 34.37 mm and 28.98 mm respectively. The mean length and breadth among the females were 33.80 mm and 27.60 mm respectively. The results clearly indicate that males displayed larger mean values than females for both LFM and WFM. Statistically significant sex differences were observed for both LFM and WFM (Table 1 & 2).

**Table No 1: Statistical analysis of length of the foramen magnum (LFM) in relation to sex determination. (N – Number of skulls, SD – Standard Deviation)**

Parameters	Sex	N	Mean(mm)	SD	P- Value
LFM	Male	63	34.37	2.38	0.004
	Female	38	33.80	2.56	

**Table No 2: Statistical analysis of width of the foramen magnum (WFM) in relation to sex determination. (N – Number of skulls, SD – Standard Deviation)**

Parameters	Sex	N	Mean(mm)	SD	P- Value
WFM	Male	63	28.98	2.22	0.000
	Female	38	27.60	2.67	

### **DISCUSSION**

The sex determination of incomplete or damaged skeletons is a difficult task in forensic medicine and in this sequence the foramen magnum plays a vital role because of its ability to remain intact in cases where the rest of the cranium has been compromised [7]. And also the degree of sexual dimorphism within the foramen magnum may be explained by its development compared to many other skeletal elements. The foramen magnum reaches its adult size rather early in childhood [4] and is therefore unlikely to respond to significant secondary sexual changes. From a mechanical point of view, no muscles act upon the shape and size of the foramen magnum and its prime function is to accommodate the passage of structures into and out of the cranial base region and in particular, medulla oblongata which occupies the greatest portion of the foramen space. Population differences are also important in defining sexual differences in the cranium. Therefore sexual differences in the foramen magnum have been studied in various

populations. Therefore, it is necessary to know the source population of any unidentified skull and adopt a method based data from that population or a population with similar expression of sexual dimorphism. The LFM and WFM in the South Indian population is a useful indicator of sex, and comparison to values from other populations demonstrates similar results among some of the populations.

In the present study, the average length of the foramen magnum (LFM) of South Indian male skulls was found to be  $34.37 \pm 2.38$ , which was lower than the Brazilian male skulls ( $35.7 \pm 0.29$ )<sup>[8]</sup>, the Turkish ( $37.2 \pm 3.43$ )<sup>[9]</sup>, Spanish ( $36.2 \pm 0.3$ )<sup>[10]</sup>, and the English populations ( $35.91 \pm 2.41$ )<sup>[11]</sup>. Similarly LFM of the female skulls of the South Indian population was found to be  $33.80 \pm 2.56$  which was lower than Brazilian population ( $35.1 \pm 0.33$ )<sup>[8]</sup>, Turkish ( $34.6 \pm 3.16$ )<sup>[9]</sup>, Spanish ( $34.30 \pm 0$ )<sup>[10]</sup>, and English populations ( $34.71 \pm 1.91$ )<sup>[11]</sup>. Regarding the width of the foramen magnum (WFM), the values of the South Indian male skulls was found to be  $28.98 \pm 2.22$  which was lower than Brazilian male skulls ( $30.3 \pm 0.20$ )<sup>[8]</sup>, the Turkish ( $31.6 \pm 2.99$ )<sup>[9]</sup>, Spanish ( $31.1 \pm 0.3$ )<sup>[10]</sup>, and English populations ( $30.51 \pm 1.77$ )<sup>[11]</sup>. The same measure for the female skulls of the South Indian population was found to be  $27.60 \pm 2.67$  which was lower than the Brazilian population ( $29.4 \pm 0.23$ )<sup>[8]</sup>, Turkish populations ( $29.3 \pm 2.19$ )<sup>[9]</sup>, Spanish ( $29.6 \pm 0.3$ )<sup>[10]</sup> and English populations ( $29.36 \pm 1.96$ )<sup>[11]</sup>. The results demonstrated that sexual dimorphism is present in the foramen magnum and also racial difference is seen. Our study was compared with the results other Indian studies, as tabulated in Table no. 3

**Table No 3: Comparison of foramen magnum measurements with the other Indian studies** <sup>[12,13,14,15,16]</sup>

Authors	LFM (mm)		WFM (mm)	
	Male	Female	Male	Female
Babu Raghavendra YP et.al.	$36.40 \pm 3.27$	$31.62 \pm 2.05$	$32.93 \pm 2.35$	$28.32 \pm 2.12$
Kanchan T	$34.51 \pm 2.77$	$33.60 \pm 2.63$	$27.36 \pm 2.09$	$26.74 \pm 2.36$
Routal RR et.al	$35.5 \pm 2.8$	$32.0 \pm 2.8$	$29.6 \pm 1.9$	$27.1 \pm 1.6$
Singh G et.al	$33.54 \pm 2.80$	$32.31 \pm 3.24$	$27.77 \pm 2.10$	$27.21 \pm 2.99$
Radhakrishna SK et.al	$34.04 \pm 2.36$	$31.72 \pm 2.14$	$28.63 \pm 1.89$	$26.59 \pm 1.64$
Present study	$34.37 \pm 2.38$	$33.80 \pm 2.56$	$28.98 \pm 2.22$	$27.60 \pm 2.67$

It indicates that our study is similar to the study conducted by the above authors.

## CONCLUSION

Our study demonstrates that there is a statistically significant sexual difference present between male and female skulls within South Indian population, which may be useful in determining sex from foramen magnum. Even, in case of highly fragmentary remains, where no other skeletal remains are preserved, metric analysis of the basal region of the occipital bone may provide a statistically useful indication as to the sex of an unknown skull.

With this we can conclude that the data obtained from the present study may be of use to the forensic experts, neurosurgeons, anthropologists, morphologists and clinical anatomists in carrying out further research work.

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